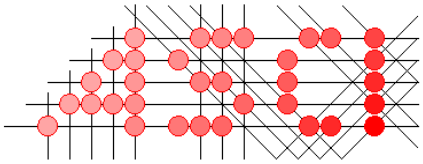

Annual Report 2004

Advanced School for Computing and Imaging

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ASCI is a Dutch graduate school established in 1993 and accredited by the Royal Netherlands Academy of Arts and Sciences. Research groups of Delft University of Technology, Vrije Universiteit, University of Amsterdam, Leiden University, University Utrecht, University of Twente, University of Groningen, Eindhoven University of Technology and the Erasmus University Rotterdam participate in ASCI.

Contents

Preface

This annual report lists the results of ASCI research for 2004. For ASCI the year 2004 was a busy year.

In March, the first ASCI Winterschool was organized in Moermund Castle at Renesse. An intensive program on Embedded Systems by experts from both universities and companies seized the attention of 30 PhD students. The last of four intense days was devoted to the traditional GNARP-workshop in which PhD students present their research projects to their colleagues.

As a continuation of a long tradition, in June the tenth ASCI conference was held at Port Zélande, Ouddorp. With more than 100 attendees the three day conference was well attended. That simple fact is half of its success. Distinguished keynote speakers delivered their insights: Rüdiger Westermann from the Computer Graphics & Visualization Group, Technische Universität München, Thomas Funkhouser from Princeton University, and Hans Mulder from Intel Research.

As a preparation for a renewed accreditation, the internal assessment was defended before an evaluation committee of international experts. The committee was impressed by the quality and productivity of the research in ASCI. To the committee, the added value of the courses was evident. As a consequence of the positive review, a detailed request for renewed accreditation was submitted to the KNAW.

As a sign of strength, the number of groups (and the number of people) grew. The number of PhD students in ASCI passed the 100 mark.

I hope you find the report an interesting read if only by the following key-numbers:

- 17 PhD degrees granted to ASCI PhD students, 15 of them acquired the ASCI certificate
- 542 scientific papers published in international journals, conferences, books and abstracts
- Production of 36 advanced software packages
- Participation in 119 externally funded research programs

This is the last report under the responsibility of prof. dr. Andy Tanenbaum as scientific director of ASCI. He has lead ASCI from the onset up to this point, 10 years later where ASCI is in full bloom. We thank him for his endless energy in building ASCI to what it now is.

For additional information about ASCI, please visit our web page at http://www.asci.tudelft.nl

Prof.dr.ir. Arnold W.M. Smeulders

Scientific Director (starting 2005)

Chapter 1 ASCI and its Research

1.1 About ASCI

ASCI is a national research school on advanced computer and imaging systems. The school was founded in December 1993, and it was approved by the KNAW (Dutch Royal Academy of Sciences) in May 1995. In 2000 the school got its new accreditation for the coming five years.
Participants in ASCI are groups from Delft University of Technology, the University of Amsterdam, the Vrije Universiteit, Leiden University and the University of Utrecht; the University of Twente, the University of Groningen, and Eindhoven Technical University have joined ASCI by association agreements.

Research within the school can be characterized as applied, experimental and technical computer science, focussed primarily on parallel and distributed systems and processing, as well as the processing of sensor data, image data and other media. With the emphasis on system development, integration of software and hardware, and the processing of sensory information, it directly addresses the needs in high-performance computing and computing intensive applications, with a special emphasis on computational science, and media-oriented applications such as multimedia, medical imaging, computer vision, industrial automation and CAD/CAM. Other important topics are embedded systems and wide-area systems.

The school organizes a graduate program and a research program covering all major subjects concerning parallel, distributed, embedded, and real-time systems, performance analysis, image processing, image analysis, image synthesis, sensor interpretation, pattern recognition and computer vision. Every year ASCI organises the Annual ASCI Conference, the scientific meeting place for all participants in ASCI. Another annual activity is the GNARP workshop (GNARP Graduate Network of Applied Research in Parallel systems) which is organized by PhD students and which is a platform for presenting work in progress. There is also a workshop on imaging topics. This workshop is organized every two or three years.

1.2 Participating Groups

The following reseach groups participate in ASCI. They are represented together with their abbreviations. For each group the members are listed (situation December 2003).

VU-WI-I Vrije Universiteit, Faculty of Sciences, Division of Mathematics and Computer Science, Dept. of Computer Science
http://www.cs.vu.nl/
Prof.dr. A.S. Tanenbaum, Prof.dr. H.E. Bal, Dr. D. Grune, Dr. W. de Jonge, Prof.dr. M.R. van Steen,, Dr. C.D. Gamage, Dr.ing. T. Kielmann, Dr. G.E.O. Pierre, Dr. B.J. Overeinder, Dr. R. van Nieuwpoort, Dr. J. Maassen, Dr.ir. H.J. Bos, Dr.B. Crispo, Dr.ir. C. van Reeuwijk, B.C. Popescu M.Sc., Drs M.D. den Burger, Drs. A.M. Dobber, Drs. N. Drost, Drs. T. van der Schaaf, S. Sivasubramanian M.Sc, drs. M. Szymaniak, drs. S. Voulgaris, drs. J.M.S. Wams, drs. M. Wrzesinska; D. Gavidia Simonetti, MSc, M.R. Rieback MS, drs. W.J. de Bruijn, S. Krishnan Nair, Drs. MH.J. Nijhuis,

UvA-FdNWI-caps University of Amsterdam, Department of Computer Science, Computer System Architcture Group http://www.science.uva.nl/research/arch/
Prof.dr. L.O. Hertzberger, Dr. A. Belloum, Prof.drs. M. Boasson, Dr. A. Pimentel, dr. C.T.A.M. de Laat, Dr. P.M.W. Knijnenburg, C.Erbas MSc, drs. J.J. van der Ham

UvA-FdNWI-ias University of Amsterdam, Faculty of Science, Informatics Institute, Intelligent Autonomous Systems.
http://www.science.uva.nl/research/ias/
Prof.dr. F.C.A. Groen, Dr. B.J.A. Kröse, Dr. L. Dorst, Dr. N. Vlassis, Drs. J. Portegies Zwart, drs. W. van der Mark, drs. J.J. Verbeek, drs. J.R. Kok, drs. M.T.J. Spaan, drs. W.P. Zajdel, H. Sunyoto MSc, drs. S. van Gosliga, drs. J.J. Verbeek, O. Booij MSc, ir.J.A. van Kleef

UvA- FdNWI-isis University of Amsterdam, Faculty of Sciences, Informatics Institute, Intelligent Sensory Information Systems Group. http://www.science.uva.nl/research/isis

	Prof. dr. A.W.M. Smeulders, Dr. R. van den Boomgaard, Dr. M. Worring, Dr.Ing. J.M. Geusebroek, Dr. T. Gevers, Dr. D. Koelma,Dr. C.J. Veenman, R.F. Aldershoff, Dr. V.T. Pham, Dr. F.J. Seinstra, J. van de Weijer, A. Diplaros M.Sc., Drs. C.G.M. Snoek, ir. G.J. Burghouts, Mw. G.P. Nguyen, S. Mehra M.A.
UvA-FdNWI-scs	University of Amsterdam, Faculty of Science, (Informatics Institute/CSP Laboratory), Section Computational Science. http://www.science.uva.nl/research/scs *Prof.dr. P.M.A. Sloot, Dr. G.D. van Albada, Dr. A.G. Hoekstra, Dr. J.A. Kaandorp, Dr. R.G. Belleman, K. Iskra M.Sc, .*
TUD-EWI-isa-pds	Delft University of Technology, Faculty of Electrical Engineering, Mathematics & Computer Science, Parallel and Distributed Systems Group. http://www.pds.ewi.tudelft.nl *Prof.dr. H.J. Sips, dr. D.H.J. Epema, Prof.dr.ir. A.J.C. van Gemund, dr. C. Witteveen, dr. K. Langendoen, dr. A.G. Baggio, P.J. Garbacki MSc, ir. G.P. Halkes, Haratcherev M.Sc., ir. N. Reijers,ir. J. Pietersma, ir. A. Iosup, A.L. Varbanescu MSc*
TUD-EWI-me-ce	Delft University of Technology, Faculty of Electrical Engineering, Mathematics & Computer Science, Computer Engineering Group http://ce.et.tudelft.nl *Prof. dr. S. Vassiliadis, Dr. B.H.H. Juurlink, ir. P.J. de Langen*
TUD-EWI-mm-cgcc	Delft University of Technology, Faculty of Electrical Engineering, Mathematics & Computer Science, Computer Graphics and CAD/CAM Group**.** http://graphics.tudelft.nl *Prof.dr. F.W. Jansen, Dr. W.F. Bronsvoort, ir. F.H. Post, Dr. W. Pasman, M. Koutek, A. Noort, E. van den Berg, C.P. Botha M.Sc., ir.B.Vrolijk, ir. H.A. van der Meiden, L.Zhao, MSc.*
TUD-EWI-mm-ict	Delft University of Technology, Faculty of Electrical Engineering, Mathematics & Computer Science, Department of Mediamatics, Information and Communication Theory Group. http://www.ict.ewi.tudelft.nl *Prof.dr.ir. J. Biemond, Prof.dr.ir. R.L Lagendijk, dr.ir.R.P.W. Duin,Dr. E.A Hendriks, Dr.ir. J.C.A. van der Lubbe,Prof.dr.ir. M.J.T Reinders, Dr. A Hanjalic, dr. L.F.A. Wessels,. dr.ir. D. de Ridder, dr.ir.E.P. van Someren, Dr. E.M. Pekalska, ir. R.J.M. den Hollander, MTD A.I. Deac, ir. P.J.O. Doets, P.Juszczak M.Sc., C. Lai MSc., ir.J.F. Lichtenauer, ir. M. van Staalduinen, ir. J.R. Taal, A. Harol MSc, ir. Th.A. Knijnenburg, S.A. Verzakov MSc, J.Wang*
TUD-TNW-tn-qi	Delft University of Technology, Faculty of Applied Physics, Imaging Science & Technology, Quantitative Imaging Group http://www.qi.tnw.tudelft.nl/ *Prof.dr. I.T. Young, Prof.dr. L.J. van Vliet, Dr. P.P. Jonker, Prof.dr. A.M. Vossepoel, J. Caarls, drs. F.G.A. Faas, B.E. TuanQuangPham, I.W.O. Serlie,ir.G.O.F. Parikesit, ir. C. van Wijk, B.J. Vermolen*
UL-WI-I	Leiden University, Faculty of Mathematics and Natural Sciences, Leiden Institute of Advanced Computer Science (LIACS) Computer & Software Systems Division- Leiden Embedded Research Center (LERC) http://www.liacs.nl/ *Prof.dr. H.A.G. Wijshoff, Prof.dr. E.F. Deprettere, Prof.dr. F.J. Peters, Dr. M.S. Lew, Dr. A.A. Wolters, Dr. D.P. Huijsmans, Dr. P.M.W. Knijnenburg, Dr. E.M. Bakker, Dr.ir. T.P. Stefanov, L.-D. Nicolae M.Sc, Drs. P.J. van der Mark, Drs. J.T. Rijsdam, C. Zissulescu-Ianculescu M.Sc., M. Haneda M.Sc., A. Turjan, drs.M.L. Cristea, drs. V. Zivkovic, drs.I.Cimpian, Drs. Hui Li, H. Nikolov MSc, rs.ing. J.H.T. Rohling*
UU-WI-ics	Utrecht University, Faculty of Mathematics and Computer Science, Institute of Information and Computing Sciences, Center for Geometry, Imaging and Virtual Environments. http://www.give.nl *Prof.dr. M.H. Overmars, Dr. M. van Kreveld, Dr. F. van der Stappen, Dr. R. Veltkamp, dr. R.W. van Oostrum, Dr. P. Min, J-S. Cheong M.Sc., M. Tanase*

M.Sc.,Dr. O. Grigore, Dr. R.W. van Oostrum, M.Sc., Drs R. Geraerts, Drs. A. Kamphuis, dipl.ing. Iris Reinbacher, drs. J.P. van den Berg, drs. E.J. Moet, Dipl.Inform. R.Typke, O.C. Goemans MSc. Ir. R. van Gulik

TUD-L&R-frs Delft University of Technology, Faculty of Aerospace Engineering
Department of Earth Observation and Space systems (DEOS)
Photogrammetry and Remote Sensing Group
http://www.lr.tudelft.nl/olrs
Prof.dr. M.G. Vosselman, Dr. B.G.H. Gorte, dr.ir. F. van den Heuvel T.R. Shah M.Sc.

UG-CS-svcg University of Groningen, Faculty of Mathematics and Physical Sciences, Institute of Mathematics and Computing Science, Scientific Visualization and Computer Graphics. http://www.cs.rug.nl/informatica/onderzoek/programmas/svcg
Prof.dr. J.B.T.M. Roerdink, Dr. G. Vegter, Dr. H. Bekker

UG-CS-IS University of Groningen, Faculty of Mathematics and Natural Sciences, Institute of Mathematics and Computing Science, Intelligent Systems.
http://www.cs.rug.nl/ *Prof.dr. N. Petkov, Dr. M.H.F. Wilkinson*

TUE-EE-dmes Technische Universiteit Eindhoven, Faculty of Electrical Engineering, Design Methodology for Electronic Systems
http://www.es.ele.tue.nl/es/ *Prof.dr.ir. R.H.J.M.Otten, Dr.ir. T. Basten, Prof.dr. H. Corporaal, Dr.ir.M.C.W. Geilen, Prof.dr.ir. G. de Haan, Dr.ir. J.P.M. Voeten, A. Beric M.Sc., S.H. Fatemi M.Sc., S. Stuijk, M. Zhao M.Sc.; Dipl.Ing. O. Florescu, Dipl.Eng. S.V. Gheorghita, A.H. Ghamarian Msc.*

TUE-WI-vis Technische Universiteit Eindhoven, Department of Mathematics and Computer Science, Visualization Group,
http://www.win.tue.nl/vis *Prof.dr.ir. J.J. van Wijk, dr. R. van Liere, dr.ir. A.J.F. Kok, dr. A.C. Telea, dr.ir. H.M.M. van de Wetering, ir. F.J.J. van Ham, A.J. Pretorius MSc, PD.Eng. S.L. Voinea*

TUE-BMT-bmia Technische Universiteit Eindhoven, Department of Biomedical Engineering
Biomedical Image Analysis http://www.bmi2.bmt.tue.nl/image-analysis/
Prof.dr. B.M. ter Haar Romeny, Prof.dr.F.A. Gerritsen, Dr. L.M.J. Florack, Dr. A.M.R. Schilham, Dr. A. Vilanova Bartroli, dr.ir. J.M. Hofman, H. Bouma, R. Duits, F. Kanters, P. Sereda M.Sc., E. Balmachnova MSc, ir. E.M. Franken, ir. T.H.J.M. Peeters, ir. B. Platel

UL-LUMC-lkeb Leiden University Medical Center, division of Image Processing, laboratorium voor klinische en Experimentele Beeldverwerking www.lkeb.nl
Prof.dr.ir. Johan H.C. Reiber, dr.ir. Faiza Admira Behloul, ir. Johan G. Bosch, dr.ir. B.P.F. Lelieveldt, Isabel Maria Adame MSc, Luca Ferrarini MSc, drs Marijn van Stralen, drs. Avan Suinesiaputra

1.3 ASCI Research Themes

In this report the scientific output of ASCI over the year 2004 has been collected and categorized along the two main research lines of ASCI, Computing and Imaging.
These are divided into research themes (A,B,C and D – see matrix) of which the denomination has changed a bit.
ASCI research historically comprises two main themes: Computing and Imaging. Within these themes, activities can be divided into methods & algorithms and systems & architecture. Methods & algorithms deals with the development of models and tools for scientific and industrial applications.
Systems & architecture deals with the large scale integration in areas like telematics, embedded systems, communication and networks. Both types of activity are targets for fundamental and applied research within ASCI.

These themes and target areas make it possible to construct the following matrix, in which four fields can are defined. These fields are indicated as A, B, C and D and are made more specific in the following paragraphs.

	Methods & Algorithms	*Systems & Architecture*
Computing	A High Performance Computing and Computational Science	B Large scale distributed Information Systems and Embedded Systems
Imaging	C Image and Multimedia Sensing, Processing, Interpretation and Visualisation	D Multimedia Information Systems

A: High Performance Computing and Computational Science

A1: High Performance Computing

High Performance Computing (HPC) is the collective name of large scale and/or real-time calculations on state-of-the-art computers. These computers are the very tools used in computational science to allow thrusting back the frontiers of knowledge.

The Computing branch of ASCI is interested in HPC to develop, improve, and study program models and programming tools for different HPC architectures. Of special interest to ASCI is research on distributed HPC architectures, which will form the basis of future Grid computing. To this purpose ASCI has a research distributed HPC system available: the DAS (Distributed ASCI Supercomputer). The research in distributed HPC comprises applications, algorithm design, languages and compilers, run-time systems, and scheduling techniques.

A2: Computational Science

Besides theoretical and experimental research, modeling and simulation has become the powerful third paradigm of scientific inquiry in the natural sciences. Here, models of natural phenomena are analyzed through (in many cases large-scale) simulations executed on state-of-the-art computing system, ranging from desktop workstations to heterogeneous distributed (grid-based) environments or massively parallel computers. Over the years, researchers have realized that modeling and simulation has many generic elements, not connected to a specific application field. Furthermore, it became clear that successful modeling and simulation requires multidisciplinary teams, where computer scientists, numerical mathematicians and researchers from application fields work closely together. These developments led to the evolution of the field of computational science. Here, research focuses on computational methods, models, and tools, using new insight from computer science and (numerical) mathematics, with the goal to facilitate the study of processes, through simulation, that was hitherto not possible.

Within ASCI a number of groups are active in the field of Computational Science. Their embedding in ASCI provides necessary input from basic computer science, especially from the computing theme. Computational Science within ASCI is basic research (as opposed to application driven computational science), focusing on generic models, enabling tools and problem solving environments.

Generic Models : Capable to capture many natural systems, allowing for formal study (using e.g. concepts from theoretical computer science), and preserving inherent parallelism. Examples include Cellular Automata, particle based models, and natural solvers. Also, study of fundamental issues related to e.g. synchronous vs. asynchronous execution in generic (parallel) models.

Enabling Tools : Examples include Virtual labs, grid based computing environments, automatic load balancing and scheduling systems, scientific visualization and virtual reality environments, data analysis and data retrieval systems (e.g. for BioInformatics), web based computing, etc.

Problem Solving Environments : Tailored towards specific application fields (e.g. climate models) or generic environments for e.g. interactive simulation.

The main challenge for computational science within ASCI lies in obtaining a true fundamental understanding of all issues related to the modeling and simulation chain. This can be achieved by thorough study of generic models and execution environments, and through detailed analysis of (possibly application oriented) case studies, in combination with realization of specific tools and problem solving environments.

B: Large-scale Distributed Information Systems and Embedded Systems

With the advent of the Internet, a new dimension has been added to the notion of computing. Computing not only concerns high-performance computations, but includes collecting, processing, and communicating information across large-scale networks. These developments are leading to a next generation of distributed computer systems that are characterized by their mixed scale, interconnectivity, and heterogeneity. Examples include traffic control systems and large-scale computational grids. The number of embedded system applications is growing explosively and parallels the rapidly emerging systems-on-silicon paradigm and the explosive expansion of networked applications, both wired and wireless.

Considerable research is needed by multidisciplinary teams of experts. Research topics include the following:

B1: Operating systems

Simply using existing operating systems to build the type of applications mentioned above will not do. Existing operating systems are tailored for general use and often require significant CPU power and main memory. In addition, they are still optimized for using local resources, and provide only traditional networking support. What is often needed are specialized operating systems that exploit the available networking facilities such as programmable network interfaces. In addition, the trend to customize operating systems to specific applications requires that new avenues to flexibility are explored.

B2: Distributed Systems

An important area of research covers middleware, also known as distributed systems. Middleware provides a layer of abstraction by which the underlying network infrastructure is mostly transparent to applications. Such a layer handles issues such as failure masking, resource management, caching and replication, automated storage, security, and so on. It provides applications with a convenient communication interface while hiding the intricacies related to issues such as performance and reliability. Developing scalable distributed systems is a major multifaceted research topic and includes subjects such as adaptive large-scale replication, worldwide directory services, and high-performance communication infrastructures.

B3: Embedded systems

An embedded system is a (not self-contained) part of a larger unit that provides service(s) to, or controls that unit. It typically consists of a heterogeneous collection of autonomous subsystems (ASICs, FPGAs, microcontrollers and DSPs) that require co-operation to perform (complex) tasks. They can be part of a geographically distributed system, locally distributed systems (in-home networks), or lumped systems (such as TV receivers). Reactive real-time embedded systems are becoming ubiquitous. Such systems react continuously to their environment at the speed of the environment. Research in this area ranges from the development of hardware and software components for digital signal processing to the development of advanced communication software. Formal methods must be called for to guarantee time-to-market, correctness and safety. However formal specifications, verifications and synthesis of software and hardware from high levels of abstraction have been demonstrated only for small, specialized languages with restricted semantics. This is at odds with the complexity and heterogeneity found in typical embedded systems of tomorrow.

One challenge is to base the approach of designing heterogeneous reactive embedded systems on the use of appropriate formal models to describe the behavior of the system at a high level of abstraction, before a decision on its decomposition into hardware and software components is taken. Another challenge is the systematic

development of embedded applications such as networked embedded applications. In the same way as embedded system design is a hardware/software co-design effort, embedded application and embedded system should be specified and explored in concert. Important issues here are scalability, robustness, re-use, quality of service, adaptive resource contracts, balancing processing load and data allocation over available processing and storage resources, both local and distributed.

C: Image and Multimedia Sensing, Processing, Interpretation, and Visualization
On the junction of Imaging and Methods and Algorithms we deal with the development and evaluation of generic models, methods, algorithms and tools for image sensing, processing, interpretation, and visualization that can be used in many concrete applications. The past decade has witnessed a huge increase in the amount of digital visual data that is generated, processed, and stored. Because humans are good in the processing of visual information, and computers are strong in the fast processing of huge amounts of data, the best of both worlds can only be combined if computers can adequately process visual data for analysis and visualisation. Many theoretical and technological breakthroughs are required before we reach that goal. New fundamental insight into the inherent complexity of problems, new algorithms with proven practical behaviour are required.
Research topics include:

C1: Image and multimedia sensing
The sensing of the real world with satellites, cameras, all kinds of (medical) scanners etc. The resulting data streams are typically large amounts of digital still images and video. Important aspects of research are the development of technology for image acquisition, image sensors and other media, motion capturing, image filtering, image coding, restoration, high quality image compression, and conversion.

C2: Image processing
Taking an image as input, process the digital image data, and output data either as an image, or as geometrical, numerical, or statistical data. Fundamentally difficult issues are topics such as: representation of images, segmentation, digital geometry, measurement, and mathematical morphology.

C3: Image interpretation
Classification and recognition of information in images. The problem is often ill-posed, and the image data often ambiguous. Challenging research questions are the development of new models for sensor data fusion, parameter estimation, adaptive control, statistical and geometrical pattern recognition, neuro computing, learning, goal directed computation, model-based interpretation, image database techniques.

C4: Visualization and modeling
The (interactive) modeling of complex objects and whole scenes, and the generation of images from these descriptions. Relevant research aspects are multi-modal data integration, 3D modelling and feature recognition, motion and path planning, computational geometry, data and information visualisation, rendering, 3D interaction, virtual environments, levels of detail.

This list is not complete, and the classification of topics is not strict, there is much overlap between various topics. Each of the techniques plays a natural role in many applications, including bio-medical imaging, industrial inspection, image and video archiving and retrieval, document analysis, geographic information systems, earth observation, computer-aided design and reverse engineering, robotics and manufacturing, robot vision and path planning. See also multimedia information systems at the junction of Imaging and Communication and Systems.

D: Multimedia Information Systems
Multimedia systems are systems that are concerned with the handling of multimedia. It includes the acquisition, representation, composition, interaction, architecture, analysis, retrieval and distribution of one or multiple information streams like images, video, speech, sound, free text, language, and graphics. New uses of information require new ways of representing the information, not only because of the availability of multiple information streams but also because of their interaction and the way they can support one another. New methods, techniques and means for the manipulation and architecture of the information are required. It will not only influence the user and the use of information, extensive use of multimedia will also fire back at the internals of the computer, the computer organization and the networks connecting them.
Research topics include:

D1: Multimedia repositories
The processing of multimedia information relies on new designs of the system architectures. Research questions are directed towards data and storage structures for multimedia data. Efficient use of storage space is necessary. Indexing multimedia data based on a higher, more abstract level are to be investigated. New search techniques to handle the large databases efficiently and to uncover information are to be developed.

D2: Image, video and audio compression
Although substantial progress has been achieved in efficient representation (compression) of images and video, it is no longer studied as an isolated problem, but is considered as one of the components of an entire system. Compression optimization is now investigated in relation with overall performance, including limited or adaptive bandwidth, quality of service, scaling of information and the ability to analyze and to manipulate content in the compressed domain directly. To interact with multimedia data, techniques are investigated to describe the data as coherent spatio-temporal objects.

D3: Multimedia understanding
At the multimedia level, understanding the information is reached by fusing the information of different modalities and sources. The main issue is how to combine multiple information streams to facilitate a better understanding. Learning from multimedia repositories is a challenging problem. Multimedia mining covers the conversion of the content of large databases into generic rules on the content.

D4: Multimedia editing systems
For the design of multimedia products the availability of multimedia editing systems is indispensable. Research questions are how to make these systems work on a sufficient level of abstraction in order not to obstruct the designer, but which are - at the same time - intuitive to understand.

D5: Delivery
To secure multimedia data through e.g. the Internet, watermarking, security and encryption techniques are inevitable for copy protection, authentication or hiding of data. Research issues are for instance the development of watermarking techniques that are resistant to various deformations and privacy guaranteed exchange of multimedia data.

D6: Multi-modal man-machine interaction
The need grows for personalized video delivery, that is, for developing systems able to filter the incoming programs, to analyze them and prepare them for retrieval according to user preferences. This is only possible if such systems are capable of learning about the user profile. An important research issue here is to find ways of characterizing, quantifying and measuring emotions.

D7:Multimedia applications
Multimedia applications are found in many different circumstances. To mention a few examples, disciplines such as the textile branch, detective work and the medical profession drive on multimedia files. The management of data in bio-informatics, especially in the area of bio-diversity and microscopic analysis and the spatial location of metabolic processes invariably are multimedia of nature. Exploring the depth of the content is an important task for the development of new knowledge. In the Internet based tele-working and other aspects of professional life, multimedia transport of information to escape human transportation is of great societal relevance.

Chapter 2 Scientific Output along Research Themes

For each ASCI subtheme this chapter contains a subsection in which the contribution of the various research groups in ASCI has been collected. The following scheme lists the enrollment of the groups with respect to the subthemes (*x.y.z* in a cell (*group, theme)* refers to the section in which the scientific ouput of *group* with respect to *theme* is reported).

	A	B	C	D
VU-WI-I		2.2.2		
UvA-FdNWI-caps		2.2.3		
UvA-FdNWI-scs	2.1.1			
UvA-FdNWI-ias			2.3.2	
UvA-FdNWI-isis			2.3.9	2.4.2
TUD-EWI-st-pds		2.2.4		
TUD-EWI-me-ce	2.1.4	2.2.6		
TUD-EWI-mm-cgcc			2.3.8	
TUD-EWI-mm-ict			2.3.7	2.4.1
TUD-TNW-tn-qi	2.1.2		2.3.13	
UL-WI-I	2.1.3	2.2.5		
UL-LUMC-lkeb			2.3.10	
UU-WI-ics			2.3.5	
TUD-L&R-frs			2.3.6	
UG-CS-is			2.3.11	
UG-CS-svcg			2.3.1	
TUE-EE-dmes		2.2.1	2.3.3	
TUE-WI-vis			2.3.4	
TUE-BMT-bmia			2.3.12	

2.1 A: High Performance Computing and Computational Science

2.1.1 Contribution of UvA FdNWI-scs

Main themes in our research are Modelling and Simulation, and Problem Solving Environments and Visualisation.

Modelling and Simulation

AMCG

People involved J.A. Kaandorp, J.Cui.

The bioinformatics group of Amsterdam Genomics Center (AmGC) is a collaboration between researchers from SILS-UVA, IvI-UvA and Academic Medical Center Amsterdam working on bioinformatics. The bioinformatics group is coordinated by Antoine H.C. van Kampen (Academic Medical Center Amsterdam) and Jaap Kaandorp (Section Computational Science, UvA). One of the major current research themes within the AmGC is the analysis and modelling of biological networks. The bioinformatics of biological networks involves a broad range of research and approaches. This research includes topics like identification of common regulatory elements for genes in a pathway, the modelling and simulation of pathways, the reconstruction of pathways from experimental data, the visualization of pathways, and the representation of pathways in graphs and databases. To accelerate our understanding of the (dynamics of) biological networks, it is imperative that these efforts are combined. Subsequently they have to be applied to real biological problems.

Recently three projects related to modelling and simulation of biological networks have been started up within the Section Computational Science (Mesoscale simulation paradigms for biological systems, Simulation of developmental regulatory networks, Mathematics and Computation for the System Biology of Cells). In March 2004 the bioinformatics group organised an international symposium on networks in bioinformatics.

Mesoscale simulation paradigms for biological systems

People involved J.A. Kaandorp, J.Cui.

Project funded by the Applied Mathematics programme of the Dutch Science foundation, duration 2003 - 2007, total value Eur 329000

In this proposed project we want to develop and compare computational models of parts of the living cell that can calculate in detail system properties from experimentally obtained molecular and physical-chemical data. Such a model is as close as possible to the biological experiments and therefore can be used not only for understanding the principles of function but also to steer further biologicalexperiments.

Simulation of developmental regulatory networks
People involved J.A. Kaandorp, Y. Fomekong Nanfack, B. Leskes
Funded by Computational Life Sciences programme of the Dutch Science foundation, duration 2003 - 2007, total value Eur 328000
In this project we will develop a model for simulating regulatory networks that are capable of quantitatively reproducing spatial and temporal expression patterns in developmental processes. The model is a generalization of the standard connectionist model used for modelling genetic interactions. The model will be coupled with a biomechanical model of cell aggregates and used to study the formation of spatial and temporal expression patterns of gene products during development in cellular systems (sponges and scleractinian corals).

Mathematics and Computation for the System Biology of Cells (Cell.Math.)
People involved J.A. Kaandorp, J. Vidal Rodriguez
Project funded by Computational Life Sciences programme of the Dutch Science foundation, duration 2003 - 2007, total value Eur 487000
The aim of the project is to develop, implement, and validate mathematical and computational techniques for the systems biology of the cell. Biologists and mathematicians together will formulate realistic mathematical models of metabolic and regulatory networks including intrinsic spatial non-homogeneity. Depending on the cellular phenomenon considered, models and methods of appropriate temporal and spatial scales will be developed and can then be applied: models in the form of ordinary differential equations and methods for system reduction; multi-adaptive computational methods for partial differential equations (PDEs) for moderate spatial and temporal variability within a cell or an organelle; particle models describing the interaction of individual molecules and computational methods for the evaluation of the dynamic behavior; and methods for integration of these different approaches into a single simulation.

Modelling and Analysis of Growth and Form of Sponges and Scleratinian Corals
People: J.A. Kaandorp, R.M.H Merks
In the bio-informatics field our research in the area of marine biology also continues. Understanding external deciding factors in growth and morphology of reef corals is essential to elucidate the role of corals in marine ecosystems, and to explain their susceptibility to pollution and global climate change. A model has been developed for simulating the growth and form of a branching coral and simulated morphologies have been compared to three-dimensional images of the coral species *Madracis mirabilis*. With this model it is possible to generate morphologies that are virtually indistinguishable from the three-dimensional images of the actual colonies. Such models can be used to test hypotheses on mass transfer through boundary layers and the impact of the physical environment on coral growth.

BMI
People: P.M.A. Sloot
In the BMI project, we work on the modelling of HIV infections and drug therapy of HIV-infected patients in collaboration with C. Boucher of the University of Utrecht and A.V. Boukhanovsky and A.B. Degtyarev of the IHPCIS in St. Petersburg. In 2003 significant results describing the Stochastic Modeling of Temporal Variability of HIV-1 Population were published.

Nato SfP
People: A.G. Hoekstra, M Yurkin, K. Gilev, K. Semianov
In the context of the Science for Peace program of Nato we collaborate with institutes in Minsk (Belarus) and Novosibirsk (Russian Federation) on new sensitive methods for cytological analysis of heamatological samples. We concentrate on the computational science aspects and HPC simulations in the field of computational electromagnetics of the project.

LBM:
A.G. Hoekstra, L. Abrahamyan
The work on mesoscopic modeling and simulation concentrated on adapting the LBM method, and specifically the L-BGK method, for unsteady flow, and to apply this to modeling flow of blood during a full heart beat in the lower abdominal aorta. We also initiated research to adapting the models to take advantage of state of the art (parallel) numerical algorithms (such as multi grids). Moreover we studied fluid-structure interaction in LBM, and have demonstrated that for 2D time-harmonic flow coupled to a simple elastic wall a theoretical expression for a dispersion relation is recovered, thus demonstrating the correctness of our model.

