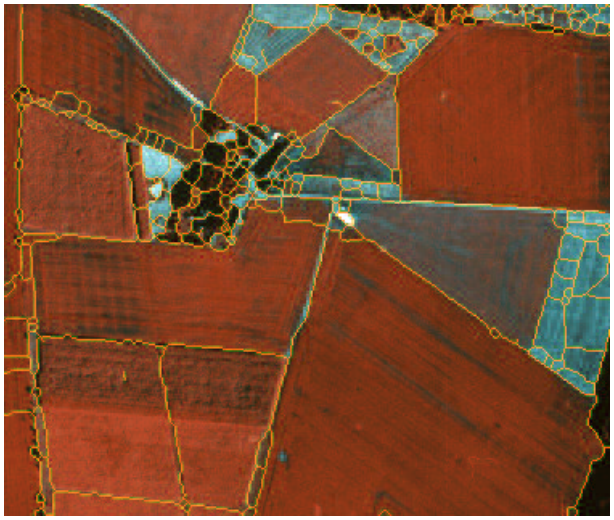
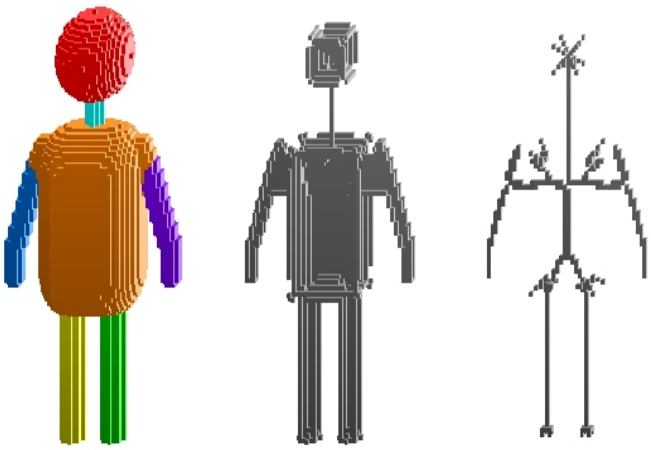
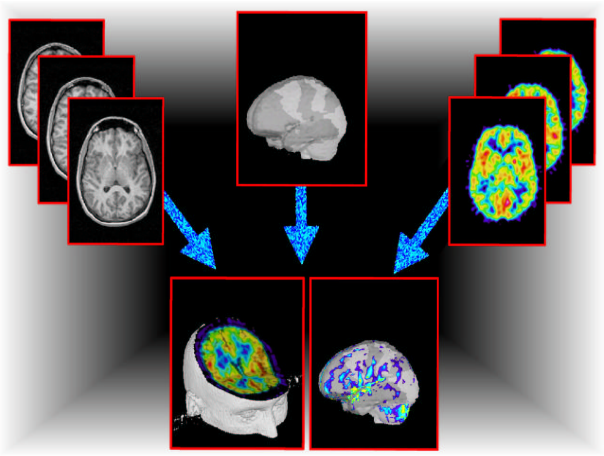
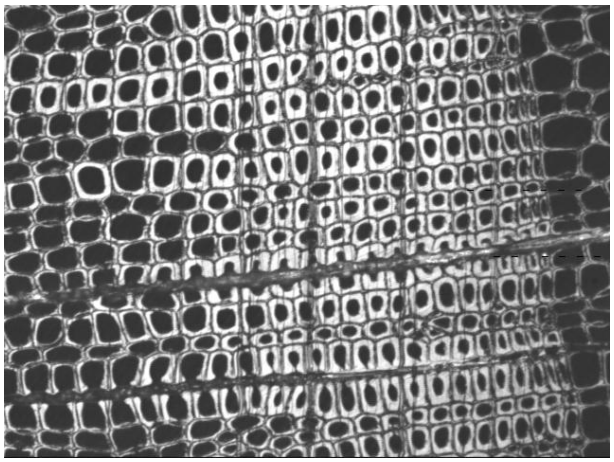
ANNUAL REPORT 2001









Annual Report 2001

Centre for Image Analysis

Centrum för bildanalys

Cover:
Illustrations from the four PhD theses presented at CBA during 2001. See Abstracts in Section 4.3.

Top-left:

Anna Rydberg — Automatically generated field boundaries presented on an NIR colour aerial image, with 1×1 m resolution.

Top-right:

Stina Svensson — Three types of representation schemes of a man-like (3D) object:
Decomposed object with its parts visualized using different colours, its surface skeleton, and the curve skeleton computed from its surface skeleton.

Bottom-left:

Roger Lundqvist — Fusion of information from an MR and a PET scan. The information from the PET scan is rendered together with the structures from a computerised brain atlas to better determine the location of the brain activity of interest.

Bottom-right:

Mattias Moëll — "Typical" transverse section of Scots pine (*Pinus sylvestris L.*). The task is to measure each individual cell.

Edited by:
Mattias Aronsson, Gunilla Borgefors, Ingela Nyström, Lena Wadelius
Centre for Image Analysis
Uppsala, Sweden
February 22, 2002

Contents

1 Introduction

1.1 General background

The Centre for Image Analysis (CBA) is a joint university entity between Uppsala University (UU) and the Swedish University for Agricultural Sciences (SLU). The employees are formally employed at either university. The whole of CBA is administrated through UU.

The main activities of CBA is graduate education and research. During 2001 we "produced" four Doctors and two Licentiates, divided between the three faculties where we have PhD programmes — Science and Technology (TN) at UU, Forestry (S) and Agriculture, Landscape planning and Horticulture (JLT) at SLU. The personnel at CBA, from both universities, participates in undergraduate education, mainly through the large Dept. of Information Technology at UU. There is also an undergraduate course at SLU.

At the end of 2001, there were 23 persons at CBA, 11 of which are PhDs and 11 graduate students. We were also main supervisors for three PhD students at other universities (see Section 2.3). The number of PhDs will rapidly decrease, as most of the new Doctors will leave for jobs in industry.