PECVD
Involved: V.K. Krzhizhanorskaya, P.M.A. Sloot
In this project a grid-based PSE to study the plasma enhanced chemical vapour deposition of thin films is being developed. Internally funded project in close collaboration with the IHPCIS in St. Petersburg. The research was conducted with financial support from the Dutch National Science Foundation NWO and the Russian Foundation for Basic Research under grants number 047.016.007 and 047.016.018, and with partial support from the CrossGrid EU project IST-2001-32243.

Cluster of Grapes
People involved: S. Portegies Zwart, A. Gualandris, M.S. Sipior, E. Gaburov, B. Bastijns, P.M.A. Sloot, G.D. van Albada + collaboration with the Pannekoek Astronomical Institute
One of the other research areas in which the SCS group is active, is computational astronomy. "A Cluster of Grapes", a joint NWO proposal with the astronomical institute "Anton Pannekoek" to NWO was honoured in 2001. The research covers a wide range of subjects on the boundary of Astronomy and Computational Science. As an example, Gualandris, Tirado-Ramos and Portegies Zwart studied the performance of a parallel astrophysical N-body solver on pan-European computational grids. It was demonstrated that especially for large problems grids constitute a suitable computational environment. Sipior is working to merge the “Kira integrator” with the GADGET tree code developed at MPI Garching. The end result will allow us to make use of the unique advantages of each numerical approach – the high precision of Kira for studying the dynamics of a large stellar cluster, and the computational speed of a tree code, used to simulate the galaxy in which the cluster is embedded. The first stage of this effort is now completed and undergoing testing.

Problem Solving Environments and Visualization

CrossGrid
People: A.G. Hoekstra, E.V. Zudilova, A. Tirado Ramos, R. Shulakov, D. Shamonin, P.M.A. Sloot, G.D. van Albada, M. Scarpa
In the CrossGrid project, we participate in a large European collaboration of 21 partners in the development of interactive applications in a Grid environment. These environments are characterized by the participation of multiple, geographically distributed organizations, sharing computational resources and data. This gives an improved access to these resources and data, at a cost in network and scheduling delays. In CrossGrid, we provide an application aiming to support vascular surgeons in pre-operative planning. 2004 was a consolidation of a consortium-wide integration of grid support tools and applications. The result is a fully integrated virtual vascular surgery on the grid, which will be demonstrated live during the European Grid Conference 2005 in Amsterdam.

Token2000
People: A.G. Hoekstra, P.M.A. Sloot, E.V. Zudilova, M. Scarpa, L. Abrahamyan
Token2000 is a nationally funded project (NWO), where we collaborate closely with the Universities of Leiden and Twente on the development of an interactive medical application, somewhat similar to the work in CrossGrid. This application is intended for training of surgeons. In collaboration with Leiden University Medical Centre we have created Hemosolve, a problem solving environment for image based computational Heamodynamics. Hemosolve includes our L-BGK solver, but also a FEM Navier-Stokes solver. Moreover, it contains a 3D editing tool and powerfull visualization modules.

ViSE-VL
People: J.A. Kaandorp, R.G. Belleman, P.M.A. Sloot In the ViSE-VL project we have developed a Visualisation and Simulation Environment, specifically aimed at medical applications. The results of the ViSE project are being used in the CrossGrid and Token2000 projects.
ViSE-VL was funded through the ICES/KIS 2 Min EZ project

High Performance Simulation on the GRID
Dutch-Russian project: NWO-RFBS-047.016.007
between Amsterdam, St. Petersburg, Moscow and Novosibirsk.

Dynamite
People: K.A. Iskra, T. Gubala, B. Ö Nualláin, D.A. Kaarsemaker, G.D. van Albada, P.M.A. Sloot.
The People: P.M.A. Sloot, A.V. Bogdanov.
In this project we study the use of Grid systems for High Performance Simulations. The project is a collaboration Dynamite project (now internally funded) is the continuation of work on the dynamic scheduling and migration of tasks in parallel programs started in the ESPRIT project Dynamite. In 2004 work continued on the single task

checkpointer (ironing out some smaller remaining defects) and on developing support for MPI and grid environments.

PDES
Involvement: K.A. Iskra, G.D. van Albada, P.M.A. Sloot.
This research on parallel discrete event simulation is a continuation of the work by Overeinder on the behaviour of optimistic PDES, extended to grid-like environments. In 2004 further important results regarding the behaviour of PDES in a wide-area distributed environment were obtained. Important strategies like dedicated routers, message aggregation and lazy cancellation were studied and different methods of "global virtual time" evaluations were evaluated.

External projects

Projectname	period	Funding agency	Total funding	partners in ASCI	Brief description
CrossGrid	2002 – 2006	EU, 5th framework	k€ 405		Interactive Grid applications
A Cluster of Grapes	2001 - 2005	NWO Computational Science	kf 690		N-Body simulations. P.I: E.van den Heuvel, UvA Astronomy
Mesoscale simulation paradigms for biological systems	2003-2007	NWO Applied Mathematics	k€ 329		See report
Simulation of developmental regulatory networks	2003-2007	NWO Computational Life Sciences	k€ 328		See report
Mathematics and Computation for the System Biology of Cells	2003-2007	NWO Computational Life Sciences	k€ 487		See report
Token 2000	2002 – 2007	NWO - EW	k€ 150	LKEB/LUMC (P.I.: Reiber)	Mesoscopic bloodflow simulation

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Cooperations within ASCI
Much of the research described in the preceding sections was performed making use of the DAS and the facilities provided on the DAS, The Linux version of Dynamite was developed and tested on the system, and the GRAPE-4 boards were attached to two nodes in the system. The DAS II system will be used extensively for the CrossGrid project.

Highlight

Virtual Vascular Surgery on the Grid
By Peter Sloot and Alfons Hoekstra, The University of Amsterdam, The Netherlands.
Medical simulations and visualizations typically require computational power that is not usually available in a hospital. The University of Amsterdam recently demonstrated Virtual Vascular Surgery (a virtual by-pass operation), where large-scale simulation and visualization capabilities were offered as services on the Grid.

Vascular diseases
Arteriosclerosis is a widespread disease that particularly manifests itself in the developed countries. Treatment often involves surgery, such as the placement of bypasses that lead the blood around clogged arteries to restore normal blood flow. A surgeon plans these interventions on basis of 3D images obtained from MRI or CT scans. Besides considerations such as accessibility, the attainable improvement in the blood flow will determine which treatment among alternatives is best. Improvements in the support for planning these procedures are expected to improve their success rate. We have developed a prototype grid-based system for virtual vascular surgery, which may be used in a pre-operative planning setting, or as a valuable tool in training of novice vascular surgeons. The prototype uses advanced distributed simulations and visualisations to support vascular surgeons in their pre-operative decision-making.

The Virtual Radiology Explorer
The Virtual Radiology Explorer (VRE), developed at the University of Amsterdam, is a Grid-based Problem Solving Environment for virtual vascular surgery. VRE contains an efficient mesoscopic Computational Haemodynamics solver for blood flow simulations based on parallel Cellular Automata. To convert the medical scans into computational meshes, raw scanner data is first segmented so that only the arterial structures of interest remain in the data set. The segmented data is then converted into a computational mesh. The patient's blood flow is simulated using Grid resources. The VRE system uses a desktop virtual reality environment where the patient's data obtained from a scanner is visualized as a 3D stereoscopic image, together with the graphical

interpretation of the simulation results. A user can then manipulate the 3D images of arteries. This would be the virtual surgical procedure, e.g. the addition of a bypass. Blood flow in this new geometry is also computed, and the user can then assess the effectiveness of the proposed treatment, and could try other alternatives to optimize the procedure.

The medical scanners, the visualization environment and the computational resources required for the flow computations and visualizations are usually located in various geographical locations and in distinct administrative domains. Transparent access to these resources, high efficiency and strict data security together triggered the development of our advanced Grid-based simulation and interactive visualization for virtual vascular surgery. The middleware to support this was developed in the CrossGrid project.

CrossGrid
The CrossGrid project is oriented towards compute- and data-intensive applications characterized by the interaction with a person in the loop. The CrossGrid pan-European distributed test bed shares resources across sixteen European sites. One key component of Crossgrid is the Migrating Desktop (MD) grid portal. The MD produces a transparent user work environment, permitting the user to access Grid resources from remote computers. It allows running applications, managing data files, and storing personal settings, independently of the location or the terminal type. We have incorporated our VRE system into the Grid via the MD grid portal. We achieved secured grid access, node discovery and registration, grid data transfer, application initialization, medical data segmentation, segmented data visualization, computational mesh creation, job submission, distributed blood flow visualization, and bypass creation. VRE runs on a local machine, but it is launched and initialized through the MD. The input is segmented or non-segmented medical data produced at the Leiden Medical Center (LUMC); the CrossGrid testbed provides access to this data from a medical image repository acting as a Grid Storage Element in Leiden.

A Virtual bypass operation on the Grid
We have recently demonstrated the following scenario: The abdominal aorta area of a patient is scanned, and the resulting image is stored in a Radiology Information System repository. Later, a physician (user) logs into the CrossGrid Portal using his Grid certificate and private key. The user checks if there are segmented or non-segmented medical data ready for analysis in one of the virtual nodes, and securely transfers a few to his local machine. The user then starts the VRE from within the MD, loads the segmented medical data, selects a region of interest, crops image, adds a bypass, and creates a computational mesh. The user selects the Biomedical Application icon within the MD (parameters and files are taken from user's profile), and submits the job to the CrossGrid testbed, to the nearest/most adequate Computing Element in the Grid. The user may then check job submission or progress via the MD. After the job has been completed, the velocities, pressure, and shear stress are transferred to the local Storage Element or to the Grid Visualization Kernel to be rendered and reviewed by the user. We will give a live demonstration during the upcoming European Grid Conference in Amsterdam, February 2005.

To Conclude
Successful deployment of Grids requires redesign of algorithms to support loosely coupled computer resources. It should be driven by relevant and challenging applications. With the experience gained within CrossGrid from the virtual vascular surgery application (and three other applications), it is again demonstrated that European Grid Technology is leading the way in new Grid developments worldwide.

Links:
http://www.science.uva.nl/research/scs
http://www.crossgrid.org/

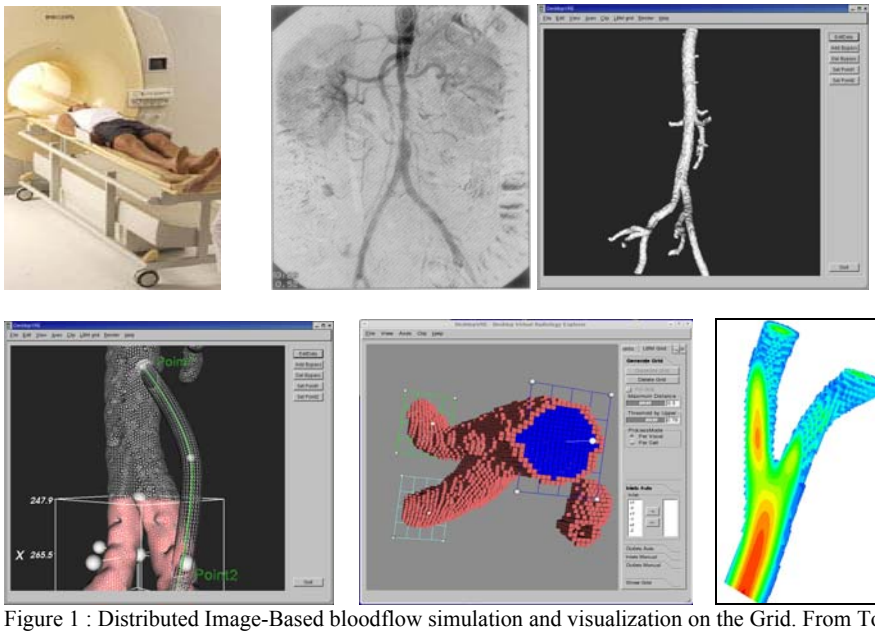


Figure 1 : Distributed Image-Based bloodflow simulation and visualization on the Grid. From Top left to bottom right: 1: A patient is scanned in Leiden, The Netherlands; 2: resulting in a raw image stored in a Storage Element on the Grid (e.g. Poznan, Poland), 3: which is segmented, filtered and cropped, using a Grid service 4: a bypass is added and, 5: a computational mesh is generated (on the local machine) that is given to the parallel flow solver, running on Compute Elements in the Grid (Amsterdam and Spain), and 6: visualization of the resulting flow fields on the local machine, however using visualization services offered by the Grid Visualization Kernel (Linz, Austria).

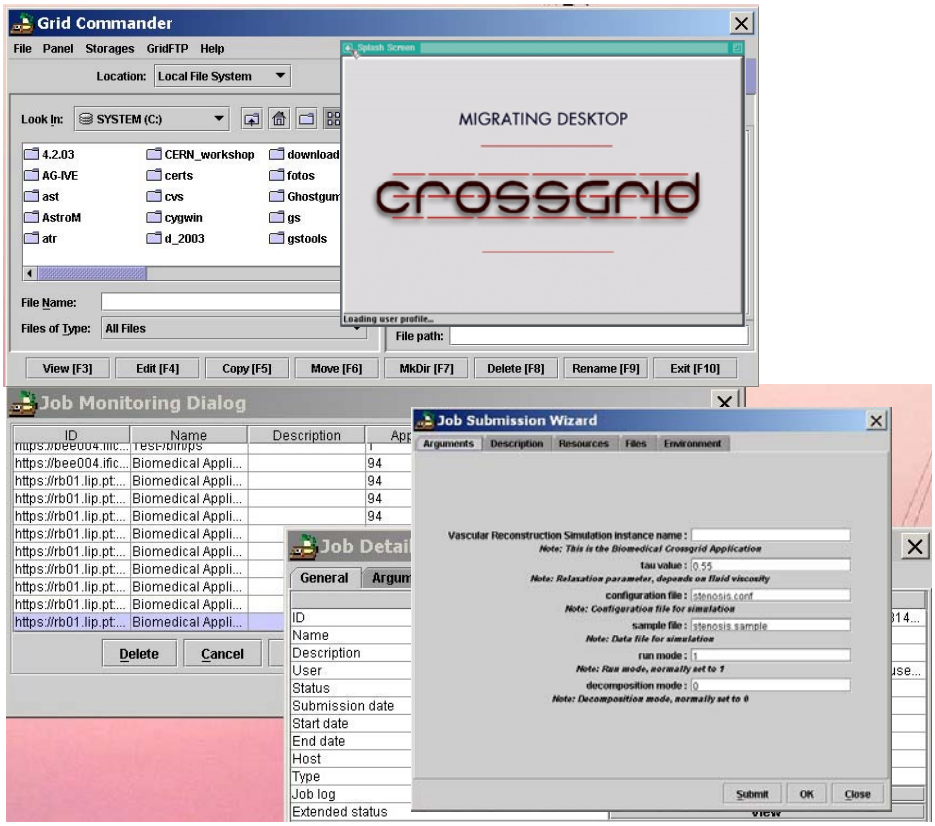


Figure 2 : The CrossGrid Grid Portal – the Migrating Desktop – with some of its functionalities, e.g. grid login and Grid Proxy creation, virtual node navigation and Grid data transfer (via the Grid Commander), submission of blood flow simulations to the CrossGrid testbed (via the Job Submission Wizard) and monitoring of jobs running in the testbed (via the Job Monitoring Dialog)

2.1.2 Contribution of TUD-TNW-tn-qi

Architectures and Algorithms, Embedded Imaging Systems
The work in 2004 encompassed projects on embedded systems that incorporate real-time computer vision subsystems.
The theoretical work was on the establishment of a parallel programming environment where heterogeneous architectures can be programmed within a single parallel programming language but use various programming paradigms, such as dataflow and data parallel. This is performed within the context of the Progress project SMARTCAM; with TUE, Philips Research and Philips CFT as main industrial partners. Data-parallelism is hidden in “algorithmic skeletons, while task parallelism is scheduled at run time over a Smartcam processor configuration incorporating TriMedia, Xetal-SIMD, FPGA with embedded PowerPC; and controller PC. Hardware design space exploration is part of the project. Carrier application is e.g. real-time stereo vision. Equivalent problems, navigation using camera's and encoders, are encountered in augmented reality applications. Within the Mobile & Wireless project of the Telematica Institute and with TUD-ITS, the positioning of virtual objects exactly in overlay with the real world, is obtained by determining the position and orientation of the human head in relation with the real world. An embedded imaging system closely coupled in a fast loop with the graphics animation system determines from visual cues, fused with information from with gyro's, accelerometers, magnetometers and tilt sensor, the position and orientation in 3D space with an update rate of 10ms.

A more or less equivalent problem can be found in the "ROBOCUP" project, in which two teams of four autonomous robots play soccer on an indoor field of about 9x5 meter. Positioning of the robot, interception of the ball, and collision avoidance of the other robots, is performed using odometry and real time image sensing and processing. This project was done in cooperation with the UvA.
Finally, within a DIOC project with partners of TUD-ITS and TUD-TNW theoretical work was performed on the development of massively parallel arrays of simple processing elements made from Single Electron Transistors. An investigation was done on the implications of quantum computing based on Josephson devices.

External projects
Mobile and Wireless
Period: 2000-2004; Funding: Telematica Research Center, with: TUD-EWI

SmartCam
Period: 2002-2006; funding STW-Progress, with: TU/e Embedded Systems

Doctoral degrees
Han, J.; 30 November 2004;
Fault-tolerant architectures for nanoelectronic and quantum devices.
TU Delft, Delft 2004, 135 pp., ISBN 3-540-22976-0, 1st money project or directly funded (=1e geldstroom)

Papers in international journals
Jonker, P.P.; Morphological operations in recursive neighbourhoods.
Pattern Recognition Letters, ISSN 0167-8655, vol. 25, no. 5, 2004, pp. 527-541.

Contributions to international conference proceedings
Caarls, W., Jonker, P.P., Corporaal, H.; Data- and Task Parallel Image Processing on a Mixed SIMD-ILP Platform using Skeletons and Asynchronous RPC. Proc. 5th PROGRESS Symposium on Embedded Systems, Nieuwegein, 20 October 2004, STW, Schweizer, M. (eds.), Utrecht, 2004, pp. 27-34.

Han, J., Jonker, P.P.; From massively parallel image processors to fault-tolerant nanocomputers. ICPR17, Proceedings 17th International Conference on Pattern Recognition, Cambridge, UK, 23-26 August, Kittler, J., Petrou, M., Nixon, M. (eds.), ISBN 0-7695-2128-2, Cambridge, UK, 2004, Vol.3, IEEE Computer Society Press, Los Alamitos, pp. 2-7.

Jonker, P.P., Terwijn, B., Driel, B. van; The Clockwork Orange Team 2004. Proc. Robocup 2004 Symposium, July 4-5, Lisboa, PORTUGAL, CD-rom, Instituto Superior Tecnico, 2004, pp. 1-4.

Jonker, P.P., Terwijn, B., Kuznetsov, J., Driel, B. van; The Algorithmic foundation of the Clockwork Orange Robot Soccer Team. WAFR '04, Proc. 6th Int. Workshop on the Algorithmic Foundations of Robotics, Zeist/Utrecht, July, 2004, pp. 1-10.

Oomes, S., Jonker, P.P., Poel, M., Visser, A., Wiering, M.; The Dutch AIBO Team 2004. Proc. Robocup 2004 Symposium, 4-5 July, Lisboa, PORTUGAL, CD-rom, Instituto Superior Tecnico, 2004, pp. 1-5.

2.1.3 Contribution UL-WI-I

Research area

The Computer and Software Systems programme concentrates on a broad range of research topics in the area of computer science: (optimising) compilers, parallel and distributed computing,grid computing, large-scale applications, large-scale database systems, embedded software development, virtual environments, application drivers, problem solving environments, analysis of multimedia information toward the needs of human computer interaction (HCI), and content based retrieval in digital libraries. We focus our research on the following sub-areas:

1. Large-scale applications, grid computing, problem solving environments
2. Parallel and distributed computing, optimizing compiler technology, embedded software development
3. New paradigms and algorithms for machine learning, analysis of multi-media information, content based retrieval; learning from user interaction.
4. Large-scale database systems, data compilation, data integration, and data mining
5. Multimedia Information Retrieval: the explosion of multimedia content in digital libraries, bio-medical science, the Internet, streaming video, databases, cultural heritage collections and peer-2-peer networks has created a worldwide need for new paradigms and techiques on how to index, integrate, navigate, search, and summarize media collections.

Mission

To investigate, analyze and improve the state of the art applications of computer and software system technology, and to rigorously demonstrate the effectiveness of the resulting novel techniques in software, algorithms, and problem-directed/data-directed computing for selected current and future computational challenges.

Description of themes and results in 2004

Analysis and modeling of the circadian pacemaker at the cellular level

The project for developing computer models and performing large-scale simulation of the circadian pacemaker at the cellular level started in 2004 as a collaboration between the Leiden Institute of Advanced Computer Science (LIACS) and the Leiden University Medical Center (LUMC). After a familiarization process, the development of the first simple computer models could only be started when more information on the single neuron activity patterns was available. This task turned out to be tedious and difficult. Unfortunately not many results were found and the analysis is still going on to obtain better data for building the computer models. However, using the few single unit activity patterns that are present and after carefully studying the literature on circadian pacemaker behavior, some simple models could be set up and are now being developed into a simulation that can predict the additive effects of single unit activity on population waveform activity.

Content-based Image Retrieval

A number of final publications appeared end of 2004 about the performance evaluation of image retrieval systems. A change of research direction, within Computer Imagery, is foreseen with an emphasis on bioinformatics and cultural heritage themes due to the retirement of Prof. Peters and transfer to a new Imaging research group within LIACS.

Cyttron Bio-Computing Search Project

The Cyttron (www.cyttron.nl) consortium wants to implement a comprehensive, integrated infrastructure for bio-imaging and modelling cells down to atomic detail. We would like to provide a generic tool for identifying the molecular causes of disease, essential for the prevention of disease and the development of new drug and therapies, and to establish a platform for advanced diagnosis and tuning of individualized therapy, increasing effectiveness in health care. The consortium is highly multidisciplinary including (bio-)physicists, chemists, mathematicians, bio-informatics and image processing specialists, cell biologists, microscopists and medical researches from various research institutes. This sub-project of Cyttron focuses on image search algorithms and methods for bio-image data bases.

HIRLAM on a grid environment
We investigate how the operational numerical weather forecast system HIRLAM could be made grid-enabled, meaning what kind of adaptions are required to execute the system efficiently on a grid. As grid platform we use the DAS-2 system, which consists of five clusters located on five different universities. After several technical problems, we are currently able to perform performance studies with one or more clusters.

Integration, Analysis and Logistics (DIAL) project
Within the Centre for Medical Systems Biology (CMSB) research groups from Leiden University, Leiden University Medical Center, TNO Prevention & Health, Vrije Universiteit Amsterdam, Vrije Universiteit Medical Center, and Erasmus Medical Center common diseases, such as cardiovascular disease, Alzheimer's, diabetes and rheumatism are studied. By combining the vast knowledge on a number of disease areas with the latest research technologies including genomics and bioinformatics, the aim is to elucidate the causes of various common diseases and apply these new insights in the development of new methods for diagnosis, new drugs and new means for prevention. During 2004 the main themes of DIAL were: inventory of the current data infrastructure of the CMSB data systems; design and development of the CMSB ArrayCGH Data Base.

Iterative Compilation
In iterative compilation we search for the best program transformations by profiling many variants and selecting the one with the shortest execution time. Since this approach is extremely time consuming one has to incorporate static models. We show that a highly accurate model as a filter to profiling can reduce the number of executions by 50%. We also show that using a simple model to rank transformations and profiling only those with highest ranking can reduce the number of executions even further, in case we have a limited number of profiles at our disposal. We conclude that a production compiler might perform best using the last approach.

Multimedia Information Retrieval
The explosion of multimedia content in digital libraries, bio-medical science, the Internet, streaming video, databases, cultural heritage collections and peer-2-peer networks has created a worldwide need for new paradigms and techiques on how to browse, search, and summarize media collections. We are interested in advancing the state of the art in the following areas:
(1) Content-based indexing, search, and retrieval of multimedia data;
(2) Bio-medical multimedia mining and indexing;
(3) Summarization and visualization of multimedia;
(4) Multi-modal human-computer interaction;
(5) Preserving cultural heritage;
(6) Learning and relevance feedback in multimedia retrieval;
Some results:
- Discovered that integrating domain knowledge with multimedia retrieval algorithms can give significant accuracy improvements.
- Derived and implemented new learning algorithms for recognizing facial expressions in video

Cooperations within ASCI
DAS-1 and DAS-2 projects (ASCI), UvA, TUD, TUE
Relevance Feedback for Content Based Retrieval, UvA
Complex Streamed Media Processor Architecture, EWI, TUD

Externally financed projects
Analysis and modeling of the circadian pacemaker at the cellular level
Funding: NWO (1 AIO at LIACS, 1 AIO at LUMC) Period: 2003-2007 Cooperation: LUMC (dr J. Meijer)

Code-generation for Large-scale Applications
Funding: NWO (1 AIO) Period: 2000 – 2004 Cooperation: KNMI/HIRLAM

Cyttron Bio-Computing Search Project
Funding: Bsik Role of LIACS: Co-leaders: Michael Lew and Erwin Bakker
Period: 2004-2008 Cooperation: Faculty of Science at Leiden University, LUMC

Distributed ASCI Supercomputer 2 (DAS 2)
Funding: NWO (Keuro 950)
Period: 2000 – 2004 Cooperation: with all partners of the ASCI graduate school

Explicit resource allocation in SMT processors
Funding: EU Transnational Access programme (7000 euro)
Period: 2004 Cooperation: UPC, Barcelona

Flexible Application Mapping Environments (FAME)
Funding: NWO (Keuro 270) Period: 2002 – 2006 Cooperation: TUE (prof.dr. H. Corporaal)

Integration, Analysis and Logistics (DIAL) project
Funding: the Netherlands Genomics Initiative Role of LIACS: Database Integration and data mining knowledge provider Period: 2003 – 2007 Cooperation: LUMC, VUMC, VU, and other research groups of the Centre for Medical Systems Biology (CMSB)

Relevance Feedback for Content Based Retrieval
Funding: NWO (1 AIO) Period: 2000-2004 Cooperation: University of Amsterdam (with dr. Theo Gevers)

Papers in International journals

F.J. Cazorla, P.M.W. Knijnenburg, R. Sakellariou, E. Fernandez, A. Ramirez, and M. Valero,
QoS for High Performance SMT Processors for Embedded Systems, IEEE Micro, Special issue on Embedded Systems: Architecture, Design, and Tools, pp. 24-31, July/August 2004.

D. P. Huijsmans and N. Sebe, How to Complete Performance Graphs in Content-based Image Retrieval: Add Generality and Normalize Scope, IEEE PAMI, vol 27, no 2, 2004, pages 245-251.

P.M.W. Knijnenburg, T. Kisuki, K. Gallivan, and M.F.P.O'Boyle, The Effect of Cache Models on Iterative Compilation for Combined Tiling and Unrolling, Concurrency and Computation: Practice and Experience. Vol. 16, pp. 247-270, 2004.

Contributions to International Conference Proceedings

F.J. Cazorla, P.M.W. Knijnenburg, R. Sakellariou, E. Fernandez, A. Ramirez, and M. Valero,
Implicit vs. Explicit Resource Allocation in SMT Processors, in Proceedings Digital System Design (DSD), pp. 44-51, 2004.

F.J. Cazorla, P.M.W. Knijnenburg, R. Sakellariou, E. Fernandez, A. Ramirez, and M. Valero,
Feasibility of QoS for SMT, in Proceedings EuroPar, pp. 534-540, LNCS 3149, 2004.

F.J. Cazorla, P.M.W. Knijnenburg, R. Sakellariou, E. Fernandez, A. Ramirez, and M. Valero,
Enabling SMT for Real-Time Embedded Systems, in Proceedings Eusipco, 2004. CD-ROM.

F.J. Cazorla, P.M.W. Knijnenburg, R. Sakellariou, E. Fernandez, A. Ramirez, and M. Valero,
Predictable Performance in SMT Processors, in Proceedings Computing Frontiers 2004. CD-ROM.

Micha Haas, Bart Thomee, Joachim Rijsdam, and Michael S. Lew, Relevance Feedback: Perceptual Learning and Retrieval in Bio-computing (Photos and Video), in Proceedings ACM SIGMM MIR'04, New York, New York, 2004.

Hui Li, David Groep, Jeff Templon, and Lex Wolters, Predicting Job Start Times on Clusters, in Proceedings of the 4th IEEE/ACM International Symposium onCluster Computing and the Grid (CCGrid2004), April 2004, Chicago,Illinois, USA, pp. 301-308.

Hui Li, David Groep, and Lex Wolters, Workload Characteristics of a Multi-cluster Supercomputer,
in Proceedings of the 10th Workshop on Job Scheduling Strategies for Parallel Processing (JSSPP 2004), June 2004, New York, NY, USA.

Hui Li, Lex Wolters, and David Groep, Workload Characteristics of the DAS-2 Supercomputer,
in Proceedings of the 10th Annual Conference of the Advanced School for Computing and Imaging (ASCI), June 2004, Ouddorp, The Netherlands, pp. 251-258.

Paul van der Mark, Lex Wolters, and Gerard Cats, Semi-Lagrangian Formulations with Automatic Code Generation for Environmental Modeling,in Proceedings of the 19th ACM Symposium on Applied Computing (SAC04), March 2004, Nicosia, Cyprus, ACM Press, pp. 229-234.

Paul van der Mark, Gerard Cats, and Lex Wolters, A Dynamic Application-Driven Data Communication Strategy, in Proceedings of the 18th ACM International Conference on Supercomputing, June 2004, Saint-Malo, France, ACM Press, pp. 146-153.

Paul van der Mark, Lex Wolters, and Gerard Cats, Optimizing Data Communication for Semi-Lagrangian Formulations on a Distributed Memory Cluster, in Proceedings of the 10th Annual Conference of the Advanced School for Computing and Imaging (ASCI), June 2004, Ouddorp, The Netherlands, pp. 381-388.

R.P.J. Pinkers, P.M.W. Knijnenburg, M. Haneda, and H.A.G. Wijshoff, Statistical Selection of Compiler Options, in Proceedings MASCOTS, pp. 494-501, 2004.

N. Sebe, D.P. Huijsmans, Q. Tian, T. Gevers, Complete Performance Graphs in Probabilistic Information Retrieval, in Proceedings PCM 2004 Tokyo, LNCS 3332, 2004, pages 229-237.

N. Sebe, M.S. Lew, I. Cohen, Y. Sun, T. Gevers, T.S. Huang, Authentic Facial Expression Analysis, International Conference on Automatic Face and Gesture Recognition (FG'04), pp. 517-522, Seoul, Korea, May 2004.

N. Sebe, M.S. Lew, and T.S. Huang, The State-of-the-Art in Human-Computer Interaction, International Workshop on Human Computer Interaction (HCI'04), pp. 1-5, Prague, Czech Republic, May 2004.

N. Sebe, Y. Sun, E.M. Bakker, M. Lew, I. Cohen, T. Huang, Towards Authentic Emotion Recognition, in Proceedings of 2004 IEEE International Conference on Systems, Man, and Cybernetics (IEEE SMC'04), The Hague, Netherlands, October 2004.

Y. Sun, N. Sebe, M.S. Lew, and T. Gevers, Authentic Emotion Detection in Real-Time Video, International Workshop on Human Computer Interaction (HCI'04), pp. 92-101, Prague, Czech Republic, May 2004.

Lei Wang, Michael S. Lew, and Guangyou Xu, Offense Based Temporal Segmentation for Event Detection in Soccer Video, in Proceedings ACM SIGMM MIR'04, New York, New York, 2004.

R.P.J. Pinkers, P.M.W. Knijnenburg, M. Haneda, and H.A.G. Wijshoff, Analysis of Compiler Options using Orthogonal Arrays, in Proceedings CPC, pp. 137-148, 2004.

Contributions to books
Computer Vision in Human-Computer Interaction, HCI/ECCV 2004
N. Sebe, M.S. Lew, T.S. Huang, Lecture Notes in Computer Science, Vol. 3058, Springer-Verlag, ISBN 3-540-22012-7, May 2004

Experimental Software
DIAL CGH Database (Preliminary Version) (www.liacs.nl/~sicking/dial/)

The Internet Content-based Image Search demo around LCPD (the Leiden 19th-Century Portrait Database) with photo historian S. Wachlin and the Print Room of Leiden University served almost 1.2 million requests in 2004.

2.1.4 Contribution of TUD-EWI-me-ce

Δ-iliad
The Δ-ILIAD research conserns with new computer architectural paradigms. The gamma of processor architectures considered include general purpose, domain (e.g. media), vector processor extensions, polymorphic processing and non-conventional architectures. Furthermore, we perform some reality checks for existing processor implementations. More specifically the Delta-Iliad team is currently working on the following research topics:
Vector Facility
Traditionally, vector processors are limited by memory accesses, sectioning, and simple-minded computations. The Δ-ILIAD vector architecture eliminates sectioning, alleviates storage access overhead by overlapping accesses with computations and merging both of them into a single instruction. In addition to traditional operations, Δ-ILIAD architecture includes new instructions that perform complex multicycle latency operations. With the introduction of the Δ-ILIAD mechanism a substantial code elimination is achieved. The specific dense and sparse architectural mechanisms of Δ-ILIAD include the Complex Streamed Instruction Set (CSI) and the Δ-ILIAD sparse vector processing, which are described below.