This year was a year of examinations, as suggested above. There were three dissertations at SLU, two at the S-faculty (Mattias Moëll and Stina Svensson), one at the JLT-faculty (Anna Rydberg), and one at the TN-faculty (Roger Lundqvist). There were also two Licentiate exams at the TN-faculty. This is of course not the average number of exams, but a consequence of a large influx of money about five years ago. Next year we expect "only" two PhD dissertations, one at each university. Perhaps as a consequence of this, we gave a really exceptional number of reviewed conference presentations and also of other seminars outside CBA.

Image analysis is in its essence interdisciplinary, its foundations being in mathematics, statistics, physics, and computer science, and its applications — in our case — ranging from shape analysis of HIV viruses to detection of coral bleaching in tropical seas. This may seem like a too wide area of research, but in fact we do concentrate on two areas of basic research and applications suitable for these. The areas are volume (three-dimensional) images, e.g., tomographic images of the human body; and hyperspectral images, that is images with up to 200 layers, where each layer represents a very specific colour. Such images are, e.g., used to detect water pollution.

In view of our many different applications it is not surprising that we have extensive contacts both nationally and internationally. The names of at least 21 international and 49 national organisations are found in this report, because we have active co-operation of some kind with them. We are also very active in international and national societies and committees, thus being part of the international community of scientists and also fulfilling the "third" task of the universities.

Since 1993/94 CBA assembles extensive annual reports, that describes in some detail what we have achieved during the year. These annual reports are intended for anyone interested in our work, not only financial sponsors, but users of image analysis in society and industry, co-operation partners, and research colleagues. In addition to this use, the annual reports should be inclusive enough to replace all the different summaries of our activities that a research organisation such as ours are required to give, in more and more detail for each passing year. This is especially true for us, since we belong equally to two universities.

In the next subsection the research at CBA is briefly summarised. A more detailed description of each research project can be found in Section 5. Section 2 describes the organisational and financial aspects of CBA; Sections 3 and 4 our undergraduate and graduate education, respectively; Section 6 lists our publications for 2001, with abstracts of the refereed ones; and Section 7, finally, lists all the various activities that takes place at CBA. Note that each Section starts with a short summary printed in a larger font than the following detailed material.

This annual report is also available on Internet, see
http://www.cb.uu.se/verksamhet/annual_report/AR2001html/

1.2 Summary of research

According to the founding documents, the objective of the CBA is "to create the know-how needed for an operative and sensible use of digital image analysis in society, particularly in the fields of environment, forestry, agriculture and medicine." The research work is organised in three groups: The Image analysis group at UU, headed by Ewert Bengtsson, which works mainly with medical applications; the Aquatic remote sensing group at UU, headed by Tommy Lindell; and the Image analysis and remote sensing group at SLU headed by Gunilla Borgefors, which concentrates on forestry and agricultural applications. Naturally, all groups also conduct basic image analysis research. The order of groups and projects below is arbitrary.

The *UU Image Analysis group* always had its main focus on medical applications of image analysis and visualisation, where tomographic volume images from different sensors and light microscopic images of tissues and cells have been analysed.

Earlier, our work on light microscopy images has mainly focused on absorption images. Recently, we started working also on fluorescent light microscopy images. This has involved two different projects. Together with researchers at the Karolinska Institute, we have developed a new way of extracting information from multiple stainings of the same cells. Together with the company Amersham Biosciences we have developed new methods for automatic cell image segmentation, including automatic splitting and merging to handle overlapping cells as well as new methods for feature extraction. Carolina Wählby and Joakim Lindblad are the two PhD students working on these projects.

The degree of vascularisation in a tissue is known to be of importance in relation to the behaviour of tumours. Our work on quantitative characterisation of the vessel distribution was presented as an invited paper at the International Congress of Cytology this year and as part of the Licentiate thesis by Mikael Vondrus.

Results from our work on 3D tomographic images was this year presented in two theses. In a licentiate thesis by Roger Hult, methods for segmentation and visualization of the brain in MR images was presented. Later, Roger Lundqvist presented a PhD thesis dealing with registration, quantitative analysis and visualization of multi-modality medical images. His results are currently being implemented in the computerised brain atlas which originally was developed some 10 years ago and has been used as a research platform in our work as well as by several medical groups. His work is part of the SSF funded VISIT programme "Fusion of 3D medical images."

A new PhD student, Seyed Rahman Razifar, was accepted jointly with the PET Centre, UU. He will be studying how the multivariate information obtained from PET studies can be analyzed and presented together with the multi-dimensional image data (3D+time).

Inspired by the problems encountered in the segmentation and registration of brain images PhD student Felix Wehrmann, is studying ways of automatically extracting and representing shape features from natural objects.

Another more basic methods development project deals with ways of representing and measuring accurate and precise surface area and volume of 3D digitized objects. This is being done mainly by Ingela Nyström and Joakim Lindblad in collaboration with Jayaram K. Udupa, University of Pennsylvania.

Our new lecturer Fredrik Bergholm has brought a new line of research to CBA in that he is studying a new way of creating optical images that has been given the name plenoscopy and which provides 3D information. Since he is using a microscope for his experiments and since the goal is to obtain 3D data it ties in with our other work on microscopy and 3D methods development.

In a project somewhat outside the image analysis field Ewert Bengtsson is supervising PhD student Anders Hast from Gävle University College, who together with Tony Barrera of Cycore Inc. has been studying how various image rendering algorithms can be implemented more efficiently. Several basic algorithms for shading and bump mapping has been significantly improved.

Some smaller industrial co-operation projects have also been carried out, mainly in the form of Master thesis projects. Thus we have looked at recognition of food products in a refrigerator in co-operation with Electrolux and at detection and automatic reading of number plates in co-operation with Sensys AB.

In support of the different projects at CBA, as well as in order to provide an improved platform for the education in image analysis, we have continued work on our general platform for image analysis, the IMP system.

The research of the *UU Aquatic Remote Sensing group* is focused on different environmental applications. The present activities vary from mapping and monitoring of algae blooms and distribution of plumes in lakes and seas to planning and management of tropical coasts and sea bottoms.

One important area of research is our continued development of image analysis techniques and environmental applications using imaging spectrometry. Much effort has been put into the procedures for pre-processing of remote sensing data and the development of bio-optical modelling for more operational monitoring of water quality from space.

In image analysis a new project on Independent Component Analysis (ICA) of water quality and geological hyperspectral data has been launched. The main researcher is PhD student Hamed Hamid Mohammed.

A big, national, project called RESE (REmote Sensing for the Environment) is focused on methods for detecting changes in aquatic ecosystems and monitoring of algae blooms. This project was built on and continued the work in the successful SALMON project, an EU project on monitoring water quality in European lakes, which was completed in 1999. The long-term goals here are using satellite, together with airborne hyperspectral data, for algae bloom detection, eutrophication, and pollution in Nordic waters. The bio-optical modelling continues to be an important part of the work. At present PhD student Petra Ammenberg is working with these issues.

A new project in this field is devoted towards colour correction of underwater photos in co-operation with the university college in Gävle, where PhD student Julia Åhlén is located.

The co-operation with the Italian groups that participated in SALMON is continuing in ROSALMA - monitoring of chlorophyll and macrophytes from satellites, Garda Lake, Italy. Finally, our work on the detection of coral bleaching from remote sources has continued and also included sensors like SPOT and IKONOS.

The *SLU Image Analysis and Remote Sensing group* has the aim to be a central SLU source for image analysis knowledge. This means that we conduct some basic image research, in addition to being involved in a number of — seemingly rather disparate — applications, from forest inventory via agricultural remote sensing to MR angiography. The main problem in the group has been the lack of seniors. However, from next year we will, for the first time, employ an Assistant Professor (“Forskarassistent”). Another, more recent, problem is that after this years dissertations, we no longer have any PhD student at the JLT faculty.

For a number of years we have developed image analysis methods for agricultural remote sensing. The most recent work is the creation of a multispectral segmentation method for automated delineation of agricultural field borders has been developed. It uses both novel multispectral edge detection techniques and region growing. After the initial segmentation, various procedures are necessary to get the final

result. This work, together with earlier work on precision agriculture, was the main contents of Anna Rydberg's PhD thesis, presented in November.

Forest inventory from air-borne sensors have been an active an productive research field in the group since its beginning in 1994. The aim is to make inventory from such data so detailed and correct that it can replace field inventories, except for small investigations to collect ground truth. At present PhD student Mats Erikson is working on counting the number and sizes of trees in high resolution CIR aerial images. Species identification is the next goal.

We also work on forests at a completely different scale. For the forest industry to be able to maximise the use of the wood fibre potential, more knowledge of the fibre morphology is needed. We have developed automatic image analysis methods to measure all individual fibres in confocal microscopy images of transverse sections of wood. We measure cell wall width, radial/tangential lumen width, fraction of cell wall area, and degree of compression wood. From 1998, the work has been done in close collaboration with Forest Research New Zealand Ltd. Mattias Moëll presented this PhD thesis on this work in December.

Another fibre project, were PhD student Mattias Aronsson is expected to graduate next year, investigate the fibre network in paper. The ultimate goal is to understand how individual fibres build up the paper and what effect different types of fibre networks have on paper properties. The necessary first stage, at actually produce a volume (three-dimensional) image of paper, is quit difficult in itself but has now been accomplished. The work of shape analysis has started, and here also Stina Svensson is involved. This project is part of the national VISIT programme, funded by SSF, and is done in co-operation StoraEnso Research, Falun and Dept. of Science and Engineering, Linköping University, Campus Norrköping.

Another project, which is also part of the VISIT programme, investigates the uses of grey-level connectivity and fuzzy set theory in two and three dimensional images. The application is mostly arteries-veins separation in magnetic resonance angiography images. Spin-offs also investigate segmentation of other images using the same principles, e.g., classification of stroke in rat brain images and detection of liver cancer metastases. We co-operate within CBA and also with Dept. of Medicine and Care, Linköping University. Our PhD student is here Xavier Tizon.

We also investigate magnetic resonance angiography (MRA) images using our latest theoretical tools. The 3D overall tree structure and the thickness of the blood vessels is modelled using curve skeletons (see below).

Another medical project with volume images is on a very small scale. We investigate the shape of HIV viruses by reconstruction from a series of electron micrograph projections. Another virus application is to segment, classify, and describe Human Cytomegalo Virus transmission electron microscopy (TEM) images of infected cell nuclei. Active in these projects are Ingela Nyström and PhD student Ida-Maria Sintorn.

A Post-Doc stipendiate, Lucia Ballerini, has been working together with Dept. of Food Science, SLU in the FOOD21 programme funded by MISTRA. Mostly, the work has been on composition and quality of meat, using colour photographs and magnetic resonance images.

Also our theoretic work has resulted in a PhD thesis this year. Stina Svensson has been working on digital shape in volume images. The work includes more exact distance transformations in 3D; decomposition of objects into significant parts, here nearly convex parts and elongated parts using distance transforms; and skeletonization. Skeletonization (or thinning) denotes the process where objects are reduced to structures of lower dimension. Objects in 3D can be reduced to surfaces or even to curves. These 3D methods have already been used in several applied projects. Stina Svensson presented her thesis in November. A new direction of the work is extend these methods to unsegmented, grey-level images. The work has been done in co-operation with Gabriella Sanniti di Baja, Istituto di Cibernetica, Napoli, Italy, and Ingela Nyström.

In medical and industrial volume images, the picture elements are often rectangular boxes rather than cubes. It would be preferable to work directly in such grids, rather than interpolating the image to a cubic

grid. PhD student Ida-Maria Sintorn has optimized distance transforms in such grids.