CSI Media Architecture
The Complex Streamed Instruction Set Architecture (CSI) is a memory-to-memory vector architecture targeted at multimedia applications. A single CSI instruction can process data streams of arbitrary length and, in addition to traditional arithmetic and logical operations, performs data accesses, conversion between storage and computation formats (packing and unpacking), and complex arithmetic hardwired computation. The main new features of the CSI are elimination of the vector sectioning instructions, elimination of the packing/unpacking instructions, and introduction of new complex media related arithmetic instructions.
Sparse Matrix Architectures
Vector processors are known for performing good on large amounts of regular data. However, when operating on sparse matrices such as the one depicted here, the irregular structure induces a performance degradation. The main reasons are the need for expensive indexed memory accesses and high vector startup overhead due to short vectors. Moreover, the need for positional information when storing sparse matrices implies an extra storage overhead. The aim of this project is to aleviate most of the aforementioned problems and increase the efficiency of vector processors on sparse operations. This is achieved by introducing a new block based Sparse Martix format. In conjunction with a harware Vector ISA extension and specialized hardware for sparse matrix computations we can aleviate the need for indexed memory accesses. Speedups of 4-5 times have been obtained for matrix-vector multiplication, an important kernel in sparse matrix processing.
Delft Sparse Architectures Benchmark
The Delft Sparse Architecture Benchmark (D-SAB) has been developed in the Computer Engineering Laboratory as a part of the Δ-iliad project. Its purpose is the evaluation of novel architectures and techniques for processing Sparse Matrices. The benchmark comprises two parts: The benchmark operations and the benchmark matrices.
Polymorphic processors
Current processor architectures force a complete separation of tasks between implementations (hardware-architectures), which interpret an architecture, and the programmer targeting this architecture. Polymorphic processors eliminate the gap between the (hardware) implementations and the programmer of the hardware. This is achieved using a new programming paradigm and emulation on reconfigurable hardware.
Delft Linpack
The TOP500 Supercomputer Sites webpage (http://www.top500.org/) presents the world best highperformance computers. The LINPACK Benchmark is used as a yardstick for performance. Companies like IBM, HP, NEC and Intel (ASCI red) are presented there with their top supercomputers. The interesting question is: Can a university student team with out of the shelf inexspensive hardware components beat the industry supercomputers on Linpack? The DelftLinpack-1 processor uses the power of reconfigurable hardware in order to attempt an answer of this question. Xilinx state of the art FPGA (XC2VP50) incorporating reconfigurable logic and four PowerPC general purpose cores will be used to implement the DelftLinpack-1 machine.

Contributions to international conference proceedings:
G. N. Gaydadjiev, S. Vassiliadis; SCISM versus IA-64 Tagging: Differences and Code Density Effects. Proceedings of 10th International Euro-Par Conference, pp. 571-577, Pisa, Italy, August 2004, Springer-Verlag Lecture Notes in Computer Science (LNCS), vol. 3149

B.H.H. Juurlink, P. J. de Langen; Dynamic Techniques to Reduce Memory Traffic in Embedded Systems. Proceedings of the 1st ACM International Conference on Computing Frontiers, pp. 192-201, Ischia, Italy, April 2004

B.H.H. Juurlink; Approximating the Optimal Replacement Algorithm.
Proceedings of the ACM International Conference on Computing Frontiers, pp. 313-319, Ischia, Italy, April 2004

G.K. Kuzmanov, G. N. Gaydadjiev, S. Vassiliadis; Visual Data Rectangular Memory.
Proceedings of the 10th International Euro-Par Conference, pp. 760-767, Pisa, Italy, September 2004, LNCS 3149

P. J. de Langen, B.H.H. Juurlink; Reducing Traffic Generated by Conflict Misses in Caches. Proceedings of the 1st ACM International Conference on Computing Frontiers, pp. 235-239, Ischia, Italy, April 2004

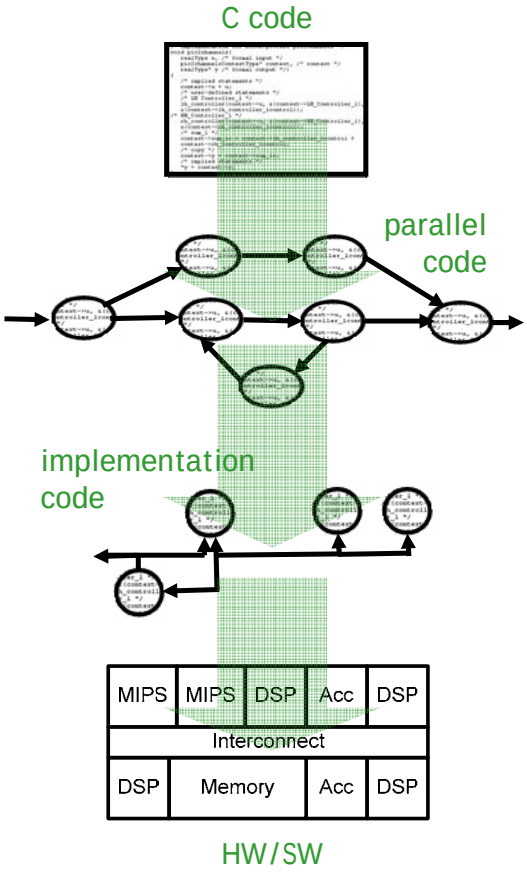
P.T. Stathis, D. Cheresiz, S. Vassiliadis; B.H.H. Juurlink, Sparse Matrix Transpose Unit.
18th International Parallel and Distributed Processing Symposium (IPDPS2004), Santa Fe, New Mexico, USA, April 2004

2.2 B: Large scale distributed Information Systems and Embedded Systems

2.2.1 Contribution of TUE-EE-dmes

Embedded multi-media systems: models, programming and design

The focus of our work is on mapping applications onto multiprocessor systems. System level design methods allow the systematic development of abstract executable models. These models are used to verify correctness and performance properties of the system. Based on the analysis results, system designers can take well-founded design decisions about the architecture of the system, hardware/software partitioning, the choice of processors, etc.
Multiprocessor implementation platforms also require novel programming techniques, and techniques to map executable specifications onto multiprocessor systems. These techniques must optimize execution time, memory usage, and energy usage and allow trade-offs. The result is implementation-level code for the application optimized towards the intended multiprocessor platform. These programming techniques build upon compiler technology that covers the final step to the hardware.
We set up an initial mapping trajectory for multi-media applications targeting multi-processor architectures. As a basic model of computation, we take Kahn process networks (KPN) and its derivates such as synchronous dataflow (SDF). We developed task-level timing models based on SDF for analyzing execution times of application components mapped on a Network-on-Silicon-based multiprocessor, and we looked at buffer sizing techniques. We proposed an extension of the KPN model with event processing, called Reactive Process Networks, and a means to formally reason about trade-offs in design flows and run-time configuration decisions in the form of an algebra of pareto points. From the application point of view, we look at multi-media applications (MPEG4, H263) and smart cameras.



For the longer term, embedded systems will evolve into ambient systems. Ambient systems are in essence nothing but networked embedded systems operating in a highly dynamic environment. More and more embedded systems have communication capabilities. This networking dimension affects the architectures, the design flow, the run-time systems, and the underlying computational models we are working on. We have already initiated some activities in this emerging area.

External projects

Betsy: BEing on Time Saves energY
Continuous multimedia experiences on networked hand-held devices, 2004-2007. EU/IST/FP6, M€ 4.4,
Philips research, CSEM, IMEC, ISI, MDH, Siemens C-lab, TUE, en de University of Cyprus

The aim of the BETSY project is to have multimedia streams on wireless hand-held devices seamlessly adapted to fluctuating network conditions and available terminal resources while reducing the energy consumption of the stream processing. This way the user can enjoy true multimedia experiences with freedom of movement in a networked home or at any hot-spot. To achieve this, we need to be able to make trade-offs between the use and consumption of network and terminal resources, such as bandwidth use, CPU consumption, memory needed and power consumption by the terminal, while guaranteeing end-to-end timeliness - required for streaming data.

Ozone
2001-2004, EU/IST, 6.3 M€
Philips research, EPICTOID, IMEC, INRIA, LORIA, T-nova, Thomson
Ozone aims at the development of an architectural framework and prototype implementations for embedded systems working in an intelligent environment with a pervasive communication and computation infrastructure.

Our work focuses on computational models for applications and devices working in such an environment, high-performance platforms, and compiler technology for low-power applications.

PreMaDoNa: *Predictable Matching of Demands on Networked Architectures,*
2004-2009, Progress/STW, k€ 694, Philips, CMG

The PreMaDoNa project focuses on the design and implementation of NoC-based platforms for multi-media applications. The research challenges mainly originate from the increasing complexity of multi-media applications and the ever-shortening design time to realise multi-media systems. The major research objective is the following: Being able to design NoC-based real-time system in a predictable way such that non-functional properties can be guaranteed, while still being able to dynamically match quality with the available resources.

PROgramming Multi-processor Embedded multi-media Systems (PROMES)
2002-2006, NWO, 295 k€
PROMES focuses on the development of both a sound theoretical framework and a programming environment for multi-media applications building on top of multi-processor systems. Important is the study of task-level analysis techniques that provide insight in concurrency-, timing-, and energy-related properties at the specification level without fully implementing an application.

SmartCam
2002-2006. STW/progress, 1.4 M€, Philips Natlab, Philips CFT, TNO-FEL, In3D, HP Bristol labs, TUD-TNW-tn-ph
The SmartCam project investigates low-cost one-chip Smart Camera solutions, contributing to a quantitatively guided design trajectory. In particular, we investigate the impact of current applications, and we try to define relevant architectural parameters and to develop an architectural template. Other aims are to enhance and integrate existing application mapping environments for SIMD and ILP processors.

Fexible Application Mapping Environment (FAME)
2003-2007, NWO, 250 k€, Leiden University, Delft University of Technology, TUD-ITS-me-ce
FAME aims to obtain low power solutions when mapping applications on processor platforms. We like to achieve this goal by creating a compiler infrastructure capable of performing source-code transformations. We propose a dynamic approach in combination with analytic pruning of the transformation search space in order to find the best low-power optimizations.

Beyond the Ordinary: Design of Embedded Real-time Control (BODERC)
2003-2007. Senter, 2.5 M€, Océ Technologies, Philips CFT, AAS, Imtech ICT, Chess iT, Katholieke Universiteit Nijmegen, Universiteit Twente
The Boderc project focuses on distributed embedded real-time controllers of complex systems. An Océ printer is taken as a case-study and acts as a driver for the project.
The target is an integral approach for a systematic architectural design, modeling, analysis, and validation methodology for such heterogeneous systems.

Contributions to Books
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Experimental software
Fatemi, H; Caarls, W; SmartCam Image Processing Library2003 - now, C/Unix, C++/MPI/Linux, 1DC/IMAP, XTC/Xetal, StreamC/kernelC/Imagine.The library is based on algorithmic skeletons for image processing operations (low, intermediate and high level). By using this library, the programmer of an image processing application can easily parallelize the application and s/he does not have to handle the problems related to communication and synchronization.

Geilen, MCW; A process-network-based programming environment2003 - now, C++/Windows/Unix.
We have started the development of a programming environment based on a new model of computation that intends to combine streaming or data flow based computation with control-oriented or reactive components such as event-driven software components or (finite) state machines. This environment is built as an extension/modification of the YAPI environment for Kahn Process Networks developed at Philips research.

Stuijk, S; Multiprocessor design flow 2002 - now , C++/JAVA/Linux/Windows.
Next-generation embedded multi-media systems will often be built on multi-processor systems to obtain high compute power at relatively low energy cost. Work is ongoing to implement a design flow to map streaming applications specified as synchronous dataflow (SDF) graphs to a heterogeneous multi-processor systems. We aim at predictability with respect to timing behavior, while minimizing energy consumption.

2.2.2 Contribution of VU – WI

Research in the group is concentrated in three areas, Large-Scale Distributed Systems, Security, as well as Cluster and Grid computing.

Large-Scale Distributed Systems
We are concentrating on three strongly interrelated subareas. First, we are putting effort into developing a fully decentralized user-centric content delivery networks, called Globule. Globule handles automatic and adaptive replication of Web pages for the sake of performance and availability. A first version of Globule was released in December 2003. Various Web sites are currently hosted by Globule software. The current version is 1.3.0 and supports Windows as well as UNIX platforms. In 2004, we have concentrated on replicating dynamically generated Web pages, and latency-driven replica placement.

Second, we are increasing our efforts concerning large-scale epidemic-based systems, covering wired as well as wireless networks. In particular, attention has been paid to protocols for decentralized membership management for very large networks, allowing nodes to regularly join and leave the system. Also, we have been looking at using epidemics for efficiently monitoring systems.

Security
This work concerns reliability and security in various forms. One area is building a new operating system with as goal high reliability. Current operating systems are structured as large monolithic lumps of code and a bug in any component, especially in a device driver, can bring down the entire system. The goal of this subproject is to compartmentalize the components of the system so that bugs and security breaches in one compartment cannot spread to other ones.

Another area is that of ubiquitous computing, including sensor networks and RFID. Consider a network of sensors deployed in a forest with the intention of detecting fires. A malicious person who looks for an finds a sensor can put a match near it and set off a false alarm. Worse yet, he can do it repeatedly. Using the (software) concept of one-time sensors, we hope to make this problem more manageable. This work is applicable to any sensor network used for safety purposes.

Another area of research is RFID security and privacy. RFID tags are being place on many products, on clothes, and passports, and elsewhere. The European bank is thinking of putting them on euro banknotes. Anyone with an easily-available RFID reader can read these tags at a distance. We are looking at ways to guard people's privacy in an RFID-enabled world.

Finally, we are looking at secure peer-to-peer content distribution networks in which people who buy digital content can be authorized by the owner to resell the content in a secure way.

Cluster and Grid Computing
Part of this effort is the Ibis project. Ibis is a Java-centric programming environment for writing distributed supercomputing applications. The Ibis project integrates results from earlier projects in this group, including Manta (a Java compiler and fast communication library) and Albatross (which studied parallel programming on wide-area systems, so-called distributed
supercomputing). Since 2004, the Ibis project takes place in the context of the BSIK project "Virtual Laboratory for e-Science" (VL-e).

The key idea behind Ibis is to benefit from Java's high portability (write once, run anywhere), making it possible to run parallel applications on heterogeneous large-scale systems (Grids). Ibis provides a range of communication primitives (Remote Method Invocation, group communication, divide-and-conquer, replicated objects, message passing) implemented in a portable and efficient fashion.

The core of Ibis has been implemented in pure Java, allowing it to run on any platform that provides a Java Virtual Machine. In addition, an efficient and dynamic communication subsystem called NetIbis has been developed that allows native solutions as special-case optimizations (e.g. to support a fast communication network like Myrinet). NetIbis can be configured completely dynamically and can handle multiple different networks and communication protocols in a single application.Also, it provides an integrated solution to connective and security problems (due to firewalls, NAT, etc.).

Ibis applications have access to Grid resources (like files or compute nodes) using the Grid Application Toolkit (GAT), for which we have developed a Java-based version within the EC-funded project GridLab. The GAT provides a set of simple APIs for Grid-aware applications, allowing to dynamically bind to proxies that give access to actual resources, services, and protocols.

Many large-scale experiments have been performed with Ibis, on the Distributed ASCI Supercomputer (DAS) as well as on a testbed of the EC GridLab project. The experiments have shown that Ibis makes it possible to run a single parallel Java application on a very heterogeneous, European-scale grid and obtain high speedups. We have also developed several applications with Ibis, including automated protein identification (with AMOLF), electromagnetic simulation (JEM3D, with researchers from the French ProActive project), and many others.

Cooperation
Industrial cooperations have been set up with Philips Research Laboratories (Eindhoven) and Chess embedded Technologies (Haarlem). Also, the Bsik I-Share project started in the Fall of 2004 in which the VUA participates regarding our epidemic-based solutions.

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Internet Messaging. J.M. Wams, M. van Steen. In M. Singh (ed.), Practical Handbook of Internet Computing, CRC Press.

Application-Level tools H.E. Bal, H. Casanova, J. Dongarra, and S. Matsuoka, In I. Foster and C. Kesselman (eds.) Blueprint for a New Computing Infrastructure (2nd Edition), Morgan Kaufmann, pp. 463-489, 2004.

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Group Formation Among Decentralized Autonomous Agents. E. Ogston, M. van Steen, F. Brazier.
Applied Artificial Intelligence, vol. 18(9-10):953-970, Oct. 2004.

Replication for Web Hosting Systems.
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Music2Share - Copyright-Compliant Music Sharing in P2P Systems. T. Kalker, D. Epema, P. Hartel, I. Lagendijk, M. van Steen. Proceedings of the IEEE, vol.92(6):961-970, June 2004.

Unifying User-to-User Messaging. J.M. Wams, M. van Steen. IEEE Internet Computing, vol. 8(2):76-82, 2004.

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Replicating Web Applications On-Demand. S. Sivasubramanian, G. Pierre, M. van Steen. Proc. 1st IEEE Int'l Conf. on Services Computing (SCC 2004), Shanghai, China, Sept. 2004

Scalable Strong Consistency for Web Applications. S. Sivasubramanian, G. Pierre, M. van Steen. Proc. 11th ACM SIGOPS European Workshop, Leuven, Belgium, Sept. 2004, pp. 182-187.

Exploiting Differentiated Tuple Distribution in Shared Data Spaces. G. Russello, M. Chaudron, M. van Steen. Proc. Int'l Conf. on Parallel and Distributed Computing (Euro-Par), Pisa, Italy, September 2004.

Scalable Cooperative Latency Estimation. M. Szymaniak, G. Pierre, M. van Steen. Proc. 10th Int'l Conf. Parallel and Distributed Systems, Newport Beach, CA, July 2004.

Exploiting Semantic Proximity in Peer-to-peer Content Searching. S. Voulgaris, A.-M. Kermarrec, L. Massoulie, M. van Steen. Proc. 10th IEEE Int'l Workshop on Future Trends in Distributed Computing Systems (FTDCS), Suzhou, China, May 2004.

An Approach to Aggregation in Large and Fully Distributed Peer-to-Peer Overlay Networks. M. Jelasity, W. Kowalczyk, M. van Steen. Proc. 12th Euromicro Conference on Parallel, Distributed and Network based Processing (PDP 2004), A Coruna, Spain, February 2004.

A High Performance Java Middleware with a Real Application Fabrice Huet, Denis Caromel, and Henri E. Bal: SC'04, Pittsburgh, PA, 6-12 Nov. 2004.

Wide-Area Communication for Grids: An Integrated Solution to Connectivity, Performance and Security Problems Alexandre Denis, Olivier Aumage, Rutger Hofman, Kees Verstoep, Thilo Kielmann, and Henri E. Bal HPDC-13, Honolulu, USA, June 4-6 2004, pp. 97-106.

FFPF: Fairly Fast Packet Filters Herbert Bos and Willem de Bruijn and Mihai Cristea and Trung Nguyen and Georgios Portokalidis Proceedings of OSDI'04, December, 2004

Scalable network monitors for high-speed links:a bottom-up approach Trung Nguyen and Willem de Bruijn and Mihai Cristea and Herbert Bos Proceedings of IEEE IPOM'04, 2004, October, Beijing, China

SNMP Plus a Lightweight API for SNAP Handling (SPLASH) Willem de Bruijn and Herbert Bos and Jon Moore Proceedings of IEEE/IFIP Network Operations and Management Symposium (NOMS'04), 2004, april, Seoul, Korea

On the feasability of using network processors for DNA queries Herbert Bos and Kaiming Huang Proceedings of the Third Workshop on Network Processors & Applications - NP3, 2004, Madrid, Spain

A DRM Security Architecture for Home Networks Bogdan C. Popescu, Bruno Crispo, Frank L.A.J. Kamperman, Andrew S. Tanenbaum Proc. 4th ACM Workshop on Digital Rights Management, pp. 1-10, October 2004.

Support for Multi-Level Security Policies in DRM Architectures. Bogdan C. Popescu, Bruno Crispo, Andrew S. Tanenbaum Presented at the 13th New Security Paradigms Workshop, September 2004.

Symmetric Key Authentication Services Revisited. Bruno Crispo, Bogdan C. Popescu, Andrew S. Tanenbaum. LNCS 3108 - Proc. 9th Australasian Conference on Information Security and Privacy, pp. 248-262, July 2004.

Safe and Private Data Sharing with Turtle: Friends Team-Up and Beat the System. Bogdan C. Popescu, Bruno Crispo, Andrew S. Tanenbaum. Presented at the 12th Cambridge International Workshop on Security Protocols, April 2004.

Towards Supporting Fine-grained Access Control for Grid Resources, E. Bertino, P. Mazzoleni, B. Crispo, S. Sivasubramanian and E. Ferrari Proceedings 10th Int.l Workshop on Future Trends in Distributed Computing Systems, Suzhou, China, 26-28 May 2004.

Experimental software
Gobule: a user-centric Content Delivery Network. Java. Solaris/Linux. For description: see above.

Scientific Cooperation
The work on Globule and other peer-to-peer related research is done a cooperation between the VU-WI-i and TUD-ti-ki

2.2.3 Contribution of UVA-fdnwi-caps

Themes:
- Highly scalable computer architectures
- Design methodologies and tools for System-on-Chip based embedded systems
- Grid based system for e-science

Microthreading and MicroGrids
Microthreading is an execution model that breaks code down into fragments that can execute simultaneously. Dependencies are managed by implementing all registers as i-structures, i.e. using dataflow or blocking read synchronisation. It is applied to an existing ISA incrementally by providing a few additional instructions to implement concurrency controls. A set of microthreads is a static partition of a basic block into concurrently executing fragments, which execute on a single processor and share a microcontext. An iterator over a set provides a dynamic and parametric family of microthreads. Iterators capture loop concurrency and can be scheduled to different processors in a "microgrid". This is a scalable CMP comprising a large number of asynchronous processors communicating with others using a ring network and a broadcast bus. Microgrids implement an SPMD model of computation using microthreading and implement a synchronised, shared-register model of memory Bulk synchronisation is used on main memory. This approach enables power scalability, even in the presence of dependencies that may restrict execution to one processor at a time during parts of the execution of the concurrent code fragments.
In 2004, several simulation studies have been performed to serve as a proof of concept

Architectures and meThods for Embedded MedIa Systems (Artemis)
In the Artemis project, an architecture modeling and simulation workbench is developed which aims at the efficient design space exploration of heterogeneous embedded media systems. In 2004, which was the final year of Artemis, we continued to address the problem of architecture model refinement. More specifically, we apply a refinement method -- based on Integer-controlled Data-Flow (IDF) models -- that allows for runtime transformation of application-level events to architecture-level events. Using case studies, we have shown that our method allows for refining both architectural communication behavior and computational behavior. In addition, we continued the development of our prototype modeling & simulation software framework, called Sesame, to support all developed modeling and simulation technology.
Moreover, we performed several studies on mathematically modeling the mapping of application models onto architecture models. For this work, we developed a multi-objective optimization tool to quickly explore different mappings under multiple criteria. Finally, we developed a layer on top of the widely-used SystemC simulation language, raising the abstraction level of this language and allowing easier construction of so-called transaction-level models (these are the performance models applied in Artemis).

Grid based system for e-science
The VL-e project aims at boosting e-Science by creating an e-Science environment and carrying out research on methodologies. The approach followed in the VL-e project is to carry out concerted research along the complete e-Science technology chain, ranging from applications to networking, focusing on new methodologies and re-usable components. The essential components of the total e-Science technology chain are: e-Science development areas, a Virtual Laboratory development area, a Large-Scale Distributed computing development area, consisting of high performance networking and grid parts.

Our contribution to this project is to develop a generic middleware which should hide the low level details from the scientists while allowing him to take advantage of the grid –enabled resource available. We have addressing a number of issues

- Resource Management in Grid based systems: the work target the improvement of the scheduling of applications on grid-enabled resources. The tasks composing the application have to be assigned to appropriate resources to minimize the cost of application execution, usually counted as overall execution time. The model for estimation of application cost (performance metric) is being studied. A number of the algorithms used to achieve sub-optimal schedules have been investigated (greedy algorithm, computation-network prioritized algorithm, and simulated annealing).

- Collaborative environment for e-science: VL-e project targets a wide range of end-users within the scientific community, the collaboration mechanisms needed for a certain experiment in a specific scientific domain may be completely different form any other ones. It thus important to select the appropriate collaboration mechanism for each of the experiment considered in the VL-e project.

- Information Management: VL-e is a multi-disciplinary environment aiming to support a variety of scientific environments from areas ranging from food informatics to bioinformatics and biodiversity. One of the VL-e research issues is targeting the management of information generated and manipulated by scientific experiments. This research effort addresses the design and implementation of a generic collaborative information management system, design and development of necessary assisting tools, and exploration of the Grid technology for federated query processing

External Projects
Artemis
1999-2004, Progress/STW, 800 K Eur., TUD-EWI-me-ce, UL-WI-I

Artemisia
2004-2009, Progress/STW, 930 K Eur., TUD-EWI-me-ce, UL-WI-I

VL-e
2004-2009, Bsik, WTCW, UvA, Amolf, Nikhef, CWI, SARA, VU, TUD, IBM, LigicaCMG, Philips, FEI

Contributions to International conference Proceedings
Thompson and A. D. Pimentel, ``A High-level Programming Paradigm for SystemC", in the Proc. of the 4th Int. Workshop on Systems, Architectures, MOdeling, and Simulation (SAMOS 2004), LNCS, Samos, Greece, July, 2004.

Thompson and A. D. Pimentel, ``A High-level Programming Paradigm for SystemC", in the Proc. of the Progress workshop on Embedded Systems, Oct. 2004.

C. Erbas, S. Cerav-Erbas and A. D. Pimentel, ``Static Priority Scheduling of Event-Triggered Real-Time Embedded Systems", in Proc. of the ACM/IEEE International Conference on Formal Methods and Models for Codesign (MEMOCODE'04), San Diego, USA, June 23-25, 2004.

C.R. Jesshope, ``Scalable Instruction-level Parallelism", In Proc. of the
Computer Systems: Architectures, Modelling and Simulation, SAMOS 2004, (LNCS 3133, Springer), ISBN 3-540-22377-0, pp383-392, Greece, July 2004.

C.R. Jesshope, ``Micro-grids - the exploitation of massive on-chip concurrency", in Proc. of HPC 2004, Cetraro, June 2004.

V. Korkhov, A.S.Z Belloum, and L.O. Hertzberger “Evaluating Meta-scheduling Algorithms in VLAM-G environment”, ASCI 2004 conference.

V. Korkhov, A.S.Z Belloum, and L.O. Hertzberger, "VL-e: Approach to design a Grid-based Virtual Laboratory" 5th Austrian-Hangarian workshop on Distributed and Parallel systems, Budapest, Hungary, September 19-22, 2004

E. C. Kaletas, H. Afsarmanesh, and L. O. Hertzberger. A Methodology for Integrating New Scientific Domains and Applications in a Virtual Laboratory Environment. In Proceedings of the 6th International Conference on Enterprise Information Systems (ICEIS 2004), 2004

Books
A. D. Pimentel and S. Vassiliadis, editors, Proceedings of the 3rd and 4th Int. Workshop on Systems, Architectures, MOdeling, and Simulation (SAMOS 2004), LNCS 3133, Samos, Greece, July, 2004.

Experimental Software
As part of Artemis(ia), we are developing a prototype modeling and simulation environment called Sesame (Simulation of Embedded System Architectures for Multi-level Exploration). See http://sesamesim.sourceforge.net/ for the software.

GVLAM: grid-based working environment for e-Science.
2000-2004 Java, C++,GT2.4, Linux OS.
This program has been designed to minimize the effort needed by scientists to develop Grid-enabled application

Cooperations within ASCI
All work by A.D. Pimentel (Artemis, Artemisia) is related to ASCI cooperation with TUD-EWI-me-ce and UL-WI-I.

VL-e consortium include a number of ASCI members UvA, VU, TUD. We can consider the work developing the generic VL-e middleware as a collaboration of ASCI members.

2.2.4 Contribution of TUD-EWI-ST-pds

Parallel and distributed systems
Our work in this area covers grids, peer-to-peer systems, wireless sensor networks, and embedded systems. In the area of grids, we have completed our simulations of processor co-allocation in multicluster systems. It turns out that when the communication overhead of wide area systems is not too large, co-allocation can benefit performance. In addition, we have made a first prototype of the KOALA co-allocating scheduler in the DAS, with the Close-to-Files placement policy and the Incremental Claiming Policy. In peer-to-peer systems, we have performed a large, world-wide measurement study of the BitTorrent file-sharing system using the DAS. In addition, we have made a first design of P2P-TV, a peer-to-peer system for sharing live and recorded TV of 10,000+ TV channels and web cams among millions of users. In wireless sensor networks, important steps have been taken to bring algorithms developed in simulation to a real working environment. We use the TNOdes hardware developed by TNO-FEL as our target platform, and integrated our energy-efficient T-MAC protocol with the TinyOS software running on top of the TNOdes. A detailed link characterization study was carried out to understand the practical behavior of the TR1001 radio, and the impact on MAC, routing and localization protocols. The results motivated the development of a statistical localization algorithm that handles the observed irregular relation between signal strength and distance, which is a known source of problems for many (idealized) localization algorithms.

Cooperative agent-based systems (CABS)
The major effort of the CABS project is directed towards the development of methods and tools for the modelling and implementation of information systems supporting independent, autonomous agents or agent organisations in mutual competition or group-wise cooperation.

Virtual Laboratory for e-Science (VL-e)
2004-2008, EZ (BSIK program), EURO 1.000.000 (TUD-EWI-st-pds part), ASCI partners TUD-EWI-mm-cgcc, VU-EW-cs-I, UvA-FdNWI-caps, UvA-FdNWI-scs.
This projects aims at designing and implementing grid technology (schedulers, communication libraries, problem-solving and visualization environments, etc) for virtual laboratories (e.g., for simulations in the sciences) on top of the basic grid fabric.

CoreGRID
2004-2008, EU (Network of Excellence), EURO 38.000, ASCI partners VU-EW-cs-i.
This network integrates the grid research of 42 universities in Europe.

I-SHARE (part of Freeband)
2004-2008, EZ (BSIK program), EURO 800.000, ASCI partners TUD-EWI-mm-ict, VU-EW-cs-i.
This projects researches sharing technology in distributed systems, particularly for video. As a research vehicle, we have chosen P2P-TV, a system for sharing live and recorded TV programs of 10,000+ TV channels and web cams among millions of users.

SCALPE
2004-2008, STW, EURO 220.000, ASCI partners VU-EW-cs-i.
This project deals with high-productivity methods for programming parallel systems on a chip.

CONSENSUS
2002 – 2006, NWO, Euro 155.000.
The CONSENSUS project will develop collaborative algorithms for Wireless Sensor Networks to overcome the limited capabilities of individual sensor nodes. TUD focuses on algorithms for communications and networking, including distributed wireless access, ad-hoc routing protocols, and reliable end-to-end transport.

MilSens
2003 – 2007, TNO-FEL (AIO fonds), Euro 160.000.
The key objective is to develop an integrated approach to operate large ad-hoc networks of wireless sensor nodes. We will take a practical approach and start from some well-defined application scenarios (to be developed at the start of the project), derive the requirements on the network, and integrate and develop the necessary algorithms.

Smart Surroundings
2004 – 2008, EZ (BSIK program), Euro 800.000.
The overall mission of the Smart Surroundings project is to investigate, define, develop, and demonstrate the core architectures and frameworks for future ambient systems. TUD focuses on two important aspects at the middleware layer: service discovery and localization. These two are related through the ServiceGRID approach, in which location serves as an index in a database of cached service providers.

LOFAR-agro
2004 2008, NN (Stichting Samenwerking Noord Nederland), Euro 200.000.
The LOFAR-Agro project carries out a pilot project in which ensor nodes will measure the conditions in a potato field; this detailed information (1 reading per 150m2) will be used to improve the advice on how to fight the fungous Phytophtora infestans disease within a crop.

Distributed Model-Based Diagnosis and Repair
2003 – 2007, Funded by STW Technische Wetenschappen, 3 PhD's.
in collaboration with Utrecht University, Maastricht University, and National Aerospace Laboratory

Task Coordination for Non-cooperative Agents
2005 – 2009 *f*unded by NWO Open Competitie programme, 2 PhD's in collaboration with CWI

IT-architecture and coordination in transportation
1998 – 2005 *networks with autonomous actors* TNO – TRAIL programme, 1 PhD Funded by TNO

Cybernetic Incident Management
2003 – 2007 SenterNovem TSIT project, 1 post-doc funded by MinEz, SenterNovem, in cooperation with VU, CWI, CMotions, Almende BV

Distributed Logistics
2004 – 2008 1 PhD.Funded by Almende BV

Real-time Optimization of Motormanagement Systems
2004 – 2008 SenterNovem TSIT project, 1 PhD, Funded by MinEZ, SenterNovem, in cooperation with van der Luijt Transport, CD-systems BV and Squarell BV

Distributed task Coordination
2005 – 2009 Casimir programme, 2 PhD's. Funded by MinEZ, SenterNovem,in cooperation with Maastricht University and Almende BV

Task Coordination in Service-based Grids
2005 – 2009n BSIK-ICIS project, 2 PhD's Funded by MinEZ, in cooperation with Thales DECIS-Lab

Doctoral degrees
Bucur, A.I.D.; March 2004;Performance Analysis of Processor Co-Allocation in Multicluster Systems. TU Delft, Delft 2004, 143 pp., ISBN 973-652-892-8, 1st money stream.

Gautama, H.; December 2004;
A Probabilistic Approach to Symbolic Performance Modeling of Parallel Systems.
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2.2.5 Contribution of UL-WI-I

Compaan

Compaan is a *translator* from the Imperative Model of Computation (MoC) to the Process Network MoC. The translation process consists of a number of methods, each of which is implemented in software as part of the Compaan tool chain. Compaan itself is a major component of a *design methodology* that has become known as the *Y–chart approach* introduced in 1998 by Kienhuis et al. The modules in Compaan are 1) *MatTransform* (code to code transformations), MatParser (from Matlab code to Single Assignment code), *DgParser* (from Single Assignment code to an intermediate Polyhedral data structure), *Panda* (from the intermediate Polyhedral data structure to a Kahn Process Network (KPN) specification). Compaan reflects the way LERC is advocating and applying modern state–of–the–art *Software Engineering Practice*, both in the way the group's projects are integrated, documented, and assessed, and in the way research software is written, tested and assessed. In 2004 the Compaan tool chain has been improved, extended, and extensively used, both internally and externally.

At the level of underlying theory, the class of programs that can be accepted by Compaan has been enlarged to include dynamic programs.

Laura
Laura is a KPN-to-reconfigurable platform (FPGA) mapper that converts KPN models delivered by Compaan to implementations in reconfigurable platforms by means of a Vistor and a library of functional IPs (Intellectual Property) . The Compaan and Laura tool chains are interfaced to a test suite allowing the testing and the comparing of results at each and every step in the path from imperative code to parallel implementation. In 2004 the Laura tool has been improved, extended, and validated by going through several examples proposed by external parties (e.g., Xilinx corporation, Philips Reseasrch, and colleagues at the Delft University of Technology).

Archer
Archer supports fast, abstract *system–level* and *platform–based* exploration and design strategies for the multimedia application domain. Platforms consist of a number of heterogeneous computing components, and a communication, synchronization, and storage infrastructure. The Archer strategy is implemented in software in three layers: An application layer, an architecture layer, and a mapping layer. Applications and Platform are modeled at a high level of abstraction, and the Mapping consists of transformations that take an application (model) representation to an architecture (model) representation. Compaan and Laura are used to *calibrate* the abstract computing component models in an Archer platform. Archer then concentrates on performance and cost exploration of the platform at the higher level of abstraction. In 2004, Archer has shown its methodology is capable of predicting performance and cost with a confidence level that is well within the range of requirements.

MASSIVE
Massive focuses on methods and tools for the *explorative specification* of distributed and high–throughput signal processing systems from user–defined (possibly incomplete or partial) *requirements and constraints.* A performance/cost exploration method and tool have been conceived and implemented in such a way that the would–be users can get answers to their *what–if* questions given their requirements and constraints (modifications). Drivers for this research are next–generation distributed radio telescopes such as LOFAR and SKA. Archer, Compaan and Laura are interfaced to MASSIVE's specification exploration tool. In 2004, a *generic platform* was specified and implemented to allow straight forward generation of user-defined platforms. Suggestion to improve exisiting IP interfacing models and methods have been worked out, and research on the control of the systems considered in MASSIVE has been initiated.

Artemis
The model of computation (application model) appearing in the application layer of Archer is similar to the Process Network model that is also appearing in Compaan. However, the PN in Compaan is deterministic whilst in Archer it is not. Moreover, Compaan only accepts static source code whilst Archer does not have that restriction. As a consequence, Compaan cannot be used to translate applications specified in the imperative language to input–output equivalent PN specifications. Artemis aims at overcoming that problem by generalizing some methods and tools that are currently restrictive in Compaan.
The extension allows for data–dependent constructs and non–determinism at the level of communicating tasks to be present in the given (sequential) specification. In 2004, the theoretical foundation has been established, prototype software tools have been constructed, and examples to demonstrate the novel features have been worked out.

MM
MM's focus is on *source code transformations* in system–level design. Source code transformations are the means on which design decisions are made when going down from application specification to architecture specification. One of the objectives is to import such transformations in the Compaan tool chain, and to integrate this chain into a design flow that is currently under investigation at Philips Research (and in which both Artemis and Archer play a role). In 2004, a case study has been worked through to measure the impact of (at least some) transformations given a certain hardware and software architecture.

ARTEMISIA
Artemisia is a project that willbuild on the Artemis project results. The intention of the Artemisia project is to come with a prototype modeling and exploration tool chain, and several designs that are relevant to the industry.

Trader
The Trader project aims to develop methods and tools to ensure the reliability of consumer electronic products. This should result in minimizing product failures that are visible to the user base. Modern consumer products such as television, DVD player/recorders, set top boxes and audio equipment is becoming increasingly complex

and interconnected. This increasing functionality is largely being achieved by the use of embedded software. The extent and complexity of this software has been rising sharply in recent years and the trend is continuing. In such software intensive systems reliability is of prime importance. Worldwide competition is driving the need for shorter development times whilst at the same time demanding a richer range of product features and interconnectivity. This in turn results in products containing many third party components, which may have come from different market sectors. There are wide concerns both with customers and industry experts that as complexity grows the scope for error conditions increases. With software driven systems errors can easily result in total failure and therefore become highly visible to the customer. This directly leads to the need to maintain the level of perceived customer reliability but on significantly more complex products.

Open Kernel Environment
The Open Kernal Environment allows third parties to load code to the lowest levels of a processing hierarchy *in a safe manner*. This includes operating system kernels and embedded systems such as *Network Processors.*

SCAMPI
The SCAMPI project developed a new monitoring *Application Programming Interface* (API) called MAPI, that is explicitly aimed at multi–gigabit networks. SCAMPI implements a monitoring platform on top of various types of programmable architectures, including among others, FPGAs, Network Processors, and Programmable Switches.

Cooperation within ASCI
University of Amsterdam, CSA group
Delft University of Technology, CE group

Externally financed projects
Artemis
Duration: March 2000 – March 2004 Partners: Delft University of Technology, University of Amsterdam, Philips Research Value: 1 Ph.D. student Sponsor: PROGRESS, Philips Research

Artemisia
Duration: September 2004 - September 2008 Partners: Delft University of Technology, University of Amsterdam, Philips Research Value: 1 Ph.D. student, 1 Post-Doc Sponsor: PROGRESS, Philips Research

Massive
Duration: August 2000 – August 2006 Partners: ASTRON, Dwingeloo Value: 2 Ph.D. students, 1 Post-Doc Sponsor: PROGRESS, ASTRON

Archer
Duration: October 2000 – October 2004 Partners: Philips Research Value: 1 Ph.D. student Sponsor: Philips Semiconductors

MM
Duration: February 2003 – February 2006 Partners: Philips Research Value: 1 Ph.D. student Sponsor: Philips Semiconductors

Trader
Duration: September 2004 – September 2008 Partners: Several universities and Philips Research Value: 1 Ph.D. student Sponsor: ESI, LIACS

Scampi
Duration: April 2002 – December 2004 Partners: Terena, 4Plus, Forth, IMEX, UNINETT, Siemens, Netikos, FORTHnet Value: 1 Ph.D. student and 1 Scientific Programmer Sponsor: EU IST

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Experimental software

H. Bos, The Open Kernel Environment (OKE) – The open kernel environment allows users other than root to load native and fully optimised code in the kernel of an operating system without jeopardising safety in any way. Explicit privileges determine what such code is allowed to do and which resources it may use, while a trusted compiler enforces these restrictions. More information, as well as the complete OKE distribution, can be found at: http://www.liacs.nl/~herbertb/projects/oke/index.html.

2.2.6 Contribution of TUD-me-ce

Arache

The general goal of the project is to investigate **novel processor architectures** that enables a ubiquitous (i.e., anywhere and anytime) and unobtrusive (i.e., without much user intervention) communication environment. In order to achieve this, we focus on the following (intertwined) research topics:

Arachne network processor

This entails the specification of the Arachne network processor. In a truly ubiquitous communication environment, the communication devices are not located in a fixed geographical location and therefore may encounter different communication settings during their utilization. For example, moving from a GSM/UMTS network to a Wi-fi network to a Bluetooth network. Instead of incorporating a multitude of heterogeneous and application-specific network processors, we seek to provide a single solution that adapts itself depending on its surroundings in order to lower design complexity and costs of such devices. Herein, we focus on the design of complex hardware units that are able to perform the required functions and on the utilization of reconfigurable hardware technologies, e.g. field-programmable gate arrays (FPGAs). Furthermore, we focus on low-power implementations of the Arachne network processor that are intended to be incorporated in battery-powered handheld devices. Finally, the research in this project also focus on other communication devices other than wireless handheld devices as suggested previously. Examples of such devices include wireless base stations, network routers, network gateways, etc.. Therefore, we investigate the possibility of a single and scalable solution that can be incorporated in these devices. This means covering bandwidths from several kilobits to several tens of Gigabits.

Internet and protocol processing

This entials the investigation into the functional and temporal requirements of Internet-related applications, such as web-based databases, database mining, content-based processing (e.g., multimedia stream processing), voice-over-IP, videoconferencing, e-learning. In addition, we investigate the requirements associated with the processing of protocols, e.g., IPv4/IPv6, TCP, RTP/RTCP, SIP, etc. and their derivatives that govern and enable the previously mentioned applications on top of the internet. The research performed entails ranging from the modeling and profiling of applications to modeling of the Arachne processor to the design of specialized hardware units.

Software and design tools

The research performed entails the development of software tools that allow (faster) modeling and profiling of Internet applications and the Arachne network processor with the purpose of investigating the attainable performance and power requirements/consumption. Related research topics include: simulation tools development, benchmarking, application and processor modeling. In addition, special attention must be paid in the integration of these tools as they provide a valuable source of information prior to the definition of the Arachne network processor (targeting a specific network environment or application set) or to the actual design of specialized hardware units. Finally, design tools must be developed that incorporate the earlier determined profiling information.

Molen

The MOLEN proposition is that reconfigurable processors, i.e. processors that adapt (dynamically or statically) their microarchitecture to fit application "design requirements", are the answer to the processor (embedded or not) hardware design challenges. To prove the viability of the proposition, we are working on multiple design aspects of (single and multi) processors on a chip using reconfigurable fabric. More specifically our team is working on the following:

The MOLEN reconfigurable microcoded processor

The main idea for the MOLEN reconfigurable processors is to utilize microcode and custom configured hardware to improve embedded system computing. The reconfigurable hardware execution of code (ranging from a single instruction to a piece of application code) is divided into two logical phases. In the first phase the reconfigurable hardware is being configured. In the second phase the execution of the code is being performed. In both phases, microcode is utilized to perform both the reconfiguration process and the execution of the code. Frequently utilized microcode resides permanently within the fixed part of an on-chip storage facility and non-frequently utilized microcode are paged into the pageable part of the same or another storage facility. The approach is generic, therefore, different applications can utilize the proposed processing capabilities. Our experimentation thus far has involved multimedia operations. In the multimedia experimentation, we investigate processing elements that are capable of performing operations and algorithms found in generating, coding, and displaying multimedia formats, i.e., pictures, video, audio, and graphics. At the current stage, the multimedia processor architecture has targeted multimedia standards including JPEG, MPEG-1/2, MPEG-4, and H.261. Currently, we consider graphic operations and power consumption. We have implemented a Molen processor prototype on the Virtex-II Pro FPGA family from Xilinx Corp. The Virtex-II Pro devices incorporate up to four PowerPC 405 GPP cores, FPGA reconfigurable fabric hardware, dedicated RAM blocks, and dedicated high-speed I/O blocks. In the future of the project we intend to consider lossless compression.

Reconfigurable arithmetic and logic processor units
The first basic goal is to speed up scientific (mostly vector based) code. Arithmetic (mostly complex to design in hardware) units normally are not present in general purpose processor instruction sets. Such operations include matrix multiplication, sparse matrix operations (such as transpose) etc. They can be implemented in reconfigurable hardware speeding up the execution of scientific programs. A second goal is to design a router and network related reconfigurable hardware. Reconfigurable processor units can be added to general purpose processors for domains (such us switches, networks, packet processing, protocols), that have not been envisioned for the general purpose processor paradigm providing substantial speed-ups.
Embedded IP execution units
We analyze embedded system computational requirements in order to determine the feasibility of hardwired accelerator units and propose implementations for such units. We have considered JPEG, MPEG-1/2, MPEG-4, H.261, and lossless compression algorithms and we have proposed numerous specialized units including DCT/IDCT, sum of absolute differences (SAD), variable length decoding (VLD), Paeth encoding for portable network graphics (PNG), filters, entropy decoders, repetitive padding units, saturated arithmetic units, accepted quality function (AQF), color space convertors. For our experimentation, we have utilized various FPGA technologies and applied the Molen processor framework to the Philips Trimedia, the IBM's PowerPCs (processors integrated on the Xilinx Virtex-II Pro devices) and the ARM (processors integrated on the Altera Excalibur devices). We will keep on exploring embedded applications for potential hardwired IP units.
Memory architecture and implementations
Multimedia and embedded processing has specific requirements for memory accesses. For high performance processing, it is required that the memory is accessed in a rectangular manner implying that to be efficient, mechanisms are needed that access memory in a two-dimensional manner. We propose mechanisms for media reconfigurable processors utilizing special addressed memory organizations and an implementation of two-dimensional memory cores that substantially improve the memory performance of the Molen FPGA implemented processor. In addition, because memory may require a significant amount of power, we propose a cache organization that reduces the number of off-chip accesses thus decreasing main memory power consumption of the reconfigurable processor architecture.
Compiler and design space exploration tools
We have defined a programming paradigm that target the Molen reconfigurable microcoded processor engine and we are developing a backend compiler and a design space exploration toolset. The programming paradigm is based on sequential consistency. It provides mechanisms for parallel and concurrent hardware execution and it is intended (currently) for single program execution. In order to conform to the Molen programming paradigm, an existing compiler has been extended to support the required instruction set and register set extensions. Moreover, a specific mechanism has been developed for passing parameters/results in the case of parallel executions. The compiler and the design space exploration tools are developed in the project The Delft Workbench.
Low-Power High-Performance Graphics Architectures
We are designing a low-power 2D/3D graphics hardware accelerator for mobile terminals equipped with an ARM processor core. The purpose of using a graphics accelerator is to move some of the graphics-related computations, in particular the rasterization, from the CPU to this dedicated hardware device in order to improve the rendering speed for graphics applications. One important concern for a graphics accelerator meant to be employed in mobile terminals is a low power consumption figure since the most current graphics accelerators are notorious for their high power consumption. Therefore, algorithmic- and circuit-level techniques for low-power graphics need to be studied and evaluated.
GraalBench Low-Power Graphics benchmark
The GraalBench is a 3D graphics benchmark suite suitable for 3D graphics on low-power mobile systems, in particular mobile phones. These benchmarks were collected to facilitate our studies on low-power 3D graphics accelerators in the Graal (GRAphics AcceLerator) project. It includes traces of several games as well as virtual reality applications such as 3D museum guides. Applications were selected on the basis of several criteria such as resolution, polygon count, pixel rate, and relevance to mobile devices. For example, 3D FPS games or 3D virtual guides were considered relevant while CAD/CAM applications, such as contained in the Viewperf package, were excluded because it is unlikely that they will be offered on mobile devices (they often have high polygon count and require high resolution). More information and downloads can be found in The GraalBench Benchmark Suite.

External projects
Profesy
01/2004-01/2008, NWO, € 159.436 PROFiling to reduce processor-memory traffic in Embedded SYstems (http://www.onderzoekinformatie.nl/nl/oi/nod/onderzoek/OND1298120/)

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I. Antochi, B.H.H. Juurlink, S. Vassiliadis, P. Liuha; Scene Management Models and Overlap Tests for Tile-Based Rendering.
Proceedings of the EUROMICRO Symposium on Digital System Design, 2004 (DSD 2004)., pp. 424-431, Rennes, FRANCE, August 2004

I. Antochi, B.H.H. Juurlink, S. Vassiliadis, P. Liuha; Efficient Tile-Aware Bounding-Box Overlap Test for Tile Based Rendering.
Proceedings 2004 International Symposium on System-on-Chip, pp. 165-168, Tampere, Finland, November 2004

D. Crisu, S. D. Cotofana, S. Vassiliadis, P. Liuha; GRAAL - A Development Framework for Embedded Graphics Accelerators. Proceedings of Design, Automation and Test in Europe (DATE'04), pp. 1366-1367, Paris, France, February 2004

D. Crisu, S. Vassiliadis, S.D. Cotofana, P. Liuha;
Low Cost and Latency Embedded 3D Graphics Reciprocation.
Proceedings of 2004 IEEE International Symposium on Circuits and Systems (ISCAS 2004), pp. II-905 - II-908, Vancouver, Canada, May 2004

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S. Jintukar, C. J. Glossner, V. Kotlyar, M. Moudgill; The Sandblaster automatic mulithtreaded vectorizing compiler. Proceedings International Signal Processing Conference, pp. 1-17, September 2004

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M.J. Schulte, C.J. Glossner, S. Mamidi, M. Moudgill, S. Vassiliadis; A low power multithreaded processor for baseband communication systems. Proceedings SAMOS workshop 2003-2004, pp. 393-402, March 2004

S. Shamsunder, C. J. Glossner; Reduced complexity software receivers for TD-SCDMA downlink. Proceedings of the International Signal Processing Conference, pp. 1-5, January 2004

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2.3 C: Image and Multimedia Sensing, Processing, Interpretation and Visualisation

2.3.1 Contribution of UG-CS-svcg

Morphological shape- and pattern description A multi-scale method based on mathematical morphology was developed which can be successfully used in segmentation, classification and object recognition tasks. The method is based on morphological hat-transform scale spaces and makes use of connected operators. The method was applied to classification of textures and object silhouettes, and also to automatic segmentation and identification of diatoms. Also, a novel, physically-motivated deformable model for shape recovery and segmentation was developed, called the Charged Particle Model. The model is based on a simulation of charged particles moving in an electric field. The flexibility and potential of the model was explored in a wide variety of settings: shape recovery, automatic segmentation and skeleton computation. The model has been extended to 3-D with promising results. We also are developing an alternative surface reconstruction method, using graphics hardware acceleration of the computations involved. Another issue is how to combine simple morphological transforms into a method for interactive segmentation which behaves analogously to mean-curvature flows widely employed by level-set methods.

Volume visualization
In the area of volume rendering, work on multiresolution representations for maximum intensity projection based on morphological pyramids was continued, with the aim to further improve approximation quality in higher levels of the pyramid. A new algorithm, called \emph{streaming MIP-splatting}, was developed which resorts all detail coefficients in decreasing magnitude and projects only those coefficients needed to attain a user-defined accuracy.
In the area of volumetric filtering and rendering, work on a Max-Tree-based data representation was continued. We have further developed modifications and extensions of the Max-Tree data structure that enable visualization of filtered data directly from the Max-Tree without the need to reconstruct the volumetric data. Rendering is done either by direct volume rendering (splatting) or by an isosurface. The new method has shown to outperform marching cubes when changing the filter threshold interactively, and it was found that that the method is competitive with interval trees for isosurface browsing.

Functional Neuroimaging
Several approaches to wavelet analysis of functional magnetic resonance imaging (fMRI) data were developed. Wavelet-based denoising was found to introduce less smoothing, and to better retain the original shapes of active regions than the usual Gaussian smoothing method. Also, application of statistical parametric mapping with false discovery rate control on denoised simulated time series produced a smaller total number of errors than Gaussian smoothing or wavelet-based methods with a large smoothing effect. A new method based on Fourier-wavelet regularized deconvolution was developed to extract the haemodynamic response function from a fMRI time series. The algorithm only requires the assumptions of the general linear model and the separability of signal and noise in the frequency and wavelet domain. The assumption of Gaussian distributed noise in the fMRI signal was critically investigated. The best approach to get symmetric, nearly-Gaussian distributed noise, was shown to consists in subtracting a second time series from the time series that is analyzed.

Gene regulatory network identification and visualization
A new multiple ontology visualization and exploration (MOVE) system was designed, based upon an existing open-source graph visualization framework. This framework supports several basic modules for input, graph management, transformations, metrics, layout, and interactive display, and allows for integrated network visualization of genomic, metabolic and proteomic information. A graph query language was developed that can search within a graph for certain (biologically relevant) sub-structures. A prototypeapplication is now almost finished, and is used in biological case studies to demonstrate its functionality. A review study on graph visualization of biological networks has been carried out, with a focus on usability issues. Possible ways to take advantage of pre-existing open source software class libraries and frameworks in building extensible, flexible and scalable graph visualization systems are presented. A component of the SARAgene virtual reality framework for genomics visualization was subjected to a two-phase usability study encompassing both heuristics and formative evaluations. The results identify key user-interface requirements for graph-based virtual environments, and report on expert domain users opinions on the design of virtual environments for genomics and related fields. The Self-Organizing Map algorithm has been applied to the MINT protein-protein interaction database for Bacillus subtilis transcriptional regulation, and has been implemented within the SARAgene framework. This result will also be used for an initial evaluation study by biologists.

Computational Geometry and Object Modeling
We continued our work on engineering robust and efficient software for geometric computing, in particular for non-linear surfaces in three-space. One of the results is a method for approximating and meshing of skin surfaces, used in molecular modeling. A distinctive feature of our approach is the guarantee of topological correctness of the output. Our algorithms compute a mesh or an approximation with the same topology as the skin surface. A crude mesh of low complexity, but with the correct topology, is further refined to obtain an arbitrarily accurate approximating mesh. We used similar ideas for the certified computation of visibility features of smooth objects, like contours of surfaces under parallel or perspective projection. In the area of Surface Modeling we obtained a new method for the evaluation of the Clough-Toucher C^1-interpolant of first order data over a triangular mesh. The algorithm saves a lot of computation steps compared to earlier methods. We also started a project on certified reconstruction of shapes from scattered data. The goal is to obtain a topologically correct reconstruction of a sampled object using a meshless approach via Radial Basis Function techniques. Some preliminary results have been reported in Master's theses on this topic. This research will be continued in two PhD projects starting in 2005.

A new method to solve small systems of polynomial equations has been devised and implemented. The method is a combination of algebraic geometry and combinatorial optimization. It is capable of solving small systems in an efficient and robust way. Using this method, a problem from computational geometry studied in the past and not solvable with conventional methods is solved in a stable way.

External projects
Vegter obtained, with Roerdink, and NWO-grant for a four year PhD-position on
the project Certified Shape Reconstruction.

Doctoral degrees
A. Meijster, Efficient Sequential and Parallel Algorithms for Morphological Image Processing, promotor: J.B.T.M. Roerdink, 2nd promotor: W.M. Hesselink, Faculty of Mathematics and Natural Sciences, University of Groningen, ISBN: 90-367-1977-1, March 5, 2004, viii+152 pages.

A.C. Jalba, Automatic Image Segmentation and Analysis with Applications to Diatom Indentification, promotor: J.B.T.M. Roerdink, Faculty of Mathematics and Natural Sciences, University of Groningen, ISBN: 90-367-2053-2, June 5, 2004, ix+157 pages.

A. Wink, Wavelet-based Methods for the Analysis of fMRI Time Series, promotor: J.B.T.M. Roerdink, Faculty of Mathematics and Natural Sciences, University of Groningen, ISBN:90-367-2090-7, September 10, 2004, viii+158 pages.

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H.W. Broer, I. Hoveijn, M. van Noort, C. Simo and G. Vegter, The Parametrically Forced Pendulum: A Case Study in 1 ½ Degree of Freedom, J. Dynamics and Differential Equations}, 16, 2004, 899--948.

C. Grigorescu, N. Petkov, M.A. Westenberg, Contour and boundary detection improved by surround suppression of texture edges, Image and Vision Computing, 22}(8), 2004, 609-622.

A.C. Jalba and M.H.F. Wilkinson and J.B.T.M. Roerdink, Morphological hat-transform scale spaces and their use in pattern classification,Pattern Recognition, 36 (8),2004, 901-915.

A.C. Jalba and M.H.F. Wilkinson and J.B.T.M. Roerdink, A Deformable Model for Shape Recovery and Segmentation Based on Charged Particles, IEEE Trans. Pattern Anal. Machine Intell., 26 (10), 2004, 1320-1335.

A.C. Jalba and M.H.F. Wilkinson and J.B.T.M. Roerdink, Automatic segmentation of diatom images for classification, Microscopy Research and Technique, 65 (1-2), 2004, 72-85.

N. Kruithof and G. Vegter, Approximation by skin surfaces, Computer Aided Design, 36, 2004, 1075-1088.

A. Wink, and J.B.T.M. Roerdink, Denoising functional MR images: a comparison of wavelet denoising and Gaussian smoothing, IEEE Trans. Med. Imaging, 23 (3), 2004, 374-387.

Contributions to International Conference Proceedings
H. Bekker, A. Brink, Reducing the time complexity of Minkowski-sum based similarity measures by using geometric inequalities, Proc. international conference on computational science and its applications, ICCSA 2004 LNCS 3045 part III, Springer Verlag, 2004, 32-41.

J-D. Boissonnat, D. Cohen-Steiner and G. Vegter, Isotopic implicit surface meshing, Proc. Thirty-Sixth Annual ACM Symposium on Theory of Computing (STOC), Chicago, USA, 2004, 2004, 301--309.

A.C. Jalba and M.H.F. Wilkinson and J.B.T.M. Roerdink, Automatic Image Segmentation Using a Deformable Model Based on Charged Particles, Image Analysis and Recognition: International Conference, ICIAR 2004, Porto, Portugal, September 29- October 1, 2004, Proceedings, Part I, 3211: ISBN 3-540-23223-0.

S. Plantinga and G. Vegter, Isotopic Implicit Surface Meshing, Proc. Symposium on Geometry Processing, Nice, France, 2004, 2004, 251--260.

Experimental software
The Matlab software for denoising fMRI time series developed by Wink in the project "Wavelet based methods for the analysis of fMRI time series" has been accepted as a plug-in of the SPM (Statistical Parametric Mapping) package, cf. http://www.fil.ion.ucl.ac.uk/spm/ext/#spm_wavelet .

Highlights
In A.C. Jalba and M.H.F. Wilkinson and J.B.T.M. Roerdink, IEEE Trans. Pattern Anal. Machine Intell., 26 (10), 2004, 1320-1335, a novel, physically-motivated deformable model for shape recovery and segmentation was developed. The model, referred to as the charged-particle model (CPM), is inspired by classical electrodynamics and is based on a simulation of charged particles moving in an electrostatic field. We demonstrated the flexibility and potential of the model in a wide variety of settings: shape recovery using manual initialization, automatic segmentation and skeleton computation. The model is easily extendable to 3-D and copes well with noisy images. We also performed a comparative analysis of the proposed model with the active contour model and showed that specific problems of the latter are surmounted by the CPM.

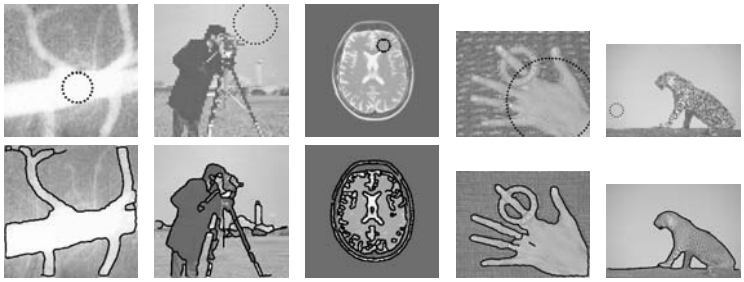

IMAGE_2004
CAPTION: Contour detection by the Charged Particle Model. First row: input images, with the particles initialized on a circle; second row: resulting contours (Jalba, Wilkinson and Roerdink, IEEE Trans. Pattern Anal. Mach. Intell. 26 (10), pp. 1320-1335, 2004).

2.3.2 Contribution of UvA-FdNWI-ias

Perception for autonomous systems
We develop methodologies for the scene interpretation from sensor data (mainly video). Applications in intelligent transportation systems typically require mobile sensor platforms, whereas public safety and the intelligent home systems (e.g. assistance of eldery, disabled) can be based on stationary platforms. We cooperate with TNO on a number of projects, such as the RoboJeep autonomous robot vehicle.

A fundamental capability of intelligent vehicles is that of detecting obstacles. In joint research with TNO we developed a real-time obstacle detection system based on dense stereo vision and SIMD processing. Evaluations were made on realistically looking simulated data (with ground truth) as well as real data from urban traffic, showing the benefit of the proposed system versus others in the public domain. A new cooperation with

DaimlerChrysler Research in Germany is furthermore looking into the challenging problem of recognizing a particular class of obstacles, pedestrians, from a moving vehicle.

In off-road environments, range based sensor systems, such as stereo vision, have difficulties distinguishing between solid obstacles such as rocks or soft obstacles such as tall patches of grass. We have developed a colour based vision method to classify typical terrain coverings, robust against illumination changes.

Also in cooperation with TNO-D&V, methodologies for public safety are being developed. Many surveillance algorithms consist of different parts, such as object detection, segmentation, tracking, and recognition. In this project we worked on a statistical framework for visual tracking applications. It allows easy adaptation of the tracking application by substitution of one of the algorithms for part of the problem, without altering the remainder of the application. Furthermore, we developed and compared a range of techniques to automatically correct for these illumination changes. This enables us to use affordable auto-gain cameras to do sophisticated image processing.
Radars become important for pubic safety. Current state-of-the-art radars are cheap, portable, and small. A disadvantage of radar is that its measurements cannot be directly visualized like an electro-optical sensor. We visualize radar measurements by showing them as a 3D scene in a virtual environment, which can be interpreted by a human observer. This is based on the estimation of human motion features from radar to animate the person.

Principles of autonomous systems
In the project on geometric algebra, we have continued the development of theconformal model as a compact language for programming geometry, though in the past year the effort was considerably reduced due to prolonged illness (RSI) of the chief investigator. We have deepened the work on efficient implementation, and on facilities for visualization of and experimentation with geometric algebra and geometry. This involves compiler and interpreter construction, and is a cooperation with the Faculty of Computer Science at the Free University (VU). We have started writing a book 'Geometric Algebra for Computer Science', based on our paper and interactive tutorials, to help spread the distribution of the technique to the field.

Learning, Probabilistic and Neural Computing
We develop learning and probabilistic reasoning methods for intelligent systems operating in a real world. One line of research focuses on smart environments which must be able to localize and track humans and analyze their behaviour. In particular we studied a surveillance application with many distributed, non-overlapping cameras. Such a system is faced with the problem whether a person observed with a camera at some time is the same person as observed by some other camera some time ago. We developed probabilistic Bayesian networks which outperform conventional (multi-hypothesis) tracking methods. A patent application is filed. The project is funded by STW.

Probabilistic inference and learning techniques were also used in a project on nonlinear dimension reduction of high dimensional data. Applications of developed techniques in the field of behaviour analysis are studied. A thesis on this work was defended. Funding of the project `Tools for non-linear data analysis' was extended with an extra year by STW.

An important new line of research concerns `cognitive devices' for intelligent environments. With top partners in Europe in the field of robots and human-robot interaction we started a 6th framework Integrated Project 'Cogniron' in which a cognitive robotic assistant is developed. Our group works on human activity analysis and on cognitive representations of objects and space. With this Cogniron project, the work started in the NWO project 'Concept learning' and the work carried out in the ITEA project 'Ambience' is continued.

Decision making in single- and multiagent systems
We have studied the problem of agent sequential decision making (planning) under uncertainty. We have developed "Perseus", an approximate value iteration algorithm for arbitrary POMDPs (partially observable Markov decision processes) which is very competitive over existing methods. We are also interested in cooperative multi-agent systems. Here we use the framework of coordination graphs which allows for a tractable approach to multi-agent coordination. Our current work on coordination graphs involves (i) message passing techniques for approximate decision making (similar to belief propagation in Bayesian networks), and (ii) distributed cooperative reinforcement learning (Q-learning). We incorporated this framework in our UvA Trilearn RoboCup simulation team which won the 2004 German Open. Similar work we have applied in the rescue simulation league.

Another research line involves `Interactive Hierarchical Awareness' in a multi-agent system. In the Interactive

Collaborative Information Systems (ICIS) project we aim at developing scalable and theoretically sound methods for constructing and updating hierarchical state representations for multi-agent systems. Additionally, in the Combined project we have introduced Distributed Perception Networks (DPN), which are multi-agent systems which support fusion based on distributed Bayesian Networks (BN). In this context, our research is focused primarily on (i) task driven self-configuration of DPN agents at runtime,(ii) efficient and robust information fusion with distributed BNs, (iii) resource allocation in distributed fusion systems based on information theoretic criteria, and (iv) approaches to improved fusion accuracy.