Shape description derived from volume images is usually local. We aim to develop global shape descriptions. If the object is topologically equivalent of a sphere, a parametrization of the object can be obtained. Coordinate functions using a linear combination of spherical harmonics can then approximate the object. Ola Weistrand is working in this area, in co-operation with the Dept. of Mathematics at UU.

Finally, a new PhD student, Nataša Sladoje at University of Novi Sad, Yugoslavia, was accepted in the Fall. She will work on fuzzy shape analysis in 2D and 3D, that is shape analysis on unsegmented, grey-level images

We have also supervised five Master Theses completed this year, of very different contents: Processing images digitized in the hexagonal grid; Evaluation of map tools in Java; Generating real-time maps in vehicles; Analysing video signals for alerting a car driver about road departure and vehicles approaching from behind; and Face recognition and verification.

1.3 How to contact CBA

CBA maintains a home-page on the *World Wide Web* (WWW) both in English and in Swedish. We have tried to make it easy to navigate by giving it a simple structure and layout. The main structure, containing such information as a presentation of CBA, information about the staff, vacant positions, current activities, etc., is continuously updated by the web masters. Web pages containing information about research projects, courses, seminars, this annual report, etc., are managed by other persons at CBA. By having different persons responsible for different parts of the home page and keeping everything together by the main pages, the aim is to keep it informative and up-to-date.

CBA home-page: http://www.cb.uu.se/

If you wish to find current information on seminars, courses,
http://www.cb.uu.se/verksamhet/index_eng.html
is the place to go. Note that our Monday seminar series is open to all interested persons.

In addition to the CBA home page, all personnel have their own home pages, that are linked to the CBA one. On these, you can usually find detailed project information and other interesting things.

CBA can be contacted in the following ways:

Address:	Lägerhyddvägen 17 SE-752 37 Uppsala Sweden
Telephone:	+46 18 471 3460
Fax:	+46 18 553447
E-mail:	cb@cb.uu.se

2 Organization

CBA is a joint entity belonging equally to Uppsala University (UU) and Swedish University for Agricultural Sciences (SLU), but administered through UU. We were at 20011231 a total of 23 persons, 11 of which are PhDs and 11 graduate students, in addition to Master Thesis students and project workers. We also supervise three PhD students employed elsewhere. Two new Doctors and one Post-Doc student will not continue after this year. About half the graduate students belong to each university, but most of the seniors belong to UU. Most of the activity at CBA is similar to any department within a single university, but the administration becomes somewhat more complicated due to our close relation to two different universities.

Of the research income SEK 50% were covered by funds from many different outside sources — a lower percentage but a higher sum than last year. The rest came from the two universities. Our total turnover for 2001 was 11.6 million SEK which is roughly the same as last year.

2.1 Constitution

The CBA was founded in 1988. In 1995 a re-organization of CBA took place to give it its present constitution. We are a joint University entity (due to administrative rules, we can not be denoted "Department") between UU and SLU. The employees are employed at either university, and the PhD students are admitted at any of the three faculties where we have a PhD program — Science and Technology (TN) at UU, Forestry (S) and Agriculture, Landscape planning and Horticulture (JLT) at SLU. CBA associated with Dept. of Information Technology (IT) at UU regarding undergraduate education, as we are not directly responsible for undergraduate education at there, even though we teach many courses. The whole of CBA is administered through UU.

All personnel (from both universities) is employed directly at CBA, except Lecturers at UU. These are employed by IT, and teach there. Their research activities, however, are carried out at CBA to a degree (usually 25%-75%) which is regulated by individual five year contracts.

The CBA is thus an independent entity within the TN faculty at UU and within the S faculty at SLU, respectively. It is supposed to be directed by a Board appointed by the Vice Chancellor of UU, with representatives from the universities (three each) and the unions (two). The Board is appointed for three years. This period expired in 20010630. When writing this (Feb. 2002) no new Board has yet been appointed.

In between board meetings CBA is headed by a Director appointed by UU and who also serves as Chairman of the board. During this year Prof. Gunilla Borgefors has served as Director, with Olle Eriksson as deputy Director. From 20010701 they have headed CBA without the help of a Board. Up until 20010630 the other Board members were: Ewert Bengtsson UU, Nils-Einar Eriksson TCO, Bengt Gustavsson UU, Anders Hemmingsson UU, Christer Kiselman UU (suppl), Tommy Lindell SACO, Kerstin Lundström SLU (suppl), Thomas Nybrandt SLU.

According to the founding documents the objective of the CBA is "to create the know-how needed for an operative and sensible use of digital image analysis in society, particularly in the fields of environment and medicine." The research work is organized in three groups: The image analysis group at UU which works mainly with medical applications and is headed by Ewert Bengtsson; the image analysis and remote sensing group at SLU headed by Gunilla Borgefors, which works with various applications in forestry, agriculture, and industry, as well as in basic research; and the group in aquatic remote sensing at UU, headed by Tommy Lindell.

2.2 Finances

The CBA is financed through the two universities and through research grants and contracts. Some of the personnel expenses are covered by undergraduate education at UU, mostly by the PhD students of both universities, who teach 20% of their time. (The UU Lecturers teaching is not included in our finances.)

The summary in Table 1 describes our overall economy for the year 2001. Since part of our economy is handled at UU and part at SLU, this summary is based on joining the two accounts and clearing internal transactions between the universities. The numbers are rounded to the nearest 1000 SEK. The same numbers for income and costs are also given as pie charts in Figure 1. Which projects that are financed by whom can be ascertained in Section 5, where each project is listed. The main change from last year is that Governmental grants have sharply decreased, while the contracts have sharply increased. The funding from SLU has also increased, but this is partly

Table 1: CBA income and costs for 2001.

Income		**Costs**	
UU	2231	Personnel	7357
SLU	2642	Equipment	235
UU undergraduate education	1260	Operating exp.[4]	1532
Governmental grants[1]	541	Rent	923
Non-governmental grants[2]	2018	University overhead	1517
Contracts[3]	2299		
Financial netto	97		
Total income	**11088**	**Total cost**	**11564**

1) Sw. National Space Board, Lantmäteriverket

2) MISTRA, SSF, etc.