In a related line of research we have studied the problem of decentralized data mining (unsupervised learning) using gossip-based communication protocols. We have provided theoretical and experimental evidence that under such protocols, nodes converge exponentially fast to the correct parameter estimates.

External Projects

Tools for non-linear data analysis
2000-2004, STW, 0.7 Mf, TUD-TN-fi-ph.
Current data analysis systems receive large amounts of data, e.g. computerized measurement systems in the industry, Web databases, etc. Tasks like storage or analysis of such data require first an appropriate *feature extraction* step in order to reduce the dimensionality of the data. In this project we investigate methods for linear and nonlinear feature extraction with emphasis on visualization and modeling of high-dimensional datasets, especially those characterized by additional spatial or temporal inter-relationships of the data points. Industrial partners include Shell, FEL-TNO, Noldus IT, KiQ, Unilever, CAP-Gemini.

Geometric Algebra: a New Foundation for Geometric Programming
2000-2006, 637kf
This projects makes geometric algebra into a practical tool for geometric programming applications within computer science, notably robotics, vision and computer graphics. New techniques for specification of geometric programs are being developed, and a freely available fast implementation constructed. This is an NWO-sponsored project.

Probabilistic models for distributed surveillance
2001-2005, STW, 545kf
This project studies how probabilistic models like belief networks can be used in distributed surveillance system, where moving objects have to be tracked by a system of cameras with non-overlapping views.The information from the different camera systems will have to be combined. A number of fundamental problems has to be solved such as the identification problem (`is the object which is observed by one camera the same as the object observed by some other camera some time ago?') and the representation problem (`how can probabilistic information be integrated in a distributed system?').

Learning Concepts in Real World Embodied Agents
2001-2004, NWO, 320 kf
Service robots, personal assistants and other intelligent computers which operate in a real world inhabited by humans, deal with the problem of communicating in a `natural' way with their environment. In this project we work on on the development of novel learning methods which can be used for concept formation in a human-robot interaction. The method will be implemented and tested on a real mobile robot.

Distributed User Modeling for Personalized Exploring Recommender Systems (DUMPERS
2002-2006, NWO(ToKen2000), 225kE
In the project DUMPERS we will develop methods for adding adaptive navigation support for users of web sites. Goal of this project is to extend existing methods with extra components like exploration of the effect of recommendation by using techniques from the field of reinforcement learning. We will use locally stored user models to provide the information about the individual users needed for personal recommendation without violating the privacy of the users.

COMBINED systems
2002-2006, 800kE
In this project we study innovative methods for disaster management. In particular aspects concerning distributed observation systems are investigated. An important property of distributed observation systems is that they autonomously extract information from the monitored area. This information is shared with other services in the disaster management platform. The project is conducted in cooperation with TUDelft, Thales en TNO within the DECIS laboratory.

Environment Representation for Autonomous Vehicles
2001-2005, 200kf
In this project we develop a "RoboJeep" robotic vehicle. This vehicle must be able to navigate and perform useful observations autonomously in an unstructured environment. Different sensors such as stereovision cameras, ultra-sonic sensors, odometers, and a laser range scanner are applied for this goal. The objective of this research is to develop techniques for acquiring reliable representations of the environment from these sensors. Collaboration with TNO.

A structure for maintaining a shared world model in a dynamic environment between differentiated embedded systems and their interaction with human supervisors
2001-2006, 490 kf
We study embedded autonomous systems in distributed environments, for applications in public safety; monitoring and control of traffic and environmental conditions; assistance and clean-up work in disaster areas. Collaboration between systems requires a collective world model, and we develop methods for its consistency maintenance, in time-critical situations. We use robot soccer (RoboCup) as a case study. This project is a collaboration with the VU and is sponsored by Progress.

COGNIRON: Cognitive Robot Companion
2004-2008, 600kE
In this 6th framework project within IST we develop a cognitive robot which interacts with humans and has conceptual representations. Our group works on human activity analysis and on cognitive representations of objects and space.

Interactive Collaborative Information Systems
2004-2009, 736 k€
The ICIS project is an attempt to bridge the gap between traditional information capture, transmission and transaction processing to full-blown intelligent information systems techniques. This is a road starting with traditional information management techniques such as better structuring and managing of information (including data mining and data warehousing) and the development of self-generating software through to artificial intelligence and agent based systems and complete integration of technologies with human and social systems.

Doctoral degree
J. J. Verbeek. Mixture Models for Clustering and Dimension Reduction. PhD thesis, University of Amsterdam, December 2004.

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A. Diplaros, T. Gevers, and N. Vlassis. Skin detection using the EM algorithm with spatial constraints. In W. Thissen, P. Wieringa, M. Pantic, and M. Ludema, editors, Proc. of the IEEE Int. Conf. on System, Man and Cybernetics, pages 3071-3075, The Hague, The Netherlands, October 2004. Omnipress. ISBN 0-7803-8567-5.

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S. H. G. ten Hagen and B. J. A. Kröse. Learning to understand tasks for mobile robots. In W. Thissen, P. Wieringa, M. Pantic, and M. Ludema, editors, Proc. of the IEEE Int. Conf. on System, Man and Cybernetics, pages 2942-2947, The Hague, The Netherlands, October 2004. Omnipress. ISBN 0-7803-8567-5.

B. Terwijn, J. M. Porta, and B. J. A. Kröse. A particle filter to estimate non-Markovian states. In F. C. A. Groen, editor, International Conference on Intelligent Autonomous Systems, IAS'04, pages 1062-1069. IOS Press, March 2004. ISBN 1-58603-414-6.

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A. Visser, G. Pavlin, S. P. van Gosliga, and M. Maris. Self-organization of multi-agent systems. In Proc. of the International workshop Military Applications of Agent Technology in ICT and Robotics, The Hague, The Netherlands, November 2004.

N. Vlassis, R. K. Elhorst, and J. R. Kok. Anytime algorithms for multiagent decision making using coordination graphs. In W. Thissen, P. Wieringa, M. Pantic, and M. Ludema, editors, Proc. of the IEEE Int. Conf. on System, Man and Cybernetics, pages 953-957, The Hague, The Netherlands, October 2004. Omnipress. ISBN 0-7803-8567-5.

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P. J. Withagen, K. Schutte, and F. C. A. Groen. Probabilistic classification between foreground objects and background. In Proceedings of the 17th International Conference on Pattern recognition (ICPR 2004), volume I, pages 31-34, Cambridge, UK, August 2004. IEEE.

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Z. Zivkovic. Improved adaptive Gaussian mixture model for background subtraction. In Proc. Int. Conference on Pattern Recognition, UK, August 2004 volume 2, pages 28-31.

Z. Zivkovic. Optical-flow-driven gadgets for gaming user interface. In Proceedings of the 3rd International Conference on Entertainment Computing, 2004, pp.90-100.

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Experimentele software

M. T. J. Spaan and N. Vlassis. “Perseus Software”, Matlab, 2004.
Software for solving partially observable Markov decision processes. Available from:
http://staff.science.uva.nl/~mtjspaan/pomdp/

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http://staff.science.uva.nl/~jellekok/robocup/2004/trilearn_rc2004_bin.tar.gz

D. Fontijne, GAIGEN 2, C++, 2004.
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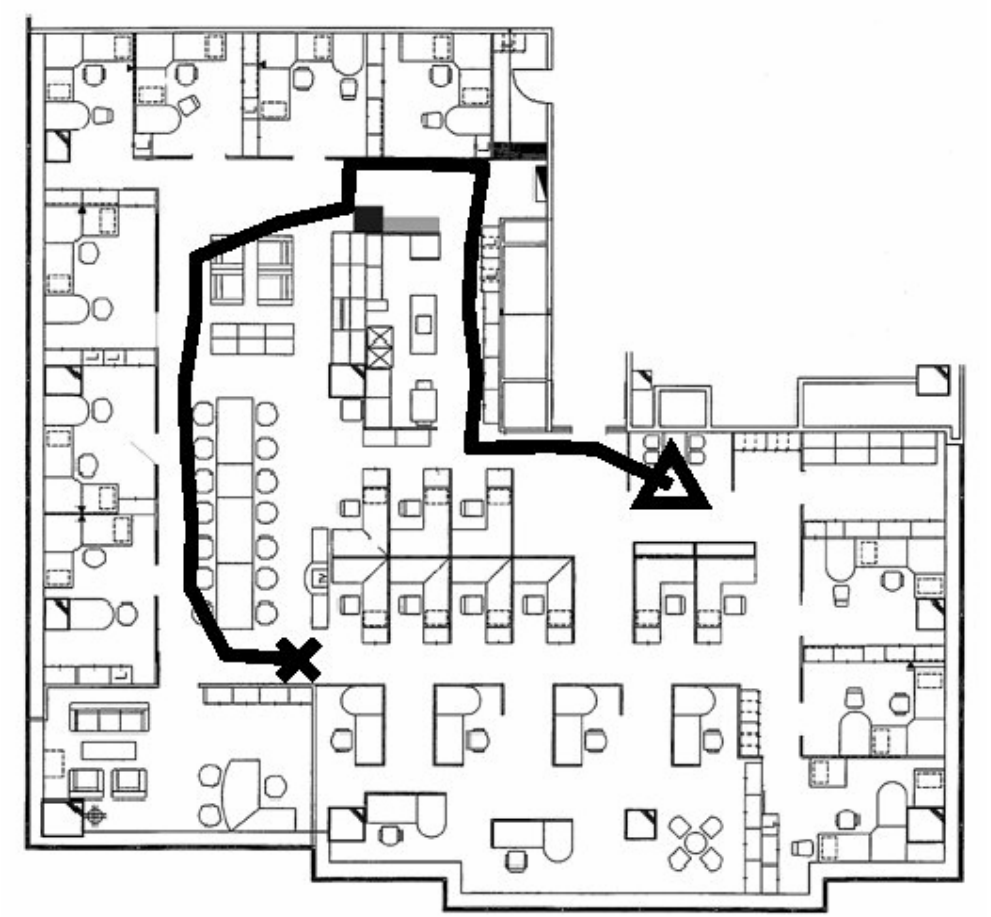
Patent
K.I. Trovato and L. Dorst. Differential budding: method and apparatus for path planning with moving obstacles and goals. *USPTO*, pages 45-52, April 2004. U.S. Patent 6,728,581.

Highlight: Perseus



In 2004 we developed the "Perseus" algorithm for solving POMDPs (Partially Observable Markov Decision Processes), which is currently the fastest approximate algorithm available (since 1965 when the research on POMDPs started). For more details, papers, software, and demos, you may visit the website:
http://www.science.uva.nl/~mtjspaan/pomdp/
The figure shows a trajectory of a simulated mobile robot equipped with an omnidirectional camera through an office environment in which many states in the environment will look similar to the robot, but require a different action. Perseus uses the POMDP framework to compute the correct action given the uncertainty regarding the true location of the robot.
In one year this work has already received numerous citations and is generally acknowledged as the leading approach for solving POMDPs. Many researchers are already using Perseus, or have extended it in several directions.

2.3.3 Contribution of TUE-EE-dmes

Video processing: algorithms and architectures
The focus of our video processing research is also targeted on high-end consumer applications. The current activities fall into two categories, format conversion and video enhancement. The emphasis in the former is on improving the cost/performance ratio, through algorithm-architecture co-design, of a motion estimation/compensation unit for picture rate up-conversion, while the latter is focused on resolution up-conversion, necessary since modern displays have more pixels than the video signal contains, with image-content dependent interpolation kernels.

For the first topic, a thorough comparison of the resulting design for motion estimation with competing designs in which algorithms where mapped to a fixed, though flexible, architecture provided initial proof that this algorithm-architecture co-design methodology yields superior cost/performance. The new architecture enables a reduction in power dissipation, with roughly an order of magnitude, since the number of accesses at each level can be carefully controlled. Also the area figure dropped an order of magnitude. In 2004, the design was extended to include picture rate up-conversion and a start was made with the algorithm/architecture co-design of an advanced de-interlacing method based on generalized sampling and directional interpolation.

Apart from a thorough bench marking of the available video-enhancement algorithms, including classification-based filters and neural networks, innovative algorithms resulted from the work on the second topic. Particularly, the gained insight of classified filters was found to enable substitution of time-consuming heuristic optimization procedures by classified mixing.

External projects

Video Enhancement

2001-2005, Philips research, 180 k€

The purpose of video enhancement is to improve the subjective picture quality. Conventional focus in this field was mainly on sharpness, contrast, and colour reproduction improvement, as well as on noise reduction. The purpose of this project is to evaluate what has been achieved in this area, and to propose an optimal technique of SD (standard-definition video) to HD (high-definition video) conversion.

Design of systems on silicon for video enhancement and format conversion

2002-2006, Philips Research, 180 k€

The goal of this research project is the design of a system on silicon for video enhancement and format conversion, aiming at the joint optimisation of algorithms and architecture for a single chip video converter/enhancer. Fields of interest are motion estimation and compensation, picture rate conversion, de-interlacing, resolution enhancement, noise reduction, power optimisation, VLSI design.

Papers in international journals

Puttenstein, J.G.; Heynderickx, I.; Haan, G. de:Evaluation of objective quality measures for noise reduction in TV-systems. Signal Process. 19, nr. 2, 2004, pp. 109-119.

Contributions to international conference proceedings

Beric, A.; Sethuraman, R.; Meerbergen, J.L. van; Haan, G. de: A 27 mW 1.1 sq mm motion estimator for picture-rate up-converter. Proceedings of 17th International Conference on VLSI Design 2004, 5-9 January 2004.

Beric, A.; Sethuraman, R.; Peters, H.; Veldman, G.; Meerbergen, J.L. van; Haan, G. de: Streaming scratchpad memory organisation for video applications. Proceedings of the IAESTED Int. Conference on Ciruits Signals and Systems 2004, 2004, pp. 427-432.

Braspenning, R.A.; Haan, G. de: True-motion estimation using feature correspondence. Proceedings of SPIE VCIP 2004, 18-22 January 2004, pp. 396-407.

Ciuhu, C.; Haan, G. de:A two-dimensional generalized sampling theory and application to de-interlacing. Proceedings of SPIE VCIP 2004, 18-22 January 2004, pp. 700-711.

Cordes, C.N.; Haan, G. de:Y/C-separation of composite color video signals using samples with non-opposite subcarrier phase. Proceedings of SPIE, VCIP 2004, 18-22 January 2004, pp. 741-752.

Hu, H.; Hofman, P.M.; Haan, G. de: Image Interpolation Using Classification-based Neural Networks. Proc. of the ISCE, 1-3 September 2004, ISBN 0-7803-8527-6; IEEE, Reading (UK, 2004, pp. 133-137.

Klompenhouwer, M.A.; Haan, G. de: Video, Display and Processing. Digest of the SID'04, 23-28 May 2004, pp. 1466-1469.

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Zhao, M.; Hofman, P.M.; Haan, G. de: Content-adaptive up-scaling of chrominance using classification of luminance and chrominance data. Proceedings of SPIE VCIP 2004, 18-22 January 2004, pp. 721-730.

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Experimental software
Zhao, M; Resolution Up-Conversion2003 - now, C++/Windows XP.Content-adaptive vertical temporal de-interlacing: De-interlacing of video data using adaptive vertical temporal filters. Classification based data mixing for hybrid de-interlacing techniques: based on classification and Least Mean Square filtering, we can achieve better data mixing result for hybrid de-interlacing. Subjective optimal Least Mean Square filtering for up-scaling: Using the inverse relationship between sharpen and blur, we designed content adaptive up-scaling techniques with build-in sharpness enhancement, thus improving the perceived up-scaling image quality.

Experimental hardware
Beric, A; Sethuraman, R; A motion compensated picture-rate up-converter 2003 - now
This design concerns a VLIW-based ASIP for motion estimation used in picture-rate up-conversion. The ASIP meets low-power and low-cost requirements apart from providing flexibility for the application domain. It consumes 27 mW and takes an area of 1.1 mm^2 in 0.13 µm technology for delivering motion estimation functionality for standard definition (SD) sequences at 140fps. The designed hardware was synthesized and tested up to the pre-layout netlist level.

Patent
Bruijn, F. de; Bruls, W.; Haan, G. de: Image coding with black dropping. Koninklijke Philips Electronics N.V., EP 1459563, 22 September 2004.

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Haan, G. de; Klompenhouwer, M.A.:Anti motion blur display. Koninklijke Philips Electronics N.V., EP 1402720, 31 March 2004.

Haan, G. de; Lodder, R.: Improved spatial resolution of video images. Koninklijke Philips Electronics N.V., EP 1442426, 8 April 2004.

Lodder, R.; Haan, G. de: Edge oriented interpolation of video data. Koninklijke Philips Electronics N.V., EP 1444824, 11 August 2004.

Mertens, M.J.W.; Haan, G. de: Foreground/background detector. Koninklijke Philips Electronics N.V., US 6771799, 3 August 2004.

Peters, F.J.; Haan, G. de; Gelissen, J.H.A.: Conversion unit and method and image processing apparatus. Koninklijke Philips Electronics N.V., EP 1399883, 24 March 2004.

Stessen, J.H.C.J.; Haan, G. de; Schutten, R.J.; Sijstermans, F.W.:Video apparatus with noise reduction. Koninklijke Philips Electronics N.V., US 6714258, 30 March 2004.

Wittebrood, R.B; Haan, G. de: Feature point selection. Koninklijke Philips Electronics N.V., EP 1435070, 7 July 2004.

2.3.4 Contribution of TUE-WI-vis

Data Visualization
Cooperation with the group of prof. M. Rumpf (Bonn) has resulted in a number of publications, around the theme of application of partial differential equations in image processing and visualization.
Our research in information visualization has led to new methods for the visualization of large graphs, DNA sequences, software, and peer-to-peer systems. The current focus of the group is now mainly on software visualization, in cooperation with LaQuSo, the TU/e laboratory for quality software.
New results were achieved in our Virtual Reality track, especially concerning interaction and modeling to support interaction.

External projects

GraphVis

2001-2005, NWO, 100KE

This project aims at the visualization of large graphs, with thousands to millions of nodes and edges, for applications such as software engineering and web visualization. Solutions are sought in interaction, clustering and above all, effective visual representations.

SMARTER

2002-2007, NWO, 572 KE

The aim of the project is to develop new methods and techniques for the simulation of anisotropic turbulent transport. These new methods are based on Local Defect Correction (LDC). This project is a collaboration between four research groups at TU/e. Our contribution concerns the development of new visualization methods.

VOLTS

2004-2008, NWO, 315 KE

The aim is to develop new methods to gain insight in large state transition graphs, such as produced when formal methods, i.e. process algebra, is applied to model dynamic systems. The project is a collaboration with the group Design and Analysis of Systems at TU/e.

Doctoral Degrees:

Pranovich, S.; May 19th 2004;
Structural Sketcher – A Tool for Supporting Architects in Early Design.
TU Eindhoven; Eindhoven 2004, 143 pp., ISBN 90-386-0872-1

Contributions to Books

Telea, A. *An Open Architecture for Visual Reverse Engineering*.
In: Khan, K., Y. Zhang (eds.); Managing Corporate Systems Evolution and Maintenance. Idea Group Publishing, pp. 211-227, 2004.

Papers in international journals

Clarenz, U., M. Griebel, M. Rumpf, M.A. Schweitzer, A. Telea. A Feature Sensitive Multiscale Editing Tool on Surfaces. The Visual Computer, vol. 20, no. 5, p. 329-343, 2004.

Clarenz, U., M. Rumpf, A. Telea.Robust Feature Detection and Local Classification for Surfaces based on Moment Analysis. IEEE Trans. on Visualization and Computer Graphics, vol. 10, no. 5, p. 516-525, 2004.

Clarenz, U., M. Rumpf, A. Telea.*Surface Processing Techniques for Point Sets using Finite Elements.* Computers and Graphics, vol. 28, no. 6, p. 851-868, 2004.

Laramee, R.S., J.J. van Wijk, B. Jobard, H. Hauser. ISA and IBFVS: Image Space-Based Visualization of Flow on Surfaces. IEEE Trans. on Visualization and Computer Graphics, vol. 10, no. 6, p.637-648, 2004

Maubach, J. A. Telea. The NumLab Numerical Laboratory for Computation and Visualisation. Computing and Visualization in Science, published first online, DOI: 10.1007/s00791-004-0142-3, August 2004.

Overveld, C.W.A.M., B. Wyvill Shrinkwrap: An efficient adaptive algorithm for triangulating a iso-surface. The Visual Computer, vol. 20, no. 6, p. 362-379, August 2004.

Telea, A *An Image Inpainting Technique based on the Fast Marching Method.*Journal for Graphics Tools, vol. 9, no.1, ACM Press, p. 23-34, 2004.

Wijk, J.J. van, R.J. Moorhead II, G. Turk. Guest Editor's Introduction: Special Section on IEEE Visualization. IEEE Trans. on Visualization and Computer Graphics, vol. 10, no. 4, p.369-370, 2004.

Wijk, J.J. van, W.A.A. Nuij. A Model for Smooth Viewing and Navigation of Large 2D Information Spaces. IEEE Trans. on Visualization and Computer Graphics, vol. 10, no. 4, p.447-458, 2004.

Wijk, J.J. van, D. Saupe. *Image Based Rendering of Iterated Function Systems.*Computers and Graphics, vol. 28, no. 6, p. 937-943, 2004.

Contributions to international conference proceedings

Abello, J., F. van Ham Matrix Zoom: A Visual Interface to Semi-External Graphs. In: Ward, M., T. Munzner (eds.), Proc. IEEE Symp. Information Visualization 2004, IEEE CS Press, p. 183-190, 2004.

Clarenz, U., M. Rumpf, A. Telea. *Finite Elements on Point Based Surfaces.* In: Alexa, M., M. Gross, H. Pfister, S. Rusinkiewicz (eds.) Proc. Symp. Point Based Graphics, Eurographics Association, p. 201-211, 2004.

Clarenz, U., M. Rumpf, A. Telea. *Fairing of Point Based Surfaces.* In: Cohen-Or, D., L. Jain, N. Magnenat-Thalman (eds.), Proc. Computer Graphics International (CGI'04), IEEE CS Press, p. 600-604, 2004.

Goga, N., F. Moldoveanu, A. Telea. Shading in a Distributed Environment. In: Banissi, E., C. Chen, B. Shneidermann (eds.), Proc. Information Visualisation (IV'04), IEEE CS Press, p. 1003-1006, 2004.

Griebel, M., M. Rumpf, T. Preusser, M. A. Schweitzer, A. Telea Flow Field Clustering via Algebraic Multigrid. In: Rushmeier, H., G. Turk, J.J. van Wijk (eds.), Proc. IEEE Visualization 2004, IEEE CS Press, p. 35-42, 2004.

Gulik, R. van, F. Vignoli, and H. van de Wetering. Mapping music in the palm of your hand, explore and discover your collection. Proc. 5th International Conference on Music Information Retrieval (ISMIR 2004), Barcelona, p. 409-414, Audiovisual Institute Pompeu Fabra University, October 2004.

Ham, F. van, and J.J. van Wijk Interactive Visualization of Small World Graphs. In: Proc. IEEE Symp. Information Visualization 2004, IEEE CS Press, p. 199-206, 2004.

Kok, A.J.F., and R. van Liere Co-location and Tactile Feedback for 2D Widget Manipulation. In: Ikei, Y., M. Goebel, and J. Chen (eds.), Proc. IEEE Virtual Reality 2004, IEEE CS Press, p. 233-234, 2004.

Liere, R. van, J. Mulder. Tangible Devices for Two Handed 3D Interaction In: Froehlich, B., Y. Kitamura (eds.), Proc. IEEE VR 2004 Workshop Beyond Glove and Wand Based Interaction, p. 47-48, 2004, http://www-human.ist.osaka-u.ac.jp/vr04w2.

Liere, R. van, A. van Rhijn. An Experimental Comparison of Three Optical Trackers for Model Based Pose Determination in Virtual Reality. In: Coquillart, S., M. Goebel (eds.), Proc. of the Eurographics Symposium on Virtual Environments 2004, p. 25-35, 2004.

Martens, J.-B, W. Qi, D. Aliakseyeu, A.J.F. Kok, and Robert van Liere. Experiencing 3D Interactions in Virtual Reality and Augmented Reality. In: Proc. 2nd European Union Symposium on Ambient Intelligence, p. 25-28, ACM Press, 2004.

Peeters, T., H. van de Wetering, M. Fiers, and J.J. van Wijk. Case Study: Visualization of annotated DNA sequences. In: Deussen, O., C. Hansen, D. Keim, D. Saupe (eds.), Proc. VisSym 2004, Symposium on Visualization, Konstanz, Germany, p. 109-114, Eurographics Press, May 2004.

Strzodka, R., A. Telea. *Generalized Distance Transforms and Skeletons in Graphics Hardware.* In: O. Deussen, C. Hansen, D. Keim, D. Saupe (eds.), Proc. IEEE VisSym '04, Eurographics Press, p. 221-230, 2004.

Telea, A., C. Sminchisescu, S. Dickinson. *Optimal Inference for Hierarchical Skeleton Abstractions.* In: Kittler, J., M. Petrou, M. Nixon (eds.), Proc. ICPR (Intl. Conf. Patt. Recogn.), IEEE CS Press, p. 19-22, 2004.

Voinea, L., A. Telea. A Framework for Interactive Visualization of Component-Based Software. In: Crnovic, I. (ed.), Proc. EUROMICRO'04 (ed. I. Crnovic) , IEEE CS Press, p. 567-574, 2004.

Voinea, L., A. Telea, J. J. van Wijk. EZEL: A Visual Assessment Tool for P2P file Sharing Networks. In: Ward, M., T. Munzner (eds.), Proc. IEEE Symp. Information Visualization 2004, IEEE CS Press, p. 41-48, 2004.

2.3.5 Contribution of UU-WI-ics

Geometry, Imaging and Virtual Environments
The advances in information and communication technology have led to an enormous amount of spatial and image data. There are many application domains where one needs to analyze, process, or visualize such data. Examples include computer-aided training and simulation, multimedia, medical imaging, molecular modeling, automated cartography, 3D web design, virtual reality, and computer games. The research program is concerned with the design, analysis, and implementation of algorithms and data structures for spatial data, and their application in the above mentioned domains. The type of research ranges from theoretical algorithms research leading to the design and analysis of fundamental geometric algorithms and data structures, to application-oriented research leading to new systems applying algorithmic results in domains like geographic information systems, automated cartography, navigation and manipulation for robots and virtual characters, and content-based image retrieval and multimedia. The program has three main lines of research:

Computational geometry The field of computational geometry studies fundamental algorithmic techniques and data structures for geometric problems. The main goal is to design correct and provably efficient algorithms and data structures for generic algorithmic questions dealing with collections of points, lines, polygons, and more complicated geometric primitives in the plane and in higher-dimensional space. The robust implementation of such algorithms has become another key research question in this line of research. We also study geometric algorithmic questions that are derived from particular application domains, in particular from geographic information systems (dealing with terrain data), automated cartography (for example map labeling), robotics, and manufacturing.

Imaging and multimedia In this line of research we study algorithmic questions related to the interpretation of images, 3D models, music, and video. The topics we work on include segmentation, feature extraction, matching of objects and organization of media in index structures, with a focus on shape-based multimedia, and music retrieval. The research is concerned with the algorithmic aspects of shape analysis, in particular the representation, decomposition, approximation, and deformation of shapes, the transformation of one shape into another, measures for similarity of shapes, and the organization of shapes in search structures for efficient content-based retrieval. Here shape can be derived from images but also from 3D models and music.

Virtual environments Navigation (or motion) and interaction (often in the form of manipulation) are key issues in virtual environments. The research concentrates on algorithms for planning and simulation of motion and manipulation in complex environments, such as models of industrial installations and computer games. Path planning and collision detection are crucial underlying algorithmic techniques for this. Motion is often not a goal in itself but a means of reaching a target area where a manipulation task is to be performed, such as the assembly of a spare part in a virtual factory or the removal of a tissue sample in virtual minimal-invasive surgery. For realistic simulation of these tasks we apply knowledge of techniques from robotics such as kinematics and the mechanics of manipulation, in combination with sophisticated models of physical behavior.

In all three lines of research we aim both for new fundamental algorithms and data structures, and for techniques that have been verified on practical problem instances and can be used in the different application domains.

External Projects
Automated Visualization of Traffic and Transportation
2000-2004 Lely stichting, 125 KEuro This project consists of research on automated visualization means of data or analyses on (road) networks. In particular, cartographic means of visualization, like schematic maps and cartograms will be studies.

SHAME
2000-2004, STW, 450 KEuro The goal of this project is to create a software library of efficient shape matching algorithms based on shape. To achieve this we implement, test, and improve existing shape matching algorithms, and develop new ones.

MOCCAM
1999-2005, NWO, 250 KEuro This project aims at developing new algorithms for motion planning in complex environment. On one hand we concentrate on efficient data structures for storing such environments, and on the other hand, we study probabilistic planners to better understand their behavior, improve them, and extend them to new domains.

SPIRIT
2002-2004, EU Fifth Framework, Utrecht part: 300 Keuro
This aim of this project is to construct an indexing system for the web that can take geographic information, like position, vicinity, size, into account. In Utrecht we primarily are concerned with relevance ranking of the found results based on geometric criteria.

MOVE-ME
2002-2006, NWO, 150 KEuro.
This project studies motion planning for large groups of entities in huge virtual environments. We will try to combine flocking techniques with motion planning techniques to let groups move together in realistic ways.

MOVIE
2003-2005, EU Fifth Framework, Utrecht part: 300 Keuro.
This project aims at applying motion planning technology to efficiently create natural looking motion for individual entities and groups of entities in complex virtual environment, for example in computer games. The project is a combination of algorithms research to obtain new motion planning techniques and more development work to integrate it in virtual environment applications.

Clamp
2003-2007, NWO, 280 KEuro
This project studies manipulation problems from an algorithmic perspective. The goal is to devise new algorithms to fixtures 2- and 3-dimensional objects and to reorient those using passive devices.

BRICKS
2004-2008, subproject Modelling, Simulation and Visualization, 320 KEuro
Our subproject concentrates on interaction with virtual environments. In particular we work on navigation through virtual environments and manipulation of objects in virtual environments.

Aim@Shape
2004-2007, EU Sixth Framework, Utrecht part: 450 Keuro
This project aims to develop techniques for advanced modeling and analysis of shapes.

Doctoral Degrees
Cabello Justo, S., 29 march 2004; Geometric problems in cartographic networks, Utrecht University, Utrecht, 134 pp., project: Automated Visualization of Traffic and Transportation, 3e geldstroom.

Haverkort, H., 17 may 2004; Results on geometric networks and data structures, Utrecht University, Utrecht, 182 pp., project: MOCCAM, 2e geldstroom.

Contribution to Books
Kreveld, M.J. van, Oostrum, R.W. van, Bajaj, C., Pascucci, V., & Schikore, D. (2004). Contour Trees and Small Seed Sets for Isosurface Generation. In Sanjay Rana (Ed.), Topological Data Structures for Surfaces (pp. 71-85). Wiley.

Kreveld, M.J. van (2004). Geographic Information Systems. In J.E..Goodm en J. O'Rourke (Ed.), Handbook of Discrete and Computational Geometry (pp. 1293-1314). Boca Raton: Chapman & Hall/CRC.

Papers in international journals
Ahn, H.-K., Cheng, S.-W., Cheong, O., Golin, M., & Oostrum, R.W. van (2004). Competitive Facility Location: the Voronoi Game. Theoretical Computer Science, 310, 357-372.

Cheng, S.-W., Cheong, O., Everett, H., & Oostrum, R.W. van (2004). Hierarchical Decompositions and Circular Ray Shooting in Simple Polygons. Discrete and Computational Geometry, 32, 401-415.

Dijk, S.F. van, Thierens, D., & Berg, M.T. de (2004). On the design and analysis of competent selecto-recombinative GAs. Evolutionary computation, 12, 243-267.

Kreveld, M.J. van, & Reinbacher, I. (2004). Good NEWS: Partitioning a simple polygon by compass directions. International journal of computational geometry & applications, 14, 233-259.

Oostrum, R.W. van, & Veltkamp, R.C. (2004). Parametric Search Made Practical. Computational Geometry: Theory and Applications, 28, 75-88.

Overmars, M.H. (2004). Learning object-oriented design by creating games. IEEE, 23(5), 11-13.

Overmars, M.H. (2004). Motion planning in virtual environments and games. ERCIM news, 57, 33-34.

Overmars, M.H. (2004). Teaching computer science through game design. IEEE, 37(4), 81-83.

Pluim, J.P.W., Maintz, J.B.A., & Viergever, M.A. (2004). f-information measures in medical image registration. IEEE Transactions on Medical Imaging, 23, 1506-1518.

Veltkamp, R.C. (2004). Shape Algorithmics. Algorithmica, 38, 1-4.

Wiering, F., Typke, R., & Veltkamp, R.C. (2004). Transportation Distances in Music Notation Retrieval. Computing in Musicology, 13, 113-128.

Contributions to international conference proceedings

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Experimental software
Geraerts, R.; SAMPLE, System for Advanced Motion Planning Experiments.
2002-2004, C++, Windows.
This is software to experimentally compare various motion planning techniques on different scenes. The software is still developed further.