3) CERN, Electrolux, Amersham Pharmacia Biotech, etc.

4) Including travel and conferences

a temporary effect of bonuses for PhD exams. In the long run, funding from both universities is about equal. Rent and university overhead has increased. The deficit of this year is covered by accumulated funds from previous years.

The total turnover is almost the same as last year, 11.6 MSEK instead of 11.1 MSEK. About 50% of our research activities were financed by outside sources, which was a slight decrease from 2001 (55%). The actual sum is, however, very slightly higher!

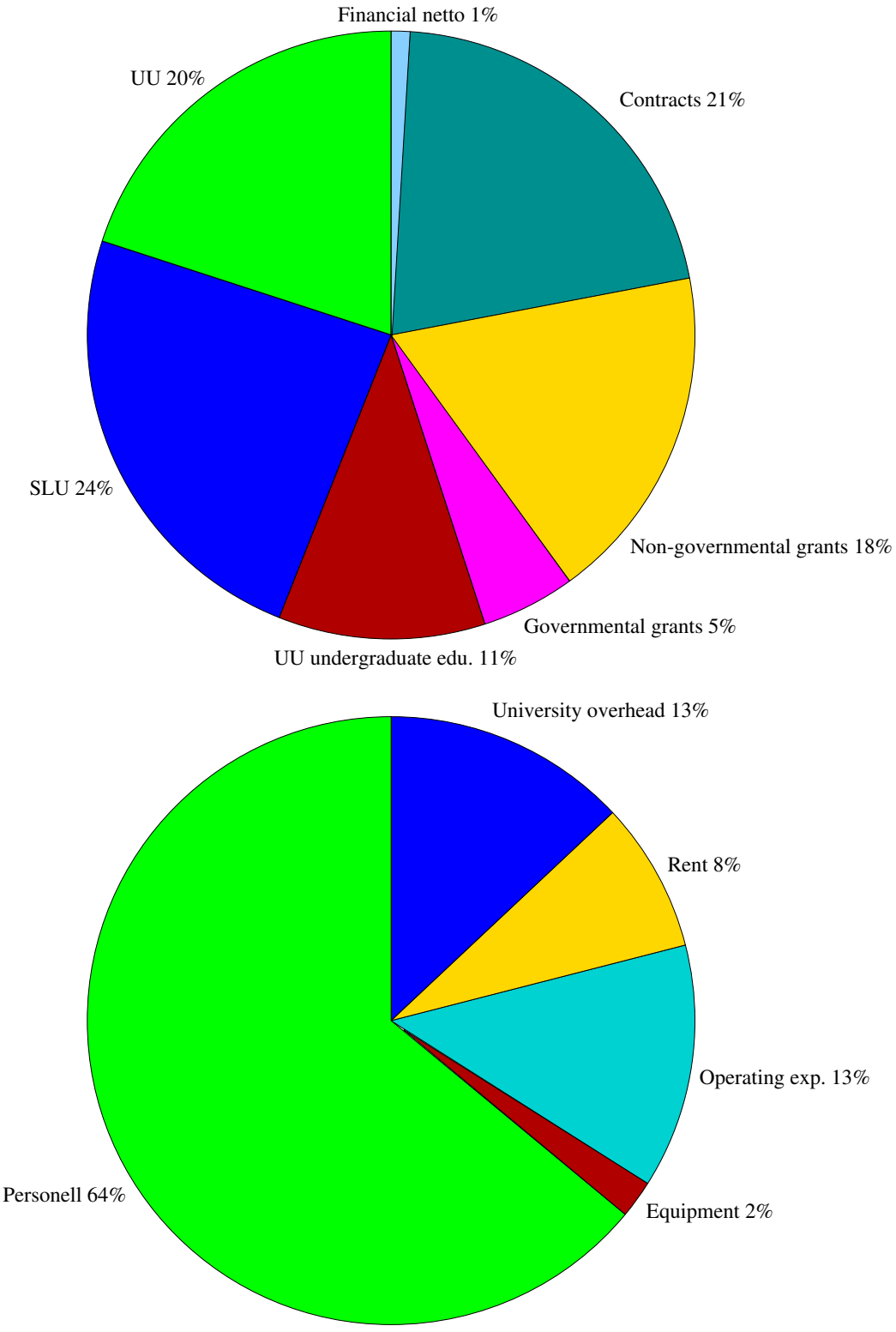


Figure 1: CBA income (top) and costs (below) for 2001.

2.3 Staff

Gunilla Borgefors, Professor, PhD, Director, SLU
Olle Eriksson, Lecturer, PhD, Deputy Director, (part time) UU

Petra Ammenberg, Graduate Student, UU
Mattias Aronsson, Graduate Student, SLU
Lucia Ballerini, Researcher, PhD, SLU
Ewert Bengtsson, Professor, PhD, UU
Fredrik Bergholm, Docent, PhD, UU
Mats Erikson, Graduate Student, SLU
Hamed Hamid Muhammed, Graduate Student, UU
Roger Hult, Graduate Student, –0430, UU
Joakim Lindblad, Graduate Student, UU
Tommy Lindell, Docent, PhD, (part time) UU
Roger Lundqvist, Graduate Student, UU
Mattias Moëll, Graduate Student, SLU
Bo Nordin, Researcher/Lecturer, PhD, (part time) UU
Ingela Nyström, Researcher, PhD, UU
Seyed Rahman (Pascha) Razifar, Graduate Student, 0110–, (part time) UU
Anna Rydberg, Graduate Student, SLU
Ida-Maria Sintorn, Graduate Student, SLU
Stina Svensson, Graduate Student, SLU
Xavier Tizon, Graduate Student, SLU
Mikael Vondrus, Graduate Student, –0930, UU
Felix Wehrmann, Graduate Student, UU
Ola Weistrand, Graduate Student, Dept. of Mathematics, UU
Carolina Wählby, Graduate Student, UU

Lena Wadelius, Administration

Cedric Cano, master thesis
Jonas Sundin, master thesis

Patrick Karlsson, project work
Björn Menze, project work
Per Bengtsson, project work

In addition to the above Graduate Students,
E. Bengtsson is supervisor to
Anders Hast, Dept. of Mathematics, Natural Sciences, and Computing,
University College of Gävle
Julia Åhlén, Dept. of Mathematics, Natural Sciences, and Computing,
University College of Gävle
G. Borgefors is supervisor to
Nataša Sladoje Matic, Faculty of Engineering, University of Novi Sad, Yugoslavia
G. Borgefors is assistant supervisor to
Anders Engqvist, Dept. of Agricultural Engineering, SLU

The letters after the name indicate the employer for each person: UU - Uppsala University, SLU - Swedish University of Agricultural Sciences. The e-mail address of the staff is `Firstname.Lastname@cb.uu.se`.

3 Undergraduate education

An undergraduate course in basic image analysis was given at SLU for the second time during the Spring of 2001. It is especially aimed at the Forestry Programme and the Natural Resources Programme.

At UU, staff from CBA organizes and participates in many courses, even though we are not the unit responsible for them. We also offer a number of Master thesis projects *(examensarbeten)* each year. Nine were completed during 2001.

3.1 SLU course

CBA organized one undergraduate course at SLU.

1. **Digital Image Analysis A, 5p**
   Examiner: Gunilla Borgefors
   Lecturers: Gunilla Borgefors, Mats Erikson, Stina Svensson
   Application lecturers: Petra Ammenberg, Fredrik Bergholm, Anna Rydberg, Carolina Wählby
   Computer exercises: Stina Svensson
   Period: 0102–0103
   Comment: A course in image analysis for undergraduate students at SLU. Its open to all, but is integrated into the Forestry and Natural Resources Programmes.

2. **Research School of Natural Sciences**
   Lecturer: Ingela Nyström
   Exercise supervisor: Carolina Wählby
   Date: 010806–10
   Address: Alfred Nobel's Björkborn, Karlskoga
   Comment: "Naturvetenskapliga forskarskolan" is a research summer school for 40 students studying the third year of the Natural Science program at a Swedish Gymnasium. During a week, the students listen to lectures by researchers within several fields of the natural sciences. Lecture on image analysis: "Measurements and measuring in digital images."

3.2 UU courses

CBA does not organize undergraduate courses at UU. However, we teach in many such courses, mainly organized through the Department of Information Technology at UU. These courses have dealt with subjects closely related to our research, i.e., Computerized image analysis and Computer graphics. We have also taught courses in programming languages such as C++.

1. **Geoinformatics, MN1, 10p**
   Petra Ammenberg
   Period: 001105–010118
   Comment: Course in remote sensing, GIS, geodesy and cartography at Dept. of Earth Sciences. Petra Ammenberg was responsible for the lectures and exercises in Remote Sensing and introduction to geodesy-GPS.

2. **Mathematics and statistics with computer aided learning, 10p**
   Hamed Hamid Muhammed
   Period: 0101–0103
   Comment: Computer exercises and assignments using Matlab

3. **Computer Programming, 4p**
   Mats Erikson
   Period: 0102–0105
   Comment: For chemistry students

4. **Digital Image Analysis, TF and**
   Computer Assisted Image Analysis, MN1, 5p
   Carolina Wählby, Xavier Tizon
   Exercises: Mattias Aronsson
   Period: 0103–0105
   Comment: Due to participating exchange students, all lecture notes were in English.

5. **Computer Programming I, 4p**
   Ida-Maria Sintorn
   Period: 0103–0105

6. **Computers and Programming, first course, 5p**
   Ida-Maria Sintorn
   Period: 0109–0111

7. **Computer Graphics I, (MN1, IT3, DV1), 5p**
   Fredrik Bergholm
   Period: 0103–0105
   Comment: Textbook: Interactive Computer Graphics (Angel). Fredrik Bergholm was examiner and held 11 lectures (of 18).

8. **Numerical Methods I, 4p**
   Fredrik Bergholm
   Period: 0102–0105
   Comment: Course given at KTH, Stockholm. Intended for students in chemistry.

   Computer Programming I, 4p
   Roger Lundqvist
   Period: 0104–0105
   Comment: For students attending the “Environment and water” program.

9. **Algebra and Geometry, 5p**
   Ola Weistrand
   Period: 0101–0103
   Comment: 20 problem sessions for the Chemical Engineering program.

10. **Linear Algebra**
    Ola Weistrand
    Period: 0104–0106
    Comment: 20 problem sessions for the Chemical engineering program.

11. **Computer Programming TDB2, 5p**
    Bo Nordin
    Period: 0103–0106
    Comment: Distance Course. C++ programming, 2nd course.

12. **Object Oriented Programming with C++, 5p**
    Bo Nordin
    Period: 0103–0105
    Comment: Distance Course. Object oriented programming in C++, object oriented analysis and design, data structures.

13. **Object Oriented Programming with Java, 5p**
    Bo Nordin
    Period: 0106–0108
    Comment: Distance Course. Object oriented programming with Java, object oriented analysis and design, data structures.

14. **Computer Programming TDB1, 5p**
    Bo Nordin
    Period: 0109–0110
    Comment: Distance Course: C++ programming, 1st course, about 30% of the lectures.

15. **Computer Programming MN1, 5p**
    Felix Wehrmann
    Period: 0109–0112

16. **Computer Programming TDB2, 5p**
    Bo Nordin
    Period: 0110–0201
    Comment: Distance Course. C++ programming, 2nd course.

17. **Computerized Image Analysis MN2, 5p**
    Ingela Nyström, Ewert Bengtsson, Fredrik Bergholm
    Period: 0110–0112
    Comment: Continuation course on image processing using the book by Sonka et al. Three computer exercise on filtering, snakes (with help of Xavier Tizon), and fuzzy segmentation.