Nieuwenhuisen, D.; CALISTO.
2002-2004, C++, Windows.
This is a library for visualization and collision checking in 3-dimensional scenes.
The software is still developed further.

2.3.6 Contribution of TUD-LR-frs

Reconstruction of building models from aerial photographs and 2D GIS databases
The research on the interpretation of the aerial images focuses on knowledge-based 3D reconstruction of buildings. Three-dimensional building models are increasingly required for urban planning, tourism, telecommunication, etc. Since manual 3D processing of aerial images is very time consuming, speeding up the reconstruction by automatic procedures has become a necessity.
Our approach relies on combining pairs of stereo images with 2D GIS (Geographic Information System) data and domain knowledge. The domain knowledge includes a building library describing primitive building models (flat roof, gable roof, and hip roof building) since most buildings can be described as an aggregation of these building primitives.
In 2002, the performance of the building reconstruction system was evaluated. About 75% of buildings in a suburban environment were successfully reconstructed. This result implies that a significant cost reduction is possible in the production of 3D city models that are currently based on manual measurements. The results were documented in a PhD thesis that was approved by the supervisor in December 2002.

Reconstruction of industrial sites from terrestrial laser scanner data and photographs (C)
We present a method for 3D reconstruction of industrial sites using a combination of images and point clouds with a motivation of achieving higher levels of automation, precision, and reliability. Recent advances in 3D scanning technologies have made possible rapid and cost-effective acquisition of dense point clouds for 3D reconstructions. As the point clouds provide explicit 3D information they have a much higher potential for the automation of reconstruction.

The modelling pipeline in our algorithm starts from point clouds as the main data source for automation. First of all we segment the point cloud using surface smoothness and detect simple objects like planes and cylinders using Hough Transform. This is followed by fitting of CSG objects to a combination of segments. The fitted CAD models are used as registration targets for adding more scans to the project. Additionally, by fitting the projected edges to image gradients we register images to point clouds. (STAR project)

Reconstruction of natural sites from terrestrial laser scanner data and photographs
The purpose of the research is 3D modelling and reconstruction of (real world) trees on the basis of terrestrial laser scans. To identify the structure of a tree in terms of stem and branches, an algorithm has been designed in 3D voxel space, based on a selection of basic and advanced 2D raster (image) processing algorithms, transferred into the 3D domain. The selection includes filtering, mathematical morphology, skeletonization, connected component labelling and shortest route computation. (Natscan project)

Traffic monitoring and modelling using helicopter video sequences
Traffic congestion is an important problem in modern society. Better understanding of its causes is needed to be able to more effectively reduce its effects. Congestion appears under a variety of circumstances. Beside the size and amount of roads and the number of vehicles on those roads, the occurrence of traffic congestion is highly dependent upon the behaviour of the individual vehicle drivers. Important factors are reaction speeds, the gap-acceptance and the lane-changing behaviour of the drivers. Due to the lack of detailed data on driver behaviour, contemporary traffic flow theories and models cannot be rigorously calibrated and validated, although there are very strong indications that these models are not able to correctly capture complex driving dynamics during congested or near-congested traffic flow.

External Projects

STAR
2002-2004, EU IST programme, k€ 224
This project aims to bring augmented reality to the factory floor for training and maintenance purposes. Our contribution to this project is research on the efficient acquisition of 3D models of industrial environments from a combination of laser scanner data and photographs.

Natscan
Nov. 2003 – Jan. 2004, University of Freiburg, k€ 25
Development of algorithms for separation of tree crowns from terrestrial laser scan data.

Tracing Congestion Dynamics
STW/CITG, Dec. 2004 – Dec. 2008, k€ 178,4
The goal of the proposed research project is to develop a traffic data collection system based on image sequences taken from a helicopter as well as to use this traffic data to calibrate and improve driver behaviour models.

Papers in international journals
Experimental comparison of filter algorithms for bare-Earth extraction from airborne laser scanning point clouds; George Sithole, George Vosselman
ISPRS Journal of Photogrammetry & Remote Sensing 59 1-2 (August 2004) 85 –101
Theme Issue: Advanced Techniques for Analysis of Geo-spatial Data Edited by: E.P. Baltsavias

Reconstruction of 3D building models from aerial images and maps
Ildiko Suveg, George Vosselman ISPRS Journal of Photogrammetry and Remote Sensing 58, 3-4 (January 2004) 202-224 Special issue: Integration of Geodata and Imagery for Automated Refinement and Update of Spatial Databases, Edited by C. Heipke, K. Pakzad, F. Willricht and A. Peledl
ISSN 0924-2716

Using Quadtree segmentation to support error modelling in categorical raster data
Bruin, Sytze de, Wit, Allarde de, Oort, Pepijn van, Gorte, Ben
International Journal of Geographical Information Science, Vol. 18, no. 2, March 2004, pp 151 - 168
ISSN 1365-8816, Uitg. Taylor & Francis Ltd., London, UK

3D-Reconstruction of Stems for Taper, Sweep and Lean Assessment Based on Laser Scanning of Standing Trees
M. Thies, N. Pfeifer, D. Winterhalder, B. Gorte Scandinavian Journal of Forest Research 2004
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Chapter 6: Basic Computer vision techniques
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G. Vosselman, M. Sester, H. Mayer
Published by the American Society of Photogrammetry and Remote Sensing (ASPRS), Bethesda, Maryland, USA, Editor: Mc. Glone ISBN 1-57083-071-1, pp 445 – 504

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Automatic reconstruction of single trees from terrestrial laser scanner data
Norbert Pfeifer, Ben Gorte, Daniel Winterhalder Conference proceedings ISPRS conference in Istanbul, Turkey, 12 – 23 July 2004 International Archives of Photogrammetry and Remote Sensing, Vol. XXXV, B5, 114-119
Editor: Prof. Orhan Altan ISSN 1682-1750

Recognising structure in laser scanner point clouds G. Vosselman, B.G.H. Gorte, G. Sithole, T. Rabbani Conference Proceedings of the International Conference NATSCAN "Laser-Scanners for Fores and Landscpae Assessment – Instruments, Processing Methods and Applications, ISPRS working group VIII/2 3-6 October, Freiburg im Breisgau, Germany Editors M. Thies, B. Koch, H. Spiecker, H. Weinacker ISSN 1682-1750

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Rabbani, T., Van den Heuvel, F. Conference proceedings ISPRS conference in Istanbul, Turkey, 12 – 23 July 2004 International Archives of Photogrammetry and Remote Sensing, Vol. XXXV, B5, 7-12
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Change detection for updating medium scale maps using laser altimetry
G. Vosselman, B.G.H. Gorte, G. Sithole Conference proceedings ISPRS conference in Istanbul, Turkey, 12 – 23 July 2004 International Archives of Photogrammetry and Remote Sensing, Vol. XXXV, B3, 207-212 Editor: Prof. Orhan Altan ISSN 1682-1750

Adjustment of Airborne Laser Altimetry Strips Sagi Filin, George Vosselman
Conference proceedings ISPRS conference in Istanbul, Turkey, 12 – 23 July 2004 International Archives of Photogrammetry and Remote Sensing, Vol. XXXV, B3, 285-289 Editor: Prof. Orhan Altan
ISSN 1682-1750

Structuring laser-scanned trees using 3D mathematical morphology Ben Gorte, Norbert Pfeifer
Conference proceedings ISPRS conference in Istanbul, Turkey, 12 – 23 July 2004 International Archives of Photogrammetry and Remote Sensing, Vol. XXXV, B5, 929-933 Editor: Prof. Orhan Altan
ISSN 1682-1750

Medphos: a new photogrammetric system for medical measurement Malian, A., A. Azizi, F.A. van den Heuvel
Conference proceedings ISPRS conference in Istanbul, Turkey, 12 – 23 July 2004 International Archives of Photogrammetry and Remote Sensing, Vol. XXXV, B5, 311-316
Editor: Prof. Orhan Altan ISSN 1682-1750

Methods For Fitting CSG Models to Point Clouds and Their Comparison. Rabbani, T., Heuvel, F.A. van den
The 7th IASTED International Conference on Computer Graphics and Imaging, pp. 279 – 284, August 17-19, 2004, Kauai, Hawaii, USA Editior: M.H. Hamza ISBN 088986-426-6
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Publisher: Institute for Forest Growth, Dep. of Remote Sensing and Landscape Information Systems, University of Freiburg, Tennenbacher Str. 4, D-79106 Freiburg, Germany

Reconstruction of Laser-Scanned Trees using Filter Operations in the 3D-Raster Domain
Gorte, B., Winterhalder, D.Conference Proceedings of the ISPRS working group VIII/2, in Freiburg, Germany October, 3-6 2004 International Archives of Photogrammetry, remote sensing and spatial information sciences, volume XXXVI, part 8/W2, blz. 39 – 44 Editors: M.Thies, B. Koch, H. Spiecker, H. Weinacker ISSN 1682-1750 Publisher: Institute for Forest Growth, Dep. of Remote Sensing and Landscape Information Systems, University of Freiburg, Tennenbacher Str. 4, D-79106 Freiburg, Germany

Modelling of Tree Cross Sections from Terrestrial Laser-Scanning Data with Free-Form Curves
Pfeifer, N., Winterhalder, D. Conference Proceedings of the ISPRS working group VIII/2, in Freiburg, Germany October, 3-6 2004 International Archives of Photogrammetry, remote sensing and spatial information sciences, volume XXXVI, part 8/W2, blz. 76-81 Editors: M.Thies, B. Koch, H. Spiecker, H. Weinacker ISSN 1682-1750 Publisher: Institute for Forest Growth, Dep. of Remote Sensing and Landscape Information Systems, University of Freiburg, Tennenbacher Str. 4, D-79106 Freiburg, Germany

Influences of Vegetation on Laser Altimetry – Analysis and Correction Approaches Pfeifer, N., Gorte, B., Elberink, S.O. Conference Proceedings of the ISPRS working group VIII/2, in Freiburg, Germany October, 3-6 2004 International Archives of Photogrammetry, remote sensing and spatial information sciences, volume XXXVI, part 8/W2, blz. 283-287 Editors: M.Thies, B. Koch, H. Spiecker, H. Weinacker ISSN 1682-1750 Publisher: Institute for Forest Growth, Dep. of Remote Sensing and Landscape Information Systems, University of Freiburg, Tennenbacher Str. 4, D-79106 Freiburg, Germany

Experimental Software
Gorte, B.G.H., Pfeifer, N.; Natscan Nov. 2003 – Jan. 2004; C, C++, awk; Linux 3D Reconstruction of Trees from Terrestrial Laser Point Clouds

2.3.7 Contribution of TUD-mm-ict

Pattern Recognition
A typical human ability is the recognition of patterns in the world around us. It constitutes the basis of each natural science: the laws of physics, the description of species in biology or the analysis of human behavior; they are all based on seeing patterns. Also in daily life pattern recognition plays an import role: reading texts, identifying people, retrieving objects or finding the way in a city. Once patterns are established, learned from some examples or from a teacher, we are able to classify new objects or phenomena into a class of known patterns.
The study of automatic pattern recognition has two sides, one purely fundamentally scientific and one applied. By trying to build a system with pattern recognition capabilities more will become clear about the human ability to learn, recognize and classify. At the same time, systems are constructed that may be applied in various areas of science as well as in many places in society to assist human decision making.
In our research, both aspects are treated. There are two projects focusing on the foundations of pattern recognition: representation and generalization, in which new ways of describing objects and learning from examples are studied. In addition, there are several applied projects focusing on the recognition of spectra. Like images and time signals, spectra constitute a pattern domain with an unsolved problem: how to represent patterns in their entirety, when only a set of samples (pixels or bins) is available.
The research makes clear that automatic pattern recognition systems may successfully be applied in several places but that an understanding of the human ability of recognizing patterns is still in its early days.

Bioinformatics
Knowledge discovery and machine learning play an increasingly important role in biomolecular science, now that micro-array technology reaches maturity and genomes of different organisms are being published with increasing frequency. As a consequence, massive amounts of data are being (and will be) produced that contain important facts about the "Book of Life" of living organisms. These measurements have opened new avenues to discover novel functionalities within cells (e.g. function of genes and gene pathways).
A systems approach: Although molecular biologists are extremely enthusiastic about these developments, they are confronted with the availability of enormous amounts of data about a very complex (many genes, hence many parameters) and heterogeneous (many elements such as genes, proteins metabolites etc.) system. Traditional ways to study biological phenomena in a gene-by-gene approach (reductionism) are no longer adequate. Instead, the cell should be studied as a network of complex interactions. This holistic view, coupled with the integration of already available knowledge, defines the core of our approach to biomolecular knowledge discovery.

External Projects

ALL-AGE

("Analysis of gene expression profiles of children with acute lymphomatic leukaemia by bioinformatics"), 2004-2008, EUR, 280 k€. The ALL-AGE project is a co-operation with the Department of Immunology of the Erasmus University Medical Center in Rotterdam. Jointly, we apply, evaluate and develop techniques for the analysis of microarray data and other molecular measurements. Applications include: basis molecular biology, molecular diagnosis and gene therapy.

Improving endoscopic detection of lung cancer using autofluorescence spectroscopy analyzed by a neural network

2001-2005, STW, 100k€. This project, a cooperation with the Daniel den Hoed Hospital in Rotterdam, in which we participated by studying the data-analysis. We found that by combining a set of spectral classifiers, each based on a different excitation wavelength a significant improvement of the recognition performance may be reached. However, the size of the dataset collected over the years is still too small for an advanced development of classifiers.

The analysis of spatial structures in hyperspectral images

2003-2007, STW, 470 k€. The construction of an initial toolbox for hyperspectral image recognition was finalized. We are now focusing on applications in various areas like agriculture, mining, paper production and infra-red imaging for microscopic particle analysis.

One-Class Classifiers

2001-2005, NWO 250 k€. In cooperation with some other projects like the characterization of interstitial lung disease and mineral spectral analysis a set of advanced applications has been studied, resulting in a better understanding of performance estimation of one-class classifiers. In addition we started the development of techniques for active and semi-supervised learning.

Proximity-based representations for pattern learning

2004-2008, NWO, 370 k€ The essential difference between proximity representations and kernel approached has been studied and resulted in understanding of the possible advantage of non-Euclidean object representations. Further the construction of augmented representation spaces and the application for invariant representations has been studied.

Computer-aided detection and characterization of interstitial lung disease

2004-2008, STW, 200 k€ This project started as a cooperation with the Image Science Institute in Utrecht. We intend to make use of the one-class classifier technique and will study the use of spatial data-connectivity for improved recognition.

Mineral spectral analysis

2003-2005, DeBeers, 90 k€ This project aims at a robust spectral recognition of multi-class minerals for changing class distributions. Extensive experiments have been performed in which many classification techniques have been evaluated. Unknown priors, novelty detection and changing class distributions are the challenges for this real world application.

ITB, "Innovative therapies for bone recovery"

2004-2007, Senter/Organon, 290 k€ Due to the continuous increase of people's life expectancy, there is an urgent need for effective therapies for the recovery and prevention of bone loss due to osteoporosis. In this project, the newest developments in genomics are integrated with the latest techniques in pathway discovery and pattern recognition. This will lead to a faster and novel approach to discover and functionally characterize genes involved in bone development.

REGNET

"Unravelling the hierarchy of transcriptional regulation in chemostat cultures of Saccharomyces cerevisiae: a bioinformatics approach", 2004-2008, NGI/Kluyver Centre for Genomics of Industrial Fermentation, 230 k€. The overall aim of this project is to investigate genome-wide regulatory circuitry (transcription and signal transduction), by concurrently developing and performing bioinformatic analyses of various genome-scale data sets: expression microarray data; chromosome localization microarray data; protein-protein interaction data; high throughout phenotype data; sequence data as well as data currently stored in literature and WWW databases.

YEAST

"Unravelling regulatory circuitry by combinatorial analysis of genome-scale data", 2002-2004, NWO/BMI/UMCU, 130 k€.

The overall aim of this project is to investigate genome-wide regulatory circuitry (transcription and signal transduction), by concurrently developing and performing bioinformatic analyses of various genome-scale data sets: expression microarray data; chromosome localization microarray data; protein-protein interaction data; high throughout phenotype data; sequence data as well as data currently stored in literature and WWW databases.

CANCER
"Molecular Classification of Cancer", 2002-2007, NKI, 300 k€.
This project is conducted in close collaboration with the Dutch Cancer Institute (NKI). Central to the program lies the prediction of prognosis and optimal treatment choice for cancer patients, which is dependent on correct disease classification. Our goal within this program is to perform computational analysis of all information sources to construct a taxonomy of breast cancer (sub-)types, such that the classes correlate strongly with survival and response to radio- or chemotherapy.

Books
Heijden, F. van der, Duin, R.P.W., Ridder, D. de, Tax, D.M.J.; Classification, parameter estimation and state estimation: An engineering approach using Matlab.
UK, 2004, 423 pp., John Wiley & Sons Ltd., ISBN 0-470-09013

Contribution to books
Jain, A.K., Duin, R.P.W.; Pattern Recognition.
Gregory, R.L. (ed.); The Oxford Companion to the Mind.
Oxford, 2004, 880 pp., Oxford University Press, ISBN 0-19-866224-6, pp. 698-703, 2nd edition

Papers in international journals
Lai, C., Tax, D.M.J., Duin, R.P.W., Pekalska, E., Paclik, P.; A study on combining image representations for image classification and retrieval.
International Journal of Pattern Recognition and Artificial Intelligence, ISSN 0218-0014, volume 18, 2004, number 5, pp. 867-890.

Loog, M., Duin, R.P.W.; Linear dimensionality reduction via a heteroscedastic extension of LDA: The Chernoff criterion.
IEEE Transactions on Pattern Analysis and Machine Intelligence, ISSN 0162 8828, volume 26, 2004, number 6, pp. 732-739.

Loog, M., Duin, R.P.W., Viergever, M.A.; The MDF discrimination measure: Fisher in disguise.
Neural Networks, ISSN 0893 6080, volume 17, 2004, number 4, pp. 563-566.

Musa, M.E.M., Ridder, D. de, Duin, R.P.W., Volkan, A.; Almost autonomous training of mixtures of principal component analyzers.
Pattern Recognition Letters, ISSN 0167-8655, volume 25, 2004, number 9, pp. 1085-1095.

Tax, D.M.J., Duin, R.P.W.; Support vector data description.
Machine Learning, ISSN 0885-6125, volume 54, 2004, number 1, pp. 45-66.

Veld, D.C.G. de, Skurichina, M., Witjes, M.J.H., Duin, R.P.W., Sterenborg, H.J.C.M., Roodenburg, J.L.N.; Clinical study for classification of benign, dysplastics and malignant oral lesions using autofluorescence spectroscopy.
Journal of Biomedical Optics, ISSN 1083 3668, volume 9, 2004, number 5, pp. 940-950.

Contributions to international conference proceedings
Duin, R.P.W., Pekalska, E., Paclik, P., Tax, D.M.J.; The dissimilarity respresentation, a basis for a domain-based pattern recognition?
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Highlight
Foundation and Applications of the Dissimilarity Representation forPattern Recognition

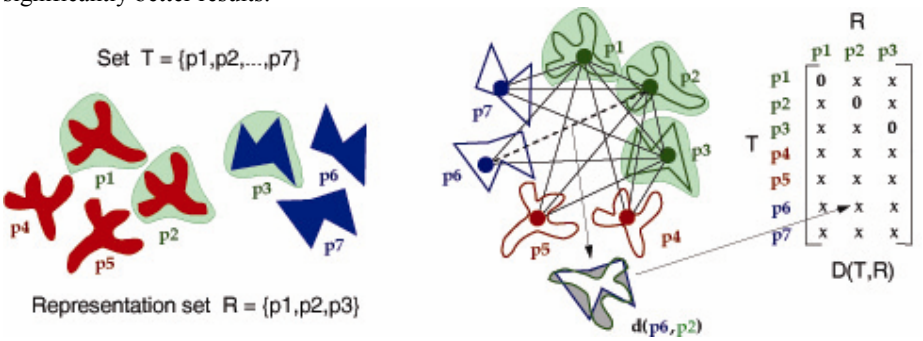
Robert P.W. Duin, Elzbieta Pekalska, Pavel Paclik

Learning patterns in observations is traditionally based on a feature representation. A statistical analysis of a set of examples given by features is a powerful approach if an appropriate set of features is determined by using expert knowledge. If not, pattern classes cannot be separated well.

Dissimilarity representations offer an alternative approach to learning, in which class overlap may be reduced and expert knowledge can be used differently. In this case, objects are not described independently from each other by features, but directly compared on the basis of a dissimilarity measure supplied by an expert.

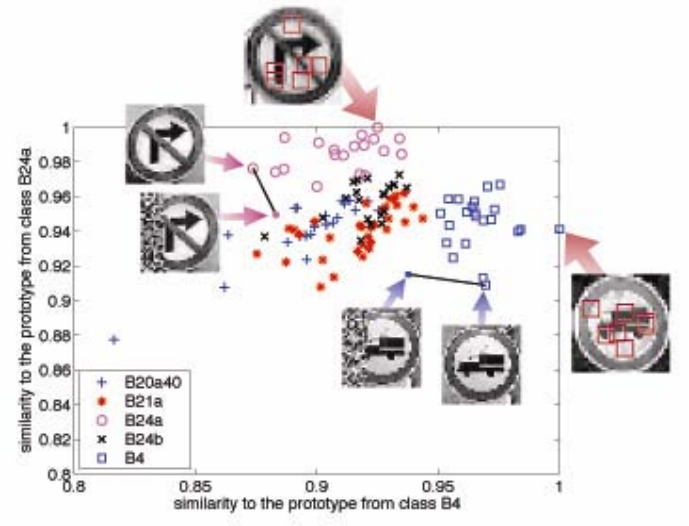
Two PhD research projects have been recently finalised, which studied the foundation and a set of applications. Elzbieta Pekalska [2] investigated the possibilities of a proper mathematical description, starting from a pre-topological neighbourhood description. She verified her finding by a large set of experiments based on artificial and real world datasets. Pavel Paclik [1] concentrated on applications in the areas of spectral recognition and road sign classification and extended the dissimilarity approach with a trainable similarity representation.

The dissimilarity representation (see figure 1)is related to the kernel used in support vector machines, however, it is more general, as the kernel becomes a specific similarity representation in our approach. Any (indefinite) dissimilarity measures can be used and combined with a large set of classifiers. It appears that many distance measures applied to the pattern recognition problems are indefinite (or non-Euclidean). Attempts to make suitable corrections often deteriorate the performance. The usage of a dissimilarity space or a pseudo-Euclidean (or Krein) space overcome the traditional restrictions of the nearest neighbour approaches and yield significantly better results.



Procedures for the training of classifiers, cluster analysis, determining invariances, dimension reduction and prototype selection had to be verified and sometimes redefined for the use of dissimilarities. A number of applications has been studied for which feature definition appeared to be difficult or less effective. Especially in the cases in which measurement samples like image pixels or spectral wavelengths are used instead of features, dissimilarity-based methods appeared to be profitable.

In cooperation with other institutes, we studied applications such as autofluorescence spectra, mineral spectra, hyperspectral images, flow-cytometer histograms, hand-written text and road signs. Various dissimilarity measures have been used. Examples are normalized cross-correlation (Spectral Angle Mapper), Kolmogorov distance, divergence measures, distances based on derivatives of spectra, or transformation measures such as the Earth Mover's distance.
In the road sign application. a trainable similarity procedure appeared to be beneficial as it allows for the recognition of partially observable objects. (see figure 2)



In the future we hope to extend our understanding of various (non-Euclidean) spaces that play a role in the handling of indefinite measures. We especially hope to gain insight in the reasons why in the recognition of real world objects such measures seem sometimes to be crucial.

[1] P. Paclik, Building Road Sign Classifiers, Ph.D. thesis Czech Technical University (partially based on research at Delft University of technology), 2004, 1-127.

[2] E. Pekalska, Dissimilarity representations in pattern recognition, Ph.D. thesis Delft University of Technology, ASCI Dissertation Series, 109, Delft, 2005, January 17, 1-344.

2.3.8 Contribution of TUD-EWI-mm-cgcc

Geometric modeling
Research on geometric modeling is directed towards feature modeling, which allows modeling of 3D objects with features, i.e. parametric shapes with a functional meaning. The most important research issues are feature validity maintenance, constraint solving, multiple-view feature modeling and conversion, freeform features, and collaborative design.

Scientific visualisation
Research on visualisation is focused on the development of algorithms and data structures for extracting information from large scientific and engineering data sets, and visualizing this information with computer graphics and virtual reality techniques. Main application areas are flow visualization and medical visualization.

Virtual reality
Interaction techniques for exploring and manipulating data in 3D virtual environments, and techniques for collaborative visualization. Important applications are in atmospheric research and molecular biophysics.

External projects
Validity maintenance for freeform feature modelling
NWO-EW, 2000-2004, 1 OIO (Ir. E. van den Berg) Aim: to develop a feature validation approach for modelling objects with freeform surfaces. A useful set of freeform features and methods for defining such features and their properties with constraints, and for maintaining the latter during the modelling process, will be developed.

Direct Numerical Simulation of Oil/Water Mixtures Using Front Capturing Techniques
NWO-EW Computationjal Science program, 2001-2005, 1 OIO, Ir. B. Vrolijk
Joint project with the Fluid Dynamics group (Mechanical Engineering), and the Numerical mathematics group (EWI). Goal of the project is the development of visualization techniques for very large 3D time-dependent flow datasets; extension of feature extraction and time tracking techniques to visualize the shape of phase fronts in a multi-fluid flow, and its development in time; visualization for inspection of intermediary results of a running simulation.

Semantics of families of objects
NWO-EW, 2003-2007, 1 OIO, ir. R. van der Meijden Techniques for defining and classifying objects as part of a family of parametric objects. These methods will be based on semantic feature modelling, in which shapes with well-defined semantics and constraints are used to model objects.

Visualization of Cumulus Clouds in Virtual Reality

NWO-EW, 2004-2009, 1 OIO, E.J. Griffith MSc. Joint project with the Physics Department on visualiszation of Large-Eddy Simulations (LES) for atmospheric research to help resolve important research questions on cloud dynamics, cloud mixing phenomena, and precipitation. Our contribution is data handling and visualization for very large data sets.

Architectures for scientific and medical visualization
Bsik VL-e (Virtual Laboratory for e-science), 2004 - 2007, postdoc, C.P. Botha MSc. The aim of this project is to extend DeVIDE visualization architecture with more general facilities for grid-based computing (resource and data management) and intelligent techniques for semi-automatic network configuration and prototyping for component development.

Techniques for Collaborative Visualization in Virtual Environments
Bsik VL-e, 2004-2007, post-doc, dr. M. Koutek. Techniques for distributed and collaborative visualization in virtual environments, and 3D interaction; design of software architectires for multi-platform collaborative VR support.

Interaction techniques for virtual environments
Bsik BRICKS-MSV2, 2004-2008, 1 OIO, ir. G. de Haan. Research on generic Virtual Reality interaction techniques for navigation, object manipulation, and exploration, to make 3D interaction more comfortable, fast, and effective. Interaction metaphors such as pseudo-haptic visual force feedback are investigated

Surface and volume geometry processing for lesion detection and segmentation in virtual colonoscopy
Philips Medical Systems, 2004-2008, 1 AIO, Lingxiao Zhao MSc.Research on the determination and use of geometric properties of the inner surface of the human colon for automatic pre-detection of colonic polyps.

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A statistical shape model without using landmarks. In J Kittler, M Petrou & M Nixon (Eds.), *Proceedings 17th International Conference on Pattern Recognition Vol. 3. Proceedings of the IAPR international conference on pattern recognition* (pp. 714-717). Los Alamitos: IEEE Computer Society Press.

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Wang, C, Vergeest, JSM, Stappers, PJ, & Bronsvoort, WF. Freeform feature retrieval by signal processing. In S.n. (Ed.), *DETC2004: proceedings of the ASME 2004 design engineering technical conferences and computers and information in engineering conference* (pp. 1-9). New York: ASME.

Experimental software
C.P. Botha, DeVIDE = Delft Visualisation and Image Processing Development Environment
Developed from 2002-present, language: Python / C++, OS: Linux, Windows
DeVIDE is a generic software platform created in order to prototype, test and deploy new Visualization and image processing algorithms and ideas, mainly intended for medical applications, but also usable for other applications. It provides a highly interactive and flexible development and test environment, and it features integrated functionality of the VTK and ITK toolkits for visualisation and image processing.

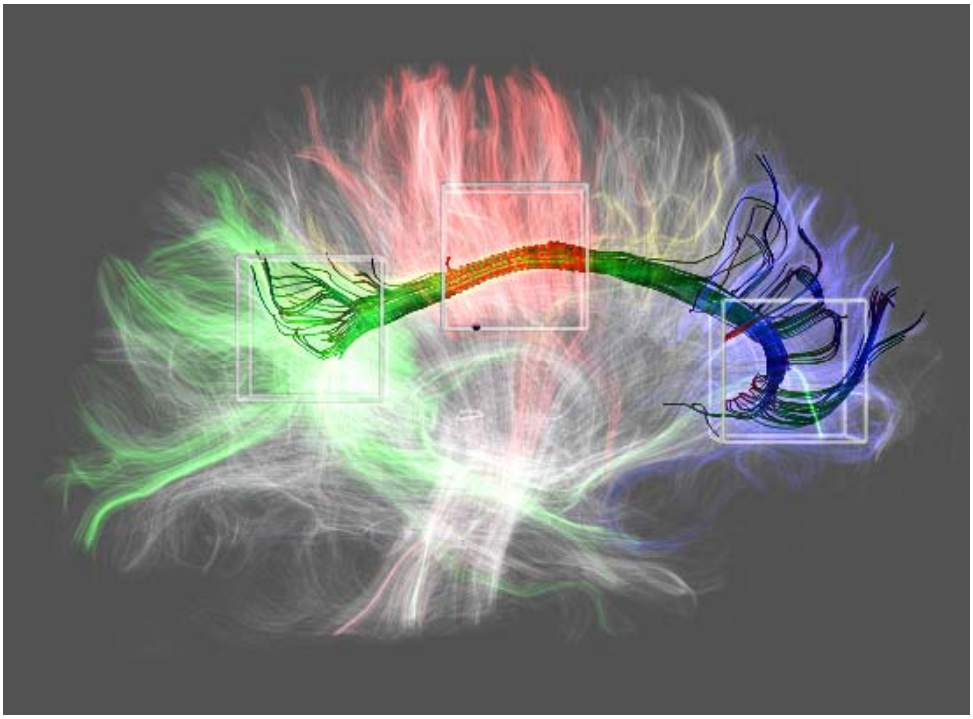
Cooperation within ASCI
On medical imaging there is a cooperation with TUD-TNW-tn-pi (Vossepoel)
See publications of Bruin, P. de, Post, F.H. and Vossepoel, A.M.

Highlight

Interactive Fiber Bundle Selection in Diffusion Tensor Imaging of the Human Brain
Jorik Blaas, Charl Botha, Frits Post
Delft University of Technology
Computer Graphics / Visualization Group.

Diffusion Tensor Imaging (DTI) is an MRI-based technique for visualization of the fibrous structure of the living human brain. The water diffuses most rapidly along the axonal fibers, and this can be used to visualize their directional structure. By tracking the main direction of diffusion throughout the brain, more than 50,000 brain fiber tracks are generated. From these tracks, anatomically important fiber bundles can be selected. This image shows the selection of the Cingulum using our DTII visualization system. The medical specialist interactively moves around three boxes, and the system determines which fibers intersect with each of the three boxes. The fibers are coloured depending on the boxes they intersect with. Fiber bundles selected in this way can be used for further processing and investigation. The three-box selection technique appears to be easy to use and highly reproducible between different operators.

2.3.9 Contribution of UvA- FdNWI-isis

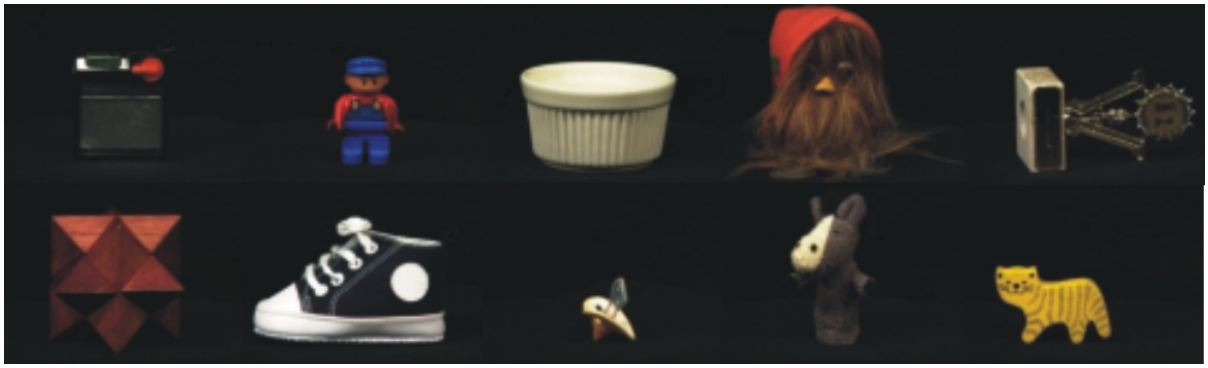


Colour in computer vision
Colour is an important cue in image analysis. Image processing of colour images requires special attention as well as new possibilities to see detail where grey value methods cannot.