18. **Computer Graphics 1, 5p**
    Joakim Lindblad, Henrik Persson
    Period: 0110–0112
    Comment: Patrick Karlsson was assisting with the assignments. All teaching in English.

3.3 Master theses projects

1. **Remote Sensing of Filamentous Algae in Shallow Waters along the Swedish West Coast**
   Students: Maria Dåverhög, Åsa Lindström
   Supervisor: Petra Ammenberg
   Examiner: Lennart Strömqvist, Dept. of Earth Sciences, Applied Environmental Impact Assessment, UU
   Publisher: Uppsala University School of Engineering, UPTEC W 01 019, 50p., 2001
   Abstract: The aim of this master thesis was to investigate if remote sensing is a feasible monitoring method for detection of filamentous algae in shallow bays along the Swedish West Coast. A satellite image, from the Landsat-7 ETM+, was used as basis for the image analysis. In order to find the algae coverage two different approaches were assessed, supervised classification and classification based on spectral signature. The algae coverage in each bay was calculated. The coverage of algae was compared to the algae coverage calculated from an air photo reference material, taken the same week as the satellite image, made by Kristineberg Marine Research Station.

2. **Real-Time Map Generation and Display for Moving Vehicles**
   Student: Henrik Hindbeck
   Supervisors: Petra Ammenberg, Ingela Nyström
   Examiner: Gunilla Borgefors
   Publisher: Uppsala University School of Engineering, UPTEC IT 01 009, 59p., 2001
   Abstract: This study at CC Systems AB aims to investigate the possibilities of using vector based maps in a real-time environment, where the requirements of update frequency is high and storage space is limited. The vector data is processed in order to reduce storage space and also increase speed when displaying it on the screen. To find the position satellite positioning systems are investigated in terms of accuracy. The properties of commercial vector formats are described. Commercially available GIS applications have been investigated and a demonstration application has been developed.

3. **Processing Methods for Hexagonal Grids**
   Student: Cédric Cano
   Supervisors: Gunilla Borgefors, Bo Nordin
   Examiner: Gunilla Borgefors
   Publisher: Uppsala University School of Engineering, UPTEC F 01 019, 41p., 2001
   Abstract: This thesis will show how traditional processing methods on the square grid can be implemented using a hexagonal grid. The coding part as been done in C++ on a Digital Unix system powered by an alpha processor, as a set of functions extending the already existing image processing software IMP++ developed by the Centre for Image Analysis at Uppsala University, Sweden. For some algorithms we will be able to compare the result between hexagonal and square processing subjectively with the existing

hexagonal resample and display simulation. Generally we will try to see the difference in speed and number of operations.

4. **Vision Based Road Departure Alarm and Lane Change Aid**
   Students: Anders Lingvall, Mattias Björkman
   Supervisors: Bert-Eric Tullson, Sigvard Brodén, CelsiusTech Electronics, Järfälla; Gunilla Borgefors
   Examiner: Gunilla Borgefors
   Publisher: Uppsala University School of Engineering, UPTEC F 01 021, 122p., 2001
   Abstract: This thesis investigates the possibilities to use a camera sensor in an automotive application. Two different applications have been investigated. The first is a *Road-departure-alarm*, which is intended to warn the driver if he is about to depart from the roadway, or if he departs the current lane without signaling. The other application is a *Lane-change-aid* system, which warns the driver to not change lanes if there are approaching vehicles in the overtaking lane. The Road-departure-alarm is based on perspective analyses of the road boundaries extracted from the colour-classified roadway. The data is used to estimate the road propagation, the road and lane width, and the lateral position of the vehicle. An algorithm for detection of road markings is later used to verify the current lane position. The method yields promising results in most road environments. There are however, difficulties in flat light and low light conditions, e.g., snow, mist, and night conditions. The Lane-change-aid system is built on two main concepts, namely optical flow and a priori road knowledge. The a priori road knowledge consists of five main items, IPT (Inverse Perspective Transformation), colour classification, curvature compensation, vehicle extraction, and target following. Colour classification is used for extraction of the road curvature. The vehicle extractions is performed using three alternative methods, the dark region extraction method, the difference-image method, and the IPT-optical-flow method. All three of them work well but the most general one is the difference image method.

5. **Identification of Food Packages Through Image Analysis**
   Student: Jonas Sundin
   Supervisor and Examiner: Ewert Bengtsson
   Publisher: Uppsala University School of Engineering, UPTEC F 01 061, 23p., 2001
   Abstract: The first part of this thesis will analyze the ability of a computer vision system to derive properties of three-dimensional (3-D) physical objects from viewing two-dimensional (2-D) images. The second part will examine the implementation of such a system used for object recognition in a closed volume.

6. **Biometrics: Face Verification/Recognition**
   Student: Alexander Lakic
   Supervisors: Charilaos Christopoulos, Ericsson Radio Systems, Media Lab, Kista; Gunilla Borgefors
   Examiner: Gunilla Borgefors
   Publisher: Uppsala University School of Engineering, UPTEC F 01 077, 69p., 2001
   Abstract: Face recognition techniques has a cross-over error of 2.5%. This is considered to be a medium good result when compared to other biometrics such as iris-scanning, fingerprints, hand geometry etc. PCA (Principal Component Analysis) is today one of the most common methods used for face recognition. It is often combined with other methods to make effective recognition. In XM (eXperimental Model), which is a simulation platform for MPEG-7, which in turn is the latest standard in for describing multimedia content, there is a face recognition algorithm implemented using PCA. This method was compared with other search methods (or descriptors) that are part of XM. The other methods were color histogram, color layout, and region-based shape.
   The database that was used for testing consisted of 1355 images of 271 different individuals. Images were manually normalized before used for testing. By measuring the average retrieval accuracy it was clear that the face recognition algorithm outscored the other methods. The average retrieval accuracy for face recognition was 0.8120 (where 1.0 is the optimal result) compared to the other three methods that had an average retrieval accuracy of 0.5475.