In previous years, local color, geometric and spatial frequency invariants were developed at ISIS. These local features aim at the robust measurement of the color, shape and texture of an object, under the most common accidental viewing conditions. These accidental conditions can be largely characterized by direction of view, the incident light, the color of the light and the other accidents as the presence of a foreground or background. An invariant representation of the object implies that the various conditions under which the same view of the object may be perceived do not have to be learned. To test the discriminative power of color, geometric and spatial frequency invariants, the ALOI collection was recorded, containing color images of 1000 real-world objects recorded under variuous illumination directions (Figure 2), and different illumination colors (Figure 3).

The invariants were shown to increase discriminative power for object recognition when compared to the visual measurements of which the invariants were composed. More specifically, the illumination intensity invariant W and the color constant shadow and shading invariant N proof to be discriminative when recognizing objects from a data set containing much photometric variation. However, the invariants are shown to be only marginally color constant. The invariant sets outperform SIFT-features extracted from distinctive keypoints when the object is recorded under various illumination directions or when the object is rotated in 3 dimensions. Combining local invariant features and the incorporation of color are known to be nontrivial problems in computer vision, for which we have provided solutions.

From the general theory, methods are derived for industrial colour vision, analysis of colour in documents, colour in microscopy, general images as appearing on the worldwide web. The topic on colour has led to many publications in journals (*International Journal on Computer Vision and IEEE Trans. on Pattern Analysis and Machine Intelligence*). We aim at expanding the analysis to take on the same invariant representation of texture next, as well as the semantic meaning of colour.



Example objects from the ALOI dataset

Example object from ALOI under different illumination directions

Theory of computer vision

Mathematical morphology is an important paradigm for low-level image processing. Our group has a long tradition on the topic at a theoretical as well as a practical level, with applications in industrial and machine vision. Research has been carried out on bringing two basic theories of low-level vision (i.e. linear theory and morphological theory) on par. To that end, the slope transform has been introduced as the morphological equivalent of the Fourier transform. Morphological scale-space has been founded on the same principles as linear scale-space. For practical mathematical morphology, we aim at developing efficient algorithms. This implies efficient decomposition schemes for structuring elements as well as the design of C++ patterns for morphological image processing.

One of the most fundamental tasks in computer vision is *edge and line detection* in images. The difficulty of edge and line detection is emphasized when the structures run close together or cross each other, as is the case in engineering drawings or two-dimensional projections of complex (3D) scenes. In these cases, one would often like to have a detection method which takes advantage of the anisotropic nature of lines and edges. We have shown the decomposition of the anisotropic Gaussian filter method in two Gaussian line filters in non orthogonal directions. The anisotropic Gaussian filtering method allows fast calculation of edge and ridge maps, with high spatial and angular accuracy.

Segmentation and Learning

Image segmentation *is the task of delineating the image of an object from the real world in the digital* data array. It is one of the fundamental difficulties of computer vision, easily surpassed by man's superior capabilities. The difficulty resides in the fact that even man cannot rarely give a formal pictorial description why a boundary is positioned at a certain location and that is what a computer needs to perform the job. We contribute a variety of solutions.

The *necklace* approach offers a solution to inhomogeneous boundaries as seen in three-dimensional images of the spine. A boundary will be inhomogeneous when there are neighboring, touching or overlapping objects, or when the boundary is out of sight due to noise or occlusion. In our example, individual vertebrae are delineated using an a priori geometrical model to be deformed for each vertebra.

A string is a variational deformable model that is learned from a collection of example objects rather than built from a priori analytical or geometrical knowledge. As opposed to existing approaches, an object boundary is represented by a one-dimensional multivariate curve in functional space, a feature function, rather than by a point in vector space. Strings have been compared with active shape models on 145 vertebra images, showing that strings produce better results when initialized close to the target boundary, and comparable results otherwise.

The watersnake approach has established a connection between the well-known watershed segmentation from mathematical morphology and energy-based segmentation methods. While the original watershed algorithm does

not allow incorporation of a priori information regarding object shape, we succeeded doing so by formalizing and representing the watershed segmentation as a minimization problem. In particular the imposing of contour smoothness on the segmentation results, solves the problem with noisy boundaries that are often encountered with the original watershed.

The topic on *image segmentation* have lead to two articles in IEEE trans. on Pattern Analysis and Machine Intelligence (IEEE PAMI). This is the most prominent journal in the area of pattern recognition and is among the top three journals in computer science in the world.

Image processing as a design process
The research topic of developing image processing tools as a design process was concluded as a separate research topic. One sub-topic was the design of methods for evaluating the performance in terms of robustness of image processing methods. Formalization of the design of image processing tools results in the use of self-reliant detectors each carefully documented on its operational domain describing the complete picture set for which the detector will operate well. The method has been applied to engineering drawings as well as seeds. The topic on design process has lead to a paper in IEEE trans. on PAMI.

External Projects
Multimodal Person Identification in Digital Video
2000-2003, TNO, 200 Keuro, Uva-Science-ISIS. The project considers the identification of persons.

Multimodal Classification of Video Documents
2001-2004, TNO, 200 Keuro, Uva-Science-ISIS. Video documents are being analyzed.

D: ImIK
2002-2005, IOP, 400 Keuro, Uva-Science-ISIS and VU. The project considers the interactive exploration of multimedia information and knowledge.

ImSeq, IOP
1999-2004, 200 Keuro, Uva-Science-ISIS. This project considers the quantification of human and animal movement in color image sequences.

A computational theory for visual cognition (NWO Veni)
2003-2007, NWO, Uva-Science-ISIS, 200 KEuro. The project aims at developing a computational theory of vision based on invariant representations.

Image retrieval
2001-2005, IOP and Markgraaf, 200 KEuro, UvA-Science-ISIS. The project aims at analyzing logos, signs to classify them on perceptual similarity.

Tracking sport video
2002-2006, IOP and Philips CFT, 200 KEuro, UvA-Science-ISIS. The project aims at tracking of subjects in sport videos.

MultimediaN
2004-2008, BSIK, 35 MEuro, UvA-Science-ISIS, CWI, TUD-Mediamatica, UT-CTIT-CS, VU-CS, UU-CS, TNO, Nederlands Forensisch Instituut, Telematica Instituut, IBM, V2_, Philips, Ilse Media, LogicaCMG, Waag Society, DBNL, eMAXX, NOC*NSF, SPSS, Compano, Beeld en Geluid, FabChannel, ZiuZ, DBNL, de Politie Amstellanden, Vereniging Digitaal Erfgoed, Roessingh. The project aims at various forms of multi-media, multi-modal analysis, interaction, system design and knowledge engineering for several scientific and applied science goals.

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IEEE Transactions on Pattern Analysis and Machine Intelligence, 26(12), 1553-1567, 2004.

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Experimental software

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http://staff.science.uva.nl/~mliempt/isis/downloads.html

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2.3.10 Contribution of UL-LUMC-lkeb

Processing, Interpretation and Visualization of Medical Images

The main goal of the Division of Image Processing is the research, implementation and validation of image processing approaches, which allow the objective and reproducible assessment of objects in medical images. LKEB activities belong to one of the seven main research fields of the LUMC under the headings " Vascular Medicine " and "Neuro-science". Part of the research involves computer vision research and algorithm development, whereas clinical applications also play an important role. Applications focus on Neuro-imaging, Pulmonology, Orthopaedics, Cardiology and molecular and cellular imaging. In 2004, important research directions were:

Statistical shape modeling

Statistical shape models are widely used to integrate a-priori knowledge about shape and image appearance into segmentation algorithms. Research at LKEB is directed towards towards dimensional extension of statistical shape models. A 3D Active Shape Model has been developed, along with 3D and multi-view Active Appearance Models; these models have been applied to segmentation of cardiac MR, CT, echo and X-angiographic data. Apart from segmentation, we have developed statistical shape models for computer-aided diagnosis to detect cardiac shape- and motion abnormalities in MR images for patients with a cardiac infarction.

Multi-agent image processing

The major objective of this research is to develop a general and adaptive learning multi-agent image interpretation system, which automatically learns how to interpret (medical) images from examples and user-interactions. The system should be flexible and easy to adapt to changes in patient context, expert preferences, or imaging devices, by the use of both low-level training / optimization and high-level rules.
It will be applied to very difficult segmentation problems in images that cannot be solved with only traditional and/or model-based segmentation methods alone. To this end we are investigating how probabilistic models, reinforcement learning techniques, evolutionary algorithms, high-level (explicit) knowledge and low-level image processing may be integrated into our current multi-agent image interpretation system.

The system will first be used for the interpretation of IntraVascular UltraSound (IVUS) and Computed Tomography Angiography (CTA) images.

Development of a virtual mobile exploration robot
In this project, we address the problem of virtual central navigation in 3D tubular structures. A virtual mobile robot, equipped with a neuro-fuzzy controller, is trained to navigate inside image datasets of tubular structures, keeping a central position; virtual range sensors are used to sense the surrounding walls and to provide input to the controller. Aim of this research is the identification of smooth and continuous central paths which are useful in several medical applications: virtual endoscopy, virtual colonoscopy, virtual angioscopy, virtual bronchoscopy, etc. We fully validated the algorithm on synthetic datasets, and performed successful experiments on a colon dataset.

Clinical Image Analysis Applications
Much of the research at LKEB is driven by questions from clinical partners. To this end, we are developing algorithms and software for:

- Detection and quantification of pulmonary emphysema in CT Images
- Early detection of micro motion of prosthetic implants in bi-plane X-ray images
- Automatic analysis of coronary vessels in intravascular ultrasound images
- Automatic analysis of coronary and left-ventricular angiograms
- Automatic analysis of cardiac MR and CT patient studies
- Automatic analysis of changes in brain structure with ageing and disease
- Automatic analysis of vascular MR data

External projects
CYTTRON
2004-2008 BSIK, with UL-WI-I and TUD-TNW-tn-qi: Development of a comprehensive, integrated infrastructure for bio-imaging and modeling cells down to atomic detail.

SAVAGE
2004-2008, NWO-E, with UL-WI-I: Development of self-learning image processing agents in a multi-agent framework for medical image interpretation.

LAISA
2004-2008, STW: Application of multi-agent image processing platform in IVUS and CTA image data.

Automated evaluation of vascular MR image data
2004-2007 STW

Autonomous virtual robots for medical image exploration
2003-2007 SNN

Automatic analysis of 3D echocardiographic data acquired with a fast rotating ultrasound probe
2003-2007, SENTER IOP BV

Software Development for the Detection and Assessment of Small Airways Disease in COPD with Multi Slice Computed Tomography,
2003-2007 Netherlands Asthma Foundation

Data fusion of different components of MR patient studies
2002-2006 STW

Computer-aided diagnosis for cardiac MR data
2002-2007, NWO VIDI

Model-based röntgen-stereofotogrammetric analysis of orthopedic implants
2002-2005 STW

Time-continuous segmentation of medical volume data
2001-2004 SENTER IOP BV

Contributions to books

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Experimental software

- Vessel wall MASS: segmentation and analysis of vessel wall MR images
- Segmentation component for QLV-CMS: AAM-based segmentation of left ventricular X-ray angiograms
- Segmentation component for MRA-CMS: segmentation and analysis of MRA datasets
- SNIPER: quantification and segmentation software for serial brain MR studies

2.3.11 Contribution of UG-CS-IS

Biologically motivated Image processing and computer vision

Models of the visual cortex are developed and used in computer algorithms. This research is relevant for the areas of image processing, computer vision, pattern recognition, visual perception, and computational neuroscience. Our goal is to understand how humans see and deploy principles of natural vision in artificial vision systems. Using facts from neuroscience and visual perception, we build models of visual neurons and use them in computer simulations to obtain insights and derive practical computer vision algorithms.

One example is the model of a grating cell that we developed [Petkov and Kruizinga: 1997 Biological Cybernetics 76 (2) 83-96] and used in a texture operator [Kruizinga and Petkov: 1999 IEEE Transactions on Image Processing 8 (10) 1395-1407], [Grigorescu, Petkov and Kruizinga: 2002 IEEE Trans. on Image Processing 11 (10) 1160-1167]. By means of computer simulations we demonstrated that grating cells may play an important role in the disambiguation of edge information in early vision (texture vs. contours). In contrast to traditional texture operators used in image processing, the texture operator derived from a computational model of a grating cell responds
only to texture and does not respond to non-textural features, such as object contours.

Another example is our model of non-classical receptive filed inhibition, also called surround suppression, in groups of orientation selective neurons [Petkov and Westenberg: 2003 Biological Cybernetics 88 236-246]. This biological mechanism was simulated and applied to a large number of natural images. We demonstrated that the biological role of this inhibitory mechanism is quick pre-attentive detection of
object contours and region boundaries in natural images that are rich in texture. We proposed various contour detection algorithms that deploy this mechanism and showed that they are more effective in detecting object contours and region boundaries than
traditional computer vision algorithms for edge detection [Grigorescu, Petkov, Westenberg: 2003 IEEE Trans. on Image Processing 12 (7) 729-739], [Grigorescu, Petkov, Westenberg: 2004 Image and Vision Computing **22** 609--622].

Currently we extend our research on the use of Gabor filters to the area of motion analysis. Another new research direction is the development of a method for the evaluation of the robustness of shape recognition algorithms to incompleteness of contours. This direction is inspired by similar psychological research on humans. Recently we started developing algorithms that mimic perceptual grouping by humans. One envisaged application is texture analysis.

Shape analysis

In shape analysis we study geometrical approaches in which a feature point is characterized by the spatial arrangement of other feature points around it. The collection of local geometrical descriptors for the different

feature points of an object is used as a shape characteristics of that object. We study the potential of this approach for object segmentation and classification in natural scenes in practical applications such as traffic sign recognition and image database retrieval [Grigorescu and Petkov:
2003 IEEE Trans. on Image Processing 12 (10) 1274-1286]. With inspiration from psychological research, we also study the robustness of shape recognition algorithms to incomplete contour representations.

Connected filters and morphological operators
Connected filters are a comparatively new field of research within mathematical morphology. They are edge preserving operators which have found use in noise removal, texture analysis, image compression and description, and feature extraction. Research on connected operators in our group entails algorithm development (including parallelization), development of new classes of filters, applications to 2-D and 3-D medical images, and the development of new connectivity measures for these filters for
increased robustness. One line of this research links to visual cortex modelling: developing morphological analogues of texture operators based on models of certain visual cortical cells. It is hoped these morphological counterparts will be an order of
magnitude faster, whilst retaining the useful properties of the cortical cell models. Finally, fast visualization based on connected attribute filters is being explored.

Segmentation is a core problem in image analysis, and methods based on both simple thresholding methods and more advanced methods such as watersheds and deformable models are being explored. Application areas are many, but the focus lies on biomedical imaging, both macroscopic (MRI, CT) and microscopic.

Machine learning and neural networks
Systems of adaptive information processing, such as neural networks, can be applied in variety of classification or regression problems. Their ability to learn from example data
makes it possible to implement tasks which are not easily formulated as a simple set of
rules, but for which example data are available.

We aim at a theoretical understanding of such learning processes based on the investigation of model systems. Besides analytical tools, computer simulations are
employed in this context. The obtained insights allow to understand and predict phenomena which are also relevant in real world learning problems. Furthermore, they enable us to systematically develop and improve practical training
algorithms.

As just one example, we are currently investigating methods of classification which are based on representing the data by prototypes. The so-called Learning Vector Quantization is a widely used approach, but lacks through theoretical understanding and systematic investigations of the typical algorithm performances.

We are furthermore studying networks of so-called Integrate-and-Fire units which model the behavior of biological spiking neurons. We aim at understanding of, for instance, masking effects in the first few layers of the visual system.

External projects
Dynamical Systems Approach to Texture Analysis
2003-2007, NWO, 110 kEuro.

Generalized Connected Morphological Operators for Robust Shape Extraction
2002-2006, NWO, 150 kEuro.

Papers in international journals
C. Grigorescu, N. Petkov and M. A. Westenberg. Contour and boundary detection improved by surround suppression of texture edges, Image and Vision Computing, 22, 2004, 609--622.

A.C. Jalba, M.H.F. Wilkinson and J.B.T.M. Roerdink. Automatic Segmentation of Diatom Images for Classification, Microscopy Research and Technique, 65, 2004, 72--85.

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N. Petkov and A. Ghosh. Recognition of objects with incomplete representations, Adv. Concepts Intell. Vis. Systems 2004, Brussels, Belgium, Aug. 31-Sept. 3, 2004, 91--95.

E.R. Urbach, J.B.T.M. Roerdink, and M.H.F. Wilkinson. Connected rotation-invariant size-shape granulometries. Proc. 17th Int. Conf. Pat. Rec.(ICPR 2004), Vol 1, Cambridge, UK, Aug 22-26 2004, 688--691.

Experimental software
N. Petkov and M.B. Wieling. Gabor filter for image processing and computer vision, internet enabled implementation, http://mathlabserver.cs.rug.nl

N. Petkov and W. T. Visser. Center-surround and dot-pattern selective operators,
internet enabled implementation, http://mathlabserver.cs.rug.nl

N. M. Hol, F. Kalsbeek and N. Petkov. Grating cell operator, internet enabled implementation,
http://mathlabserver.cs.rug.nl

Others
M.H.F. Wilkinson and A.M. Wink. LaTeX Scientific Poster Class sciposter.cls version 1.16. (2004)
http://www.ctan.org/tex-archive/help/Catalogue/entries/sciposter.html

M.H.F. Wilkinson. LaTeX Style File wallpaper.sty version 1.00. (2004)
http://www.ctan.org/tex-archive/help/Catalog

2.3.12 Contribution of TUE-BT-bmia

The group Biomedical Image Analysis, headed by prof. B.M. ter Haar Romeny, started in 2001 in the department of Biomedical Engineering (BME) at the TUE. The group is part of the BME Master track Biomedical Imaging and Modeling (BioMIM), and collaborates closely with Philips Medical Systems and the Maastricht University Hospital.

The aim of the group is to develop high quality algorithms and applications in (bio-) medical image analysis and visualization, based on fundamental computer vision research, and to offer an interesting teaching environment for BME students. The applications areas are radiology, MR biomedical imaging and microscopic imaging.

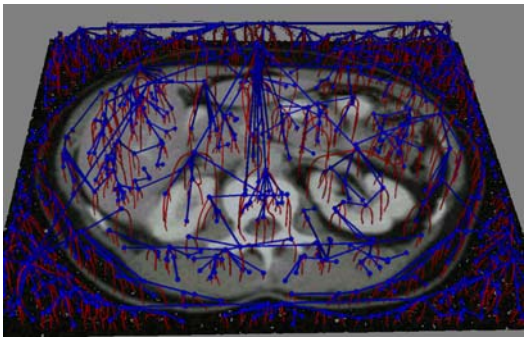

Fig. 1. Toppoints of a transversal CT slice. They provide a hierarchical tree-graph like description of the image, enabling topological, semantical and editing operations. A real-time visualization toolkit ("Scale-SpaceViz", ir. F.Kanters) is developed to study these toppoint structures for a wide variety of images.

Multi-scale computer vision
Analysis and exploitation of the deep (i.e. over scale) structure of images. This is biologically inspired, fundamental research into singularities and toppoints in images, to come to a hierarchical representation. A method has been developed to exploit the extracted toppoints for image retrieval, and to efficiently reconstruct the image from the toppoints. Together with Oce BV we develop a toppoint-based document analysis system for the IOP project "intelligent scanners".

Perceptual grouping and contect operators. This biologically inspired research focuses on the exploitation of multi-scale orientation structure of images. A new class of invertible orientation wavelet space has been developed, with applications for the detection of elongated structures (bloodvessels, electrodes) in images (project in auspices of SNN/STW).

Diffusion tensor imaging visualization:
3D visualization techniques for diffusion tensor MRI data have been investigated in an interactive setting, in close collaboration with the TUE Dept. of Computing Science. Clinical studies focus on neonatal brain fibre development, and muscle fibre orientations in the heart.

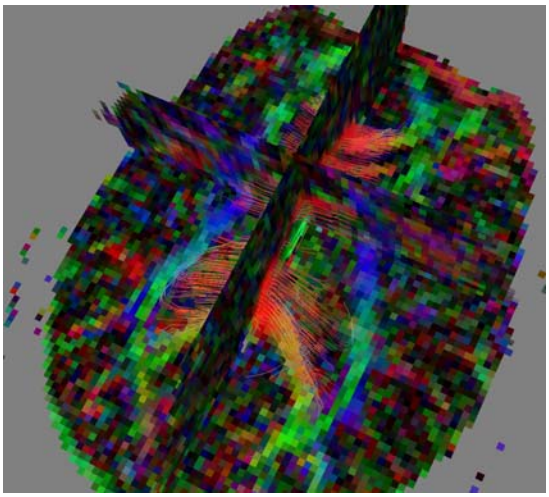

Fig. 2. Interactive visualization of the fibre directions in the brain by Diffusion Tensor Imaging with the VTK toolkit "DTI-tool" (A. Vilanova, G. Berenschot). This toolkit has been exploited in a clinical study to the effects of hypoxia in neonates (C. van Pul).

http://www.bmi2.bmt.tue.nl/image-analysis/Research/Software/DTITool/

Clinical image analysis applications:
- Automated detection of pulmonary emboli in spiral 3D CT acquisitions of the lung. A computer-aided diagnosis system is developed, based on shape and intensity features.
- Automated transfer function setting for 3D volume visualizations. Several methods are developed to establish the transfer function from the data, based on feature statistics and the task at hand.
- Segmentation of short-axis cardiac MR using active contours.
- Context-enhanced detection of electrophysiology catheters in noisy fluoroscopy images.

We collaborate with the Medical Imaging and Computer Aided Diagnosis group of the Catholic University Nijmegen on mammographic image analysis (student exchanges).

D. The development of a Mathematica software library for rapid symbolic and numerical prototyping, 'MathVisionTools'

- A general Import format to deal with a wide spectrum of image formats, such as DICOM 3.0, FDF MRI data, 3D US data etc.;
- A symbolic and numerical generalized and speed-optimized toolbox for doing high order differential geometry on multi-dimensional images;
- A library of advanced image analysis functions.

Molecular Imaging of Ischemic Heart Disease
In 2004 a major BSIK grant "Molecular Imaging of Ischemic Heart Disease" was rewarded to Univ. of Maastricht, TU/e, Philips and Organon. The BMIA group participates in the visualization of multi-spectal and tensor-based image data, classification of atherosclerotic plaque from multispectral MRI data, and the quantitative analysis of heart motion.

External projects

***Deep Structure and Singularities in Computer Vision*.**

Starting date: 1 October 2002 Duration: 36 months Funding: European Community, 5th framework.
Description: The group TUE-BMIA participates in an EU consortium (partners see below), whose overall objective is to develop sophisticated representations of images and shapes by merging principles and methods from 1) scale space theory, 2) singularity theory, and 3) algorithmics, and to create effective algorithms for solving computer vision tasks on the basis of these.
URL: http://www.itu.dk/English/research/innovation/projects/DSSCV/
Budget total project: 1.5 M€.
Partners:

- IT University of Copenhagen (IT-C), Image Group, Department of Innovation
- IT University of Copenhagen (IT-C), Algorithm Group, Theory Department
- Technical University of Eindhoven (TU/e), BME - Biomedical Image Analysis
- University of Liverpool (LU), Department of Mathematical Sciences
- University of Copenhagen, 3D Lab (3D Lab), School of Dentistry

Perceptual Grouping

Period: Sept 2001 – Sep 2005 Funding: STW-SNN (1 PhD student) and TUE-BMT (1 PhD student)
The objective of this project is to develop robust methods for segmenting contours in noisy images, inspired by the mechanisms recognized in human front-end vision.
The focus is in particular on the development of new methods to understand the multi-scale nature of grouping perceptually equivalent elements, such as edge elements and textural features. Recently a new class of steerable wavelet orientation kernels is discovered ('invertible orientation bundle') with interesting properties for feature linking.

Hemodyn

Period: September 2002 – September 2006 Funding: Philips Medical Systems (1 PhD student)
The prediction of the chance of rupture for the abdominal aorta is calculated by cardiovascular flow calculations. The data are specific for each patient, and derived from high resolution CT scans of the patient.

Advanced methods in volume visualization

Period: September 2002 – September 2006 Funding: Philips Medical Systems (2 PhD students)
The high volumes of data both from volume-CT and new MRI 3D fast scanning protocols need for fast and efficient 3D volume presentations, as an effective form of data compression and communication with the referring physician and the surgeon. New algorithms are designed in the PMS Easy-Vision environment, particularly focusing on being able to cope with rapid answers and flexibility towards new questions of users.

Fig. 3. Development of three dimensional volume visualization and computer-aided diagnosis applications on advanced diagnostic workstations.

Papers in international journals:

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2.3.13 Contribution of TUD-TNW-tn-qi

Multidimensional Image Analysis
We have continued our efforts in developing novel strategies for the processing, analysis and interpretation of multi-dimensional images, including time-series, color images and hyper-spectral images. The work focuses on the detection and subsequent characterization of geometric image structures rather than specific intensity patterns. This approach yields generic tools for image description that can be applied in a wide variety of applications. The methods are largely independent of the physical imaging technique used or the intrinsic image resolution. The theoretical component in this work has focused on
· Interactive 3D segmentation using connected orthogonal contours
· A representation for orientation in arbitrary dimensions and computation of principal curvatures of surfaces and strings;
· Curvilinear models in 3D for bent surfaces and strings based on a deformable structure tensor;
· Generalized detectors of parameterized curves, end-points, T-junctions in orientation space and/or tensor space;
· Extension of subspace morphology to accurate and precise estimation of particle size distributions;
· Motion and flow analysis of liquid flow in micro-machined nanoliter wells;
· Design of orientation selective filters for lines, planes, edges in 3D space.
· An addressable multi-resolution sampling grid for 3D orientation.
· Dynamic super-resolution in image sequences based on adaptive (scale, orientation and curvature) data fusion of registered local image data.
· Partial volume effects estimation in 3-D CT based on density and gradient trajectories.
· Computer aided diagnosis by automatic screening for polyps in colonography.
· Gamut adaptive filtering of color images

The aforementioned developments have been applied in numerous industrial collaborations and medical applications.
· Analysis of micro-structures formed by complex networks of bio-polymers;
· Detection of channels and faults in 3D seismic images;
· Analysis of liquid flow and diffision using tracer particles;
· Analysis of perceptual image quality of printed materials using local image features, scale and color;
· Analysis, transformation, visualization and registration of diagnostic and surgical images for use in minimally invasive surgery and placement of endoprostheses.
· Virtual endoscopy;
· Detection and progression analysis of glaucoma.
· MRI thermography.

External projects
Dynamic superresolution of small moving objects
Period: 2004-2007; Funding: TNO Investigating techniques for detection, registration and subsequent superresolution of small moving objects

Intelligent image interpretation for automated quality grading of young tomato plants in horticulture
Period: 2003-2006; Funding: IOP beeldverwerking Ontology driven image processing and analysis for the quality grading of young tomato plants in horticulture.

Detection and progression analysis of glaucoma
Period: 2002-2005; Funding: LDT (Laser Diagnostic Technologies, recently taken over by Carl Zeiss Meditec). Early detection of glaucoma and its progression in images acquired through scanning laser polarimetry, by means of the GDx apparatus.

Superresolution in undersampled image sequences
Period: 2002-2005; Funding: IOP beeldverwerking Increasing the spatial resolution in exchange for temporal resolution through adaptive techniques.

Automatic polyp detection in 3D CT
Period 2002-2006; Funding IOP beeldverwerking. Image processing, analysis and recognition to facilitate automatic screening for polyps in 3D CT of the colon.

Multi-dimensional measurement techniques
Period: 2002-2005; Funding: FOM. Fundamental techniques for multi-dimensional image processing and analysis.

Improved techniques for virtual endoscopy
Period: 2001-2005; Funding: Philips Medical Systems; Virtual endoscopy (VE) is a new technique to assess interior body cavities, such as the intestinal tract, the trachea or the blood vessels. Direct inspection by optical devices is replaced by simulated exploration using 3D medical images created by CT or MRI. Thus, the patient-friendliness of the examination is greatly increased. For successful exploration by virtual endoscopy it is important that the organ surface is not obscured by bodily fluids (e.g. faecal rests in the colon). Such fluid rests may easily lead to misinterpretation (false positive and missed polyps). The current practice is to scan the patient twice, in supine and prone position. Then, the distinction may be made as remaining fluid is allowed to move to a different location, whereas true polyps will remain fixated. The downside of this approach is that the patient experiences a double radiation dose. Moreover, immobile material may still impede the examination. A solution might be to mark the fluid rests in advance (e.g. in colonography letting the patient drink a contrast medium). This should facilitate segmentation and perhaps reduction of the radiation dose. However, any air/fluid interface will impede volume rendering, when a simple classification function is applied. Also, segmentation is complicated by inhomogeneous distribution of the contrast medium. Advanced image processing techniques are designed to solve this problem.

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Verbeek, P.W., Dijk, J; Werkwijze voor het bewerken van een kleurenbeeld. TU Delft, Ned. Octrooi nr. 1022258.

Cooperations within ASCI

TUD-EWI-mm-cgcc
UL-LUMC-lkeb

Highlight

Playing within the lines

Header:
Piet W. Verbeek and Judith Dijk got a patent on a class of generic methods for automatic incorporating the constraints of color rendering techniques in lightness processing of images. Every printing process, each printer and each monitor has its own characteristic restrictions. The methods proposed convert the operations of classical black and white image processing to corresponding lightness operations on color images.

Body:
The gamut of a rendering technique. A color monitor works on the basis of the primary colors red, green and blue, each with intensity range 0 to 1. It adds phosphor emission spectra. The different color combinations it can produce lie within a cube, with white at (1,1,1) and black at (0,0,0). All grey tones are on the body diagonal from black to white. Each half-plane through it corresponds to a hue, like red or yellow, and intersects the cube in a triangle, a "flag", with the grey diagonal as flagpole.
Such a three dimensional body representing the allowed colors is called a gamut. For rendering techniques like inkjet and offset printing that include multiplication of ink transmission spectra the gamut is an oblique block with sucked-in walls.

Lab-coordinates. In practice colors are characterized by Lab-coordinates. Thus plotted the gamut is deformed, the flagpole remaining straight becomes the lightness axis. The flags remain approximately plane, their borders get deformed. Now the distance from a color point to the flagpole is the chroma, a measure for colorfulness.

Image processing. For black and white images a huge set of grey processing methods is available. Many image enhancement activities are aimed at contrast enhancement and sharpening. Both are corrections of pixel lightness: translations parallel to the flagpole in the flag.

Problem and solution. Near the flagpole (like in grey images) the flag width is large (the full distance from black to white) and imposes no restrictions on translation beyond those of grey processing. Further away (as usual in color images) the flag narrows and the translations suggested by grey processing easily transgress the flag border. Existing color processing methods then revert to the nearest point on the border causing the results of neighbouring pixels to land on the same border point. The print looses nuance.
The method proposed by Verbeek and Dijk gives a compromise:
The desired translation is scaled back with the ratio of the translations allowed with and without color. The resulting translation stays within the flag. This preserves color gradation.

Variants. Other translation paths than parallel to the flagpole allow a larger change of lightness but change the chroma. A number of path recipes has been investigated (e.g. straight lines to white or to black).

Gamut-charting. Crucial for the method is charting the flag borders in a given rendering technique, like inkjet printing or offset print with a particular choice of inks. This is a complicated problem.
That Judith Dijk has found its solution deserves explicit mentioning.

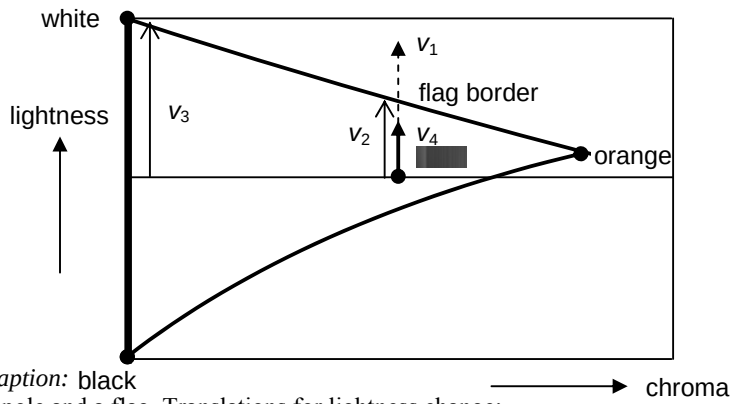

Figure caption:
The flag pole and a flag. Translations for lightness change:
v_1 suggested by grey processing, v_2 allowed in color, v_3 allowed without color,
$v_4 = (v_2/v_3)\, v_1$ realized according to the method proposed.

2.4 D: Multimedia Information Systems

2.4.1 Contribution of TUD-mm-ict

Image and Video Processing
The research on image and video processing in the ICT Group encompasses four topics:
Video compression. Compression techniques are essential in variety of Internet applications, television broadcasting, digital cameras, music distribution and consumer digital video applications, such as DVD's and DV-cam cording. Research concentrates on novel compression techniques for applications where the communication medium is error-prone and cases where the device on which the compression algorithm runs is complexity constrained.
Computer vision. Focus is on 3D reconstruction of objects from multiple cameras or moving camera(s) for e.g. face recognition, remote handling, 3D editing for 3D teleconferencing. Recent research also considers the problem of gesture recognition.
Cultural heritage informatics. Research concerns the application and development of image processing, pattern recognition and artificial intelligence techniques for the benefit of our cultural heritage. The focus is on virtual restoration of paintings as well as on the dating and authenticity of painting and etchings.
Restoration. In the area of post-processing the emphasis is on the quality improvement of degraded digital image sequences. An important application is the restoration of historically important (analogue) film and video recordings.

Multimedia Retrieval
The research efforts in the ICT Group in the field of multimedia content management address the following challenges:
- Automating multimedia content indexing and retrieval processes;
- Enabling quick, easy and personalized access to multimedia content.

To meet the first challenge, we combine our expertise in multimedia signal processing and machine intelligence with state-of-the-art achievements in the fields of "traditional" information retrieval and human perception and aim at bridging the gap between the measurable properties (features) of one hand, by optimizing the way multimedia content is stored, organized, abstracted and represented and, on the other hand, by developing methods for reliably learning user preferences and for filtering, pruning, adapting and delivering multimedia content accordingly.

External Projects
NON OBTRUSIVE GESTURE RECOGNITION
2003-2007, Delft Research Center ICT, 180 k€. In this gesture recognition project we will focus on problems involved in tracking and interpretation of hand movements (gestures) with cameras without using additional obtrusive sensors or markers and how this can be used optimally in different applications. Gestures that can be indicated as conventionalized symbols are predominantly studied in an application where a sign language recognition system will be developed and integrated in an e-learning system to assist the learning process for deaf and hearing-impaired children of Dutch sign language vocabulary. The focus is on detection and tracking of the hand/arm movements and the extraction of relevant features for recognition.

DIWAMETRIC (Digital image Watermarks resistant to geoMETRIC attacks)
2001-2004, STW, 270 k€. This project aims at the development of watermarking techniques that are robust against geometric attacks. The secret information embedded in image or video data should survive most common accidental and malicious processing operations such as filtering, compression, D/A and A/D conversion.

CACTUS
2002-2004, EZ/Freeband K.I., 1.350 M€, TUD-EWI-mm-cgcc, TUD-EWI-st-pds. In this project we concentrate on the interaction between a user and his mobile device and between the mobile device and the network. Specific research questions concern the discovery of available foreign "resources" and the willingness of users and devices to share their own resources.

AUTHENTICITY
2004-2007, NWO/TOKEN2000, 300 k€. Authenticity determination and dating of works of art play an important role in the field of art history. In the AUTHENTIC-project it is investigated how existing and new techniques from digital image processing and knowledge discovery (data mining) can be developed and applied in order to support the process of determination of authenticity, dating and the assessment of other characteristics of both graphic art and paintings.

REMBRANDT Project
2004-2007, NTWO/TOKEN2000, 300 k€. In this project methods for automatic extraction of watermarks and features concerning the paper structure are developed. On the basis of these features, etchings printed on similar papers can be recognized by means of automatic matching procedures. With this questions concerning authenticity and dating can be answered. Since the aim is to construct a database of all the papers used by Dutch artists, specific attention is paid to how to make this database self-organizing and self-learning. This requires the application of advanced techniques from computational intelligence.

2D23D
2003-2004, Philips Research, 120 k€. The main goal of the project was to derive a feasible solution for 2D-to-3D conversion. The application of interest is 3DTV which means that the objective is perceptually pleasing 3D images and not necessarily recovering the exact 3D scene geometry as is done by e.g. conventional SfM approaches.The focus was on stable spatio-temporal segmentation of video objects using a pseudo 3D curve evolution method that minimizes colour and shape differences as well as 3D from defocus information between successive frames.

I-SHARE
2004-2008, EZ BSIK/Freeband, 8 M€, TUD-EWI-st-pds. Sharing resources in virtual communities for storage, communications and processing of multimedia data. The FREEBAND I-SHARE-project investigates the sharing resources in virtual communities, which are (dynamic) groups of nodes that are willing to collaborate for the better of the whole. In particular, I-SHARE considers the sharing of resources for processing, transmitting and storing multimedia streams:
- Funtionality sharing. Specific capabilities of terminals embodied in algorithms – or, more abstractly, in services – are shared to support applications and to form new ones.
- Content sharing. This pertains to particular assets related to local hardware. We think of processing power and storage to start with, but specific processing hardware (co-processors) and special purpose hardware are possible as well.

VIDEO-AT-YOUR-FINGERTIPS
2000-2008, EZ/OC&W BSIK/Multimedian, 2,5 M€. The goal of this project is video content extraction technology suited for practical use in selectec application contexts. The basis of this technology consists of video content analysis algorithms, which include the modeling of the semantic content in terms of signal processing and analysis routines, and the methods of implementing the content models in software or hardware. In particular, Video-at-your-fingertips considers the following research topics:
1. Robust, unconstrained face detection and recognition with applications in security (smart camera's) and media (consumer home video).
2. Human body motion analysis with applications in surveillance (suspicious behavior and aggression detection) and personal health care (revalidation at home).
3. Video content management: The parsing, pruning, abstracting, summarization and classification of video content with a Video Concert Browser as media application.

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Involved ASCI-partner: TUD-EWI-st-pds

Highlight

Extracting quality parameters from compressed audio using fingerprints

An audio fingerprint is a compact representation of the perceptually relevant parts of audio content, usually derived from some kind of time-frequency representation. An audio fingerprint can be used to identify audio files based on their content, even if they are severely degraded due to compression or other types of signal processing operations. A fingerprinting system consists of two parts: fingerprint extraction and a matching algorithm. The fingerprints of a large number of songs are usually stored in a database. A song is identified by comparing its fingerprint with the fingerprints in the database. Applications can be found in the areas of broadcast monitoring, identification of music (e.g. played on the radio) using a cell phone, digital library organization and filtering in P2P networks.

Figure 1(a) shows a typical fingerprint, generated by a state-of-the-art Philips algorithm. Black/white values represent "1"/"0" bits. The bits are derived from the behavior of energies in frequency bands of the audio spectrum over time. The small side consists of 32 bits corresponding to energy differences between 33 frequency bands (frequency dimension). The length of the long side depends on the length of the used audio fragment (temporal dimension). A match is found between the extracted fingerprint and a fingerprint in the database if the Bit Error Rate (BER) between them is below a threshold of 0.35.

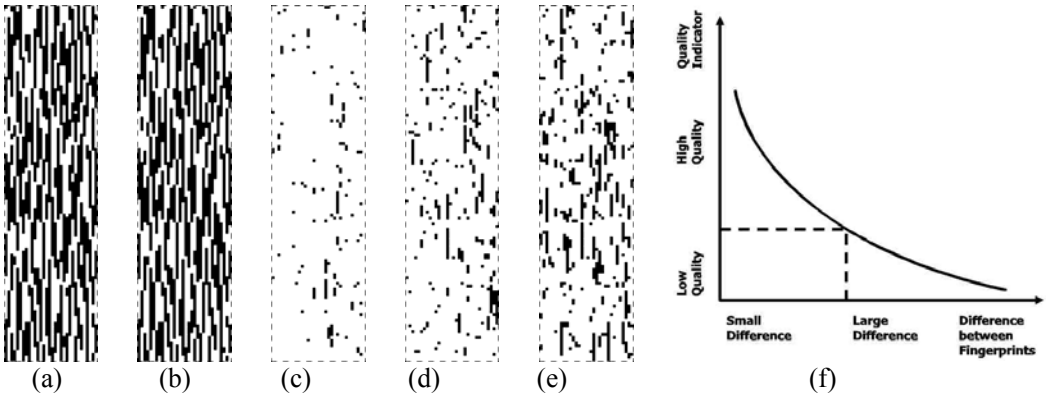
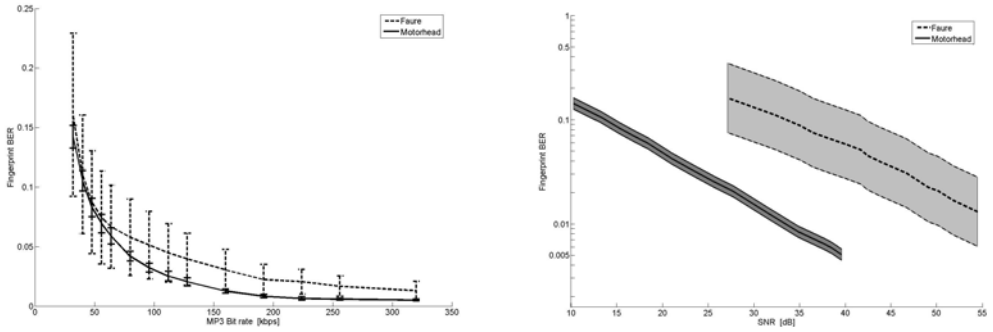


Figure 1(a-b) Fingerprints for a music excerpt (a) the original and (b) of an MP3-compressed version encoded at 128 kbps; (c-e) Differences between the fingerprints of the original and an MP3 version encoded at (c) 128 kbps (d) 80 kpbs and (e) 32 kbps. (f) Relating BER between two fingerprints to a quality indication.

The fingerprints of two arbitrary selected pieces of music are very different, while fingerprints originating from the same music recording, but which differ due to a limited amount of processing or distortion, are only slightly different, e.g. see Figure 1(b). Figures 1(c)-1(e) show the difference patterns of the fingerprint of a recording compressed at different MP3 bit-rates relative to the fingerprint of the CD-quality recording of the same song. The black sections mark the fingerprint differences due to compression, white positions indicate similarity between the fingerprints.

We use a fingerprint not only to identify the song but also to assess the (perceptual) quality of the compressed content. The goal is to roughly indicate the perceptual quality of the compressed version of the song (relative to the original, uncompressed recording) using the observed difference in the corresponding fingerprints, illustrated in Figure 1(f).

Experiments have indicated how differences in fingerprints are related to the spectral characteristics of the (original) audio signal. Differences in the local spectral characteristics may cause a large variation in the behavior of the fingerprint difference as a function of the bitrate set for compression. Figure 2(a) shows the relation between MP3 bitrate and the BER between the corresponding fingerprints for two songs, including the variations over different parts of the song. Current research focuses on how to deal with these signal-dependent variations in the BER.



(a) (b)

Figure 2 Quality vs. BER for 2 songs (a) MP3 bitrate vs. BER (b) SNR vs BER.

We have worked on modeling the Philips audio fingerprinting system for uncorrelated input signals and its behavior to additive noise. These signal and distortion models help explain, analyze and quantify what is the effect of audio compression on the extracted fingerprint. Our theoretical analysis shows, and experiments confirm, that the BER is approximately inversely proportional to the square root of the Signal-to-Noise Ratio (SNR) of the signal, see Figure 2(b). Recent work indicates that the results of our analysis may be generalized for a larger range of audio fingerprinting systems.

2.4.2 Contribution of UVA-FdNWI-isis

Content-based access of multi-media data

Content-based access to large stacks of images has been a topic of study for some time now. Based on the invariant colour features, to be described below, successful methods have been designed to achieve image retrieval robust against variations in illumination, viewpoint and occlusion.

Large *sets of documents* are analysed for their page layout characteristics, the reading order, and their type of genre (e.g. scientific/news/commercial papers). These methods were successfully applied to classify office documents and scientific papers.

Spatial and extensible databases

Spatial and extensible databases are developed in the MAGNUM-project, which ended in 1999. Amongst the results obtained, the Monet database kernel and its modules for image and geo-spatial reasoning stands out. Research in the area of database kernels was focused on consolidation of the results obtained in recent years in journal papers. The activities were realized in close co-operation with the *CWI*-database group. In the area of database kernels, an innovative experimental analysis uncovered the lack of performance improvement in database technology over the last decade. The underlying reason is the relative progress in CPU- and RAM-technology, which shows a increasing performance bottleneck. As a result, traditional database solutions use less then a few percent of the available resources. This observation has led to novel techniques to measure the resource waste and new database algorithms to avoid resource stales.

The topic on *spatial databases* resulted in papers in several conferences including the VLDB conference.

Software and systems

The year 2004 has been a period of change for software engineering from the large complex and abstract Horus system which is now completed to smaller targets systems solving one computer vision task at the time but completely.

A separate seed topic is the study of parallelism in multimedia processing tasks. The purpose of the research is to anticipate on future generation computer systems while constructing a parallel processing library compatible with Horus. A Ph.D. thesis on this topic has been completed by F.J. Seinstra entitled "User Transparent Parallel Image Processing". The research has led to publications in a.o. "IEEE Transactions on Parallel and Distributed aystems", "Parallel Computing", and "Concurrency and Computation: Practice and Experience". In addition, the developed parallel software has been applied in the 2004 TRECVID competition, in which the expected sequential processing time of over 250 days was reduced to less than 60 hours. This reduction was obtained without any hand-parallelization, and played an important role in the realization of our top-ranking TRECVID results.

2005 and beyond
With first priority we will increase the effectiveness of our solutions in image retrieval and image search engines by expanding on our experience with learning from image databases.

Computational efficiency of image search engines will be increased by the joint development with spatial and extensible databases. This is important as it will open up domains of hundreds of thousands of images, a significant step towards data-mining the content.

At the same time, we aim to expand to create full access to multimedia documents. The integration of information from text and pictures is a very interesting topic both scientifically, as it reveals a lot about the nature of information, as well as practically as multimedia documents will be ubiquitous as is the need for their access. The MultimediaN project provides the opportunity to reach this goal with the intended delivery of a large-scale experimentation platform for multimedia information analysis.

Concerning color research, we aim at the extraction of invariants from interesting regions of the image. Regions improve on the robustness when compared to strictly local interest point based object recognition. For instance, from color distributions we may derive appearance properties. Further, we aim at exploiting distributions of color edges to derive texture properties. We will concentrate on regions that are interesting from an information theoretical point of view. To increase the specifity of regions, we will incorporate the statistics of regions throughout the ALOI collection. We consider this collection to be a natural starting point for visual cognition.

Over the years we have invested in a new, object-oriented software platform for vision. By the end of the year we hope to deliver a first complete system for internal use with an expected life time of 10 years.

Further, the available parallel functionality to heterogeneous wide-area Grid systems is projected to be extended in 2005. The main focus is on the development of an efficient and easy-to-use execution model based on so-called Multimedia Grid Services, i.e. high-performance multimedia functionality that can be invoked from within sequential applications running on a standard desktop machine. A key example is our Aibo robot dog, whose video data is being processed at multiple cluster systems all over the globe. This research direction is prioritized with the arrival of the new Distributed ASCI Supercomputer 3 (DAS-3), which is co-financed by the MultimediaN consortium.

External projects
ImIK
2002-2005, IOP, 400 Keuro, Uva-Science-ISIS and VU. The project considers the interactive exploration of multimedia information and knowledge.

MultimediaN
2004-2008, BSIK, 35 MEuro, UvA-Science-ISIS, CWI, TUD-Mediamatica, UT-CTIT-CS, VU-CS, UU-CS, TNO, Nederlands Forensisch Instituut, Telematica Instituut, IBM, V2_, Philips, Ilse Media, LogicaCMG, Waag Society, DBNL, eMAXX, NOC*NSF, SPSS, Compano, Beeld en Geluid, FabChannel, ZiuZ, DBNL, de Politie Amstellanden, Vereniging Digitaal Erfgoed, Roessingh. The project aims at various forms of multi-media, multi-modal analysis, interaction, system design and knowledge engineering for several scientific and applied science goals.

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Nguyen, G.P., Worring, M.; Optimizing similarity based visualization in content based image retrieval. In Proceeding of the IEEE ICME special session Novel Techniques for Browsing in Large Multimedia Collections, 2004.

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Gevers, Th., Smeulders, A.W.M.; *ZOMAX, A General Purpose Image Processing and Retrieval System for the World Wide Web*. The system provides an interactive image processing module and an image search engine, called PicToSeek, for searching images on the web. http://www.science.uva.nl/research/isis/zomax.html

Koelma, D., Poll, E.; *Horus: a vision library based on patterns*.
http://www.science.uva.nl/~koelma/isis/projects/horus.html

Nguyen, G.P., Worring, M.; A demo on similarity based visualization of large image collections.

Snoek, C.G.M., Worring, M.; *Goalgl*e: *A Soccer Video Search Engine*, Goalgle is a prototype search engine for soccer video. A fully automatic soccer video analysis system has been developed which analyses soccer broadcasts and makes them accessible by names of players, teams, and highlight events. http://www.goalgle.com

Snoek, C.G.M., Worring, M., Geusebroek, J.M., Koelma, D.C., Seinstra, F.J.; *Mediamill demo: Semantic Video Search Engine*. This system allows for interactive retrieval based on a lexicon of 32 automatically derived semantic concepts. The demo searches a broadcast news archive of 184 hours.
http://staff.science.uva.nl/~cgmsnoek/tv/

Snoek, C.G.M., Worring, M.; *VIPER: Video Personalizer*. VIPER is a prototype search engine for personalized video retrieval over the Internet. The demo searches a broadcast news archive of 184 hours. http://staff.science.uva.nl/~cgmsnoek/viper/

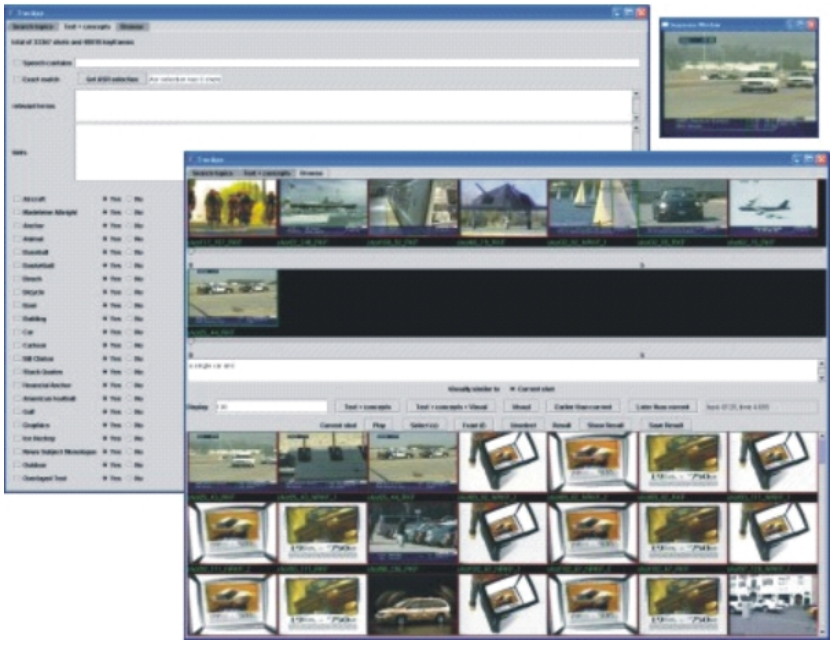
Todoran, L., Worring, M.; *Document Ground Truthing and evaluation tool*. A tool has been built for assisting users in ground truthing scanned color documents based on layout and logical information. It has been used to create the UvA color document dataset. Tools for evaluating algorithms with respect to the ground truth have been developed as well. Documents and tools will be made available to the research community.

Highlight

For the *retrieval of videos*, we aim to make multimedia archives as accessible as their textual counterpart. To that end, our research efforts concentrate on automatic semantic indexing and interactive retrieval of multimedia sources. To value the merit of our efforts on high international standards, all research is evaluated within the TRECVID benchmark for multimedia retrieval.

An import asset in our endeavor for semantic access is indexing of semantic concepts. An architecture for semantic indexing has been developed that facilitates generic indexing based on integrated analysis from multi-media sources on content, style, and context level. Experiments with a lexicon of 32 concepts on the 2004 TRECVID benchmark indicate that our approach is state-of-the-art.

Despite the good results for automatic indexing, the current lexicon is still too limited for daily practice retrieval. Therefore, we view user interaction as an essential part of multimedia retrieval systems. To this end, we have developed a novel paradigm for interactive retrieval which uses a lexicon of detectable concepts in combination with keyword and visual example search to boost interactive retrieval. Implementation of the paradigm within a video search engine, see Figure 1, yielded the highest score for the interactive retrieval task of TRECVID 2004.



Search engine for video retrieval, showing results for vehicles and cars.

We will continue this line of research with a further integration of multi-media sources, a further understanding of the structure of video documents and interactive access to the semantic content of large collections of multi-media information.

Chapter 3 ASCI-wide Events

3.1 Cooperation within ASCI

Distributed ASCI Supercomputer (DAS) project
Period: 1996-2005; Funding NWO; Grant: Kfl. 180 (DAS-1) + Kfl. 1600 (DAS-2) Much of the research described in the preceding sections was performed making use of the DAS and the facilities provided on the DAS.The DAS (Distributed ASCI Supercomputer) is a wide-area distributed cluster designed by the Advanced School for Computing and Imaging (ASCI). The DAS is a platform for research on parallel and distributed computing by five Dutch universities: Vrije Universiteit Amsterdam, University of Amsterdam, Delft University of Technology, University of Leiden, and University of Utrecht.
The DAS before 2002 consisted of four clusters, located at the first four universities. The first cluster (at the VU) contains 128 nodes, the other three clusters have 24 nodes (200 nodes in total). The system was built by Parsytec and runs the Linux operating system.
The new system, called DAS-2, has an order of magnitude higher performance than its predecessor, opening new areas of research. The key properties of DAS-2 are its physical distribution and hierarchical structure: The system consists of five cluster computers at the five universities, connected by wide-ara networks (WANs). Each cluster is built out of SMP (symmetric multiprocessor) nodes with 2 CPUs each, connected by a fast local area netwerk. Four of the clusters contain 64 CPUs, a large cluster of the Vrije Universiteit contains 144 CPUs, so the entire DAS-2 system has 400 CPUs. The total computing power of the new DAS is about a factor 15 higher than the old one.

ARCHER (Architecture Exploration)
Period: 2000-2004, Funding: Philips, 0.5 Mfl, UL-WI-i, UvA-FdNWI-caps.
Architecture Exploration. The objective is to explore the design space of (lumped) embedded systems for multimedia applications at a high level of abstraction.
Archer supports fast, abstract *system-level* and *platform-based* exploration and design strategies for the multimedia application domain. Platforms consist of a number of heterogeneous computing components, and a communication, synchronization, and storage infrastructure. The Archer strategy is implemented in software in three layers: An application layer, an architecture layer, and a mapping layer. Applications and Platform are modeled at a high level of abstraction, and the Mapping consists of transformations that take an application (model) representation to an architecture (model) representation. Compaan and Laura are used to *calibrate* the abstract computing component models in an Archer platform. Archer then concentrates on performance and cost exploration of the platform at the higher level of abstraction.
In 2003, Archer has shown its methodology is capable of predicting performance and cost with a confidence level that is well within the range of requirements.
Duration: October 2000 – October 2004

Artemis (methods and techniques to support the design of highly programmable embedded systems
1999-2004, M-Eur 1 + industrial matching of 2 M-Eur, 2e geldstroom, PROGRESS/STW, UvA, Liacs, UL, TUD This project aims at the development of an architecture modeling and simulation workbench.
The model of computation (application model) appearing in the application layer of Archer is similar to the Process Network model that is also appearing in Compaan. However, the PN in Compaan is deterministic whilst in Archer it is not. Moreover, Compaan only accepts static source code whilst Archer does not have that restriction. As a consequence, Compaan cannot be used to translate applications specified in the imperative language to input-output equivalent PN specifications. Artemis aims at overcoming that problem by generalizing some methods and tools that are currently restrictive in Compaan.
The extension allows for data-dependent constructs and non-determinism at the level of communicating tasks to be present in the given (sequential) specification. In 2003, the theoretical foundation has been established, prototype software tools have been constructed, and examples to demonstrate the novel features have been worked out.
Duration: March 2000 – March 2004
Partners: Delft University of Technology, University of Amsterdam, Philips Research
Value: 1 Ph.D. student + FPGA platform and tools
Sponsor: PROGRESS, Philips Research

ARTEMISIA
2004-2009, Progress/STW, 930 K Eur.
Leiden University, Delft University of Technology, University of Amsterdam, Philips Research Value: 1 Ph.D. student, 1 Post-Doc Sponsor: PROGRESS, Philips Research
Artemisia is a project that willbuild on the Artemis project results. The intention of the Artemisia project is to come with a prototype modeling and exploration tool chain, and several designs that are relevant to the industry

A structure for maintaining a shared world model in a dynamic environment between differentiated Embedded Systems and their interaction with human supervisors
2001-2006, 490 kf We study embedded autonomous systems in distributed environments, for applications in public safety; monitoring and control of traffic and environmental conditions; assistance and clean-up work in disaster areas. Collaboration between systems requires a collective world model, and we develop methods for its consistency maintenance, in time-critical situations. We use robot soccer (RoboCup) as a case study. This project is a collaboration between UvA and the VU and is sponsored by Progress.

Beyond the Ordinary: Design of Embedded Real-time Control (BODERC)
2003-2007. Senter, 2.5 M€, Océ Technologies, Philips CFT, AAS, Imtech ICT, Chess iT, Katholieke Universiteit Nijmegen, Universiteit Twente, TU/e
The Boderc project focuses on distributed embedded real-time controllers of complex systems. An Océ printer is taken as a case-study and acts as a driver for the project.
The target is an integral approach for a systematic architectural design, modeling, analysis, and validation methodology for such heterogeneous systems.

CACTUS (Context Aware Communications, Terminal and User)
2002-2004, STW/EZ, KEURO 300, Funding: EZ Freeband Kennisimpuls, 3 postdocs and 2 Ph.D. students for ASCI partners: TUD-EWI-isa-pgs, TUD-EWI-mm-ict , TUD-EWI-mm-cgcc, TUD-EWI-mm-dke. This project aims at the design of context-aware mobile systems for multimedia applications.

CoreGRID
2004-2008, EU (Network of Excellence), EURO 38.000, ASCI partners TUD, VU.
This network integrates the grid research of 42 universities in Europe.

CIM
2003-2007, Senter, 300k€. TUD-EWI, VU, CWI, Almende, This project aims at the development and specification of distributed incident management techniques.

COMBINED systems
2002-2006, 800kE In this project innovative methods for disaster management are being studied. In particular aspects concerning distributed observation systems are investigated. An important property of distributed observation systems is that they autonomously extract information from the monitored area. This information is shared with other services in the disaster management platform. The project is conducted in cooperation with UvA, TUDelft, Thales en TNO within the DECIS laboratory.

CSI
The CSI project is a close collaboration between LIACS of Leiden University and the CE Laboratory of TU Delft. CSI Media Architecture. The Complex Streamed Instruction Set Architecture (CSI) is a memory-to-memory vector architecture targeted at multimedia applications. A single CSI instruction can process data streams of arbitrary length and, in addition to traditional arithmetic and logical operations, performs data accesses, conversion between storage and computation formats (packing and unpacking), and complex arithmetic hardwired computation. The main new features of the CSI are elimination of the vector sectioning instructions, elimination of the packing/unpacking instructions, and introduction of new complex media related arithmetic instructions.

CYTTRON
2004-2008 BSIK, with UL-LUMC, UL-WI-I and TUD-TNW-tn-qi: Development of a comprehensive, integrated infrastructure for bio-imaging and modeling cells down to atomic detail.

D: ImIK
2002-2005, IOP, 400 Keuro, Uva-Science-ISIS and VU. The project considers the interactive exploration of multimedia information and knowledge.

Fexible Application Mapping Environment (FAME)
2002-2006, NWO, Leiden University, Delft University of Technology, 250 k€, TUD-EWI-me-ce
The FAME aims to obtain low power solutions when mapping applications on processor platforms. We like to achieve this goal by creating a compiler infrastructure capable of performing source-code transformations. We propose a dynamic approach in combination with analytic pruning of the transformation search space in order to find the best low-power optimizations.

Gigamobiel
2000-2004, Telematics Institute Research Center, ASCI partners: TUD-EWI-isa-pds, TUD-EWI-mm-ict, TUD-TNW-tn-ph. An extension of the DIOC UBICOM project aming at ambient awareness for users of GSM en UMTS systems. De user environment can be involved in the applications that run on the GSM/UMTS system. Keywords: GPS, Inertia sensing, vision.

Globule
2003-2007, KEURO 147,(a.o.Proactive Construction of Semantic Overlay Networks) The work on Globule and other peer-to-peer related research is done a cooperation between the VU-WI-i and TUD-EWI-st-pds. There has been a joint NWO proposal (granted).

I-SHARE (part of Freeband)
2004-2008, EZ (BSIK program), EURO 800.000, ASCI partners TUD-EWI-mm-ict, VU-EW-cs-i.
This projects researches sharing technology in distributed systems, particularly for video. As a research vehicle, we have chosen P2P-TV, a system for sharing live and recorded TV programs of 10,000+ TV channels and web cams among millions of users.

MultimediaN
2004-2008, BSIK, 35 MEuro, UvA-Science-ISIS, CWI, TUD-Mediamatica, UT-CTIT-CS, VU-CS, UU-CS, TNO, Nederlands Forensisch Instituut, Telematica Instituut, IBM, V2_, Philips, Ilse Media, LogicaCMG, Waag Society, DBNL, eMAXX, NOC*NSF, SPSS, Compano, Beeld en Geluid, FabChannel, ZiuZ, DBNL, de Politie Amstellanden, Vereniging Digitaal Erfgoed, Roessingh. The project aims at various forms of multi-media, multi-modal analysis, interaction, system design and knowledge engineering for several scientific and applied science goals.

SCALPE
2004-2008, STW, EURO 220.000, ASCI partners VU and TUD
This project deals with high-productivity methods for programming parallel systems on a chip.

SmartCam
2002-2006. STW/PROGRESS, TUE-EE-dmes, Philips Natlab, Philips CFT, TNO-FEL, In3D, HP Bristol labs, 1.4 M€, TUD-TNW-tn-ph The SmartCam project investigates low-cost one-chip Smart Camera solutions, contributing to a quantitatively guided design trajectory. In particular, we investigate the impact of current applications, and we try to define relevant architectural parameters and to develop an architectural template. Other aims are to enhance and integrate existing application mapping environments for SIMD and ILP processors.

ToKeN2000
2000-2004, E.Z. (To Knowledge and its Enhancement Netherlands 2000)ToKeN2000 is an interdisciplinary research project, in which cognition and computer science focus on fundamental problems affecting interaction between human beings on the one hand, and on the other, knowledge and information systems and the products they yield. In this project the universities of Delft, Maastricht, Eindhoven, Leiden and Nijmegen participate as well as the Center of Mathematics and Computer Science CWI. ASCI groups: UvA-scs, TUD-TNW-tn-qi, UL-LUMC

Tools for non-linear data analysis
2000-2004, STW, 0.7 Mf, UvA-FdNWI-ias and TUD-TN-fi-ph Current data analysis systems receive large amounts of data, e.g. computerized measurement systems in the industry, Web databases, etc. Tasks like storage or analysis of such data require first an appropriate feature extraction step in order to reduce the dimensionality of the data. In this project we investigate methods for linear and nonlinear feature extraction with emphasis on visualization and modeling of high-dimensional datasets, especially those characterized by additional spatial or temporal inter-relationships of the data points. Industrial partners include Shell, FEL-TNO, Noldus IT, KiQ, Unilever, CAP-Gemini.

Two-level Peer-to-Peer Systems
2003-2007, NWO, KEURO 147, ASCI partners TUD-EWI-pds, VU-group Large-Scale Distributed Systems. This project aims at exploring the notion of superpeers in p2p systems in order to improve the performance of such systems.

Virtual Laboratory for e-Science (VL-e)
2004-20098, EZ (BSIK program), EURO 1.000.000 (TUD-EWI-st-pds part), ASCI partners TUD-EWI-mm-cgcc, VU-EW-cs-I, UvA-FdNWI-caps, UvA-FdNWI-scs. Amolf, Nikhef, CWI, SARA, IBM, LigicaCMG, Philips, FEI
This projects aims at designing and implementing grid technology (schedulers, communication libraries, problem-solving and visualization environments, etc) for virtual laboratories (e.g., for simulations in the sciences) on top of the basic grid fabric.

3.2 ASCI 2004 Conference

ASCI 2004 was the tenth annual conference organized by ASCI. Apart from keynotes, and paper and poster presentations, the program consisted of theme presentations by senior ASCI researchers. NO ASCI PhD alumni were invited to deliver a presentation about their PhD work and their current jobs.

Keynotes
- Rüdiger Westermann from the Technische Universität München
- Thomas Funkhouser from Princeton University
- Hans Mulder from Intel

About the conference
Number of theme presentations 3
Number of poster presentations 18
Numer of paper presentations 32
Date: June 2 - 4, 2004
Location: Conference Centre Port Zélande, Ouddorp
Number of participants 103

Proceedings
Wijk, J.J. van, Heijnsdijk J.W.J., Langendoen K.G., Veltkamp R., Proceedings of the tenth annual conference of the Advanced School for Computing and Imaging, Port Zélande, Ouddorp, June 2-4, 2004, ISBN 90-803086-9-2, Delft, 2004.

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