7. **Java och karthantering — Map Tools in Java**
   Student: Åke Helgstrand
   Supervisors: Björn Alstréus, CelsiusTech Electronics, Järfälla; Gunilla Borgefors
   Examiner: Gunilla Borgefors
   Publisher: Uppsala University School of Engineering, UPTEC F 01 092, 33p., 2001
   Abstract: Initially this master's thesis evaluates map tools in the programming language Java. When the

decision was made by CelsiusTech Electronics to choose the software StriWeb, a separate layer was constructed to examine the robustness and speed. The conclusion is that the new program Lightgis, based on StriWeb, is a powerful map tool for Java.
Comment: Thesis in Swedish.

8. **Implementation and Evaluation of a Person-Tracking System**
Student: Johan Olofsson
Supervisors: Ingela Nyström, Fredrik Bergholm, José Luis Gordillo, Centro de Inteligencia Artificial, ITESM, Monterrey, Mexico
Examiner: Ewert Bengtsson
Publisher: Uppsala University School of Engineering, UPTEC F 01 095, 28p., 2001
Abstract: This thesis work describes an implementation of a vision system with the purpose to track a person walking in front of a camera. No artificial landmarks are used and the assumptions about the background and the person's clothes are very few. The modality which is used to distinguish object from background is motion and one condition is that there is enough texture to allow for motion estimation. The non-rigidity of a person generally makes the task more difficult, but the algorithm used in this implementation does not depend on rigidity. The system was designed to handle a moving camera, but it was, however, found hard to achieve stability in this case. For a fix camera, though, the algorithm is able to track a person for long periods.

9. **Automatic License Plate Detection**
Student: Patrick Karlsson
Supervisor: Joakim Lindblad
Examiner: Ewert Bengtsson
Publisher: Uppsala University School of Engineering, UPTEC F 01 098, 40p., 2001
Abstract: This M.Sc. Thesis work addresses the problem of locating a license plate within an image. This problem arises in automatic surveillance systems, e.g., in traffic monitoring, and automated car parks. The author presents a background research and then proposes a robust and highly accurate method of solving the problem. The solution is implemented in the image analysis software IMP (developed at the Centre for Image Analysis in Uppsala, Sweden).

10. **Parameterisation of the Size Distribution of Biofuel (wooden Aggregates) by Means of Image Analysis**
Student: Björn Menze
Supervisors: Lennart Säterberg, Vattenfall Utveckling AB, Älvkarleby; Ewert Bengtsson
Examiner: Ewert Bengtsson
Published: 2001
Abstract: For image analysis all processed information has to be content of a picture. To attain the needed information about the biofuel from the images, a out-spreading of the fuel is the biggest demand to the appearance of the pictures, to the way they are taken, and so to a possible incorporation of image analysis in a working or production environment.
Single biofuel particles forming bigger units on the pictures, so called clusters, can be regarded to be the biggest problem in a correct (size-) analysis of the fuel. The most straightforward approach, to take a picture, segment the objects in the picture and analyse the gotten information has been shown to be not practical with the methods of image analysis, chosen for this study.
A second approach used image analysis to generate in short time bigger amounts of data. To characterise the biofuel with typical image analysis parameters in general in a first step, and to work with this characterisation of the data from the picture in a second step, seems to be more promising.
It could be shown, that image analysis gives correct results on the determination of known size distributions - different sieving fractions - over the whole demanded range of size.
Under special circumstances this method could be more 'objective' than sieving results itself.
As an example for the value of image analysis parameters, a special relation between two of them (BtA) could be validated to be a stable characteristic over the whole size range for each of the investigated biofuels.
This parameter shows to be of some importance in the process of eliminating the bias of the clusters. Some results indicate, that a statistical approach, basing on the data provided by image analysis, could be the most promising next step in the development of a full biofuel online analysis.

4 Graduate education

This year was a "harvest year" in graduate education at CBA. We had six exams, three Doctors at SLU, one at UU, and two Licentiates at UU. This is of course exceptional. Next year we expect a more normal examination with two Doctors finishing.

At the end of 2001, we were main supervisors for 14 graduate students, nine at UU, three of which are oriented towards remote sensing; and five (together with two were we are assistant supervisors) at SLU. Of these sixteen, eleven are at CBA, while five are employed elsewhere, a proof of our extensive cooperation with other research units. The number of Graduate students is a decrease from last year, readily explained by the six exams.

4.1 Courses

During 2001 the following graduate courses were given:

1. **Discrete Geometry for Computer Imagery**
   Credits: 5 *Period:* 200104–09
   Examiners: Gunilla Borgefors, Ingela Nyström
   Lecturers: Gunilla Borgefors, Christer Kiselman, Ingela Nyström + participants
   Description: The goal of this course was to give an understanding of discrete geometry and its use in image analysis and computer graphics. The course was based on three seminal papers on discrete geometry together with 16 selected papers from "Discrete Geometry for Computer Imagery, Eds. G. Borgefors, I. Nyström, G. Sanniti di Baja, Lecture Notes in Computer Science 1953, Springer-Verlag Berlin 2000." The examination consisted of active participation and oral and written presentations of a specific paper.
   Comments: The written reports are published in "Reviews of scientific papers on Discrete Geometry for Computer Imagery," CBA Internal Report No. 22, 2001.
2. **Application Oriented Image Analysis**
   Credits: 5 *Period:* 200110–12
   Examiner: Gunilla Borgefors
   Lecturers: Petra Ammenberg, Gunilla Borgefors, Ingela Nyström, Stina Svensson
   Computer Exercises: Mattias Aronsson, Hamid Hamed Mohammed, Joakim Lindblad, Anna Rydberg, Ida-Maria Sintorn, Felix Wehrmann, Ola Weistrand
   Description: Introduction to Image Analysis concepts for PhD students that use image analysis in their research. In addition to the 16 two-hour lectures there were four half-day computer exercises.

4.2 Licentiates

1. **Grey-level Morphology Based Segmentation of MRI of the Human Cortex and Applications on Visualisation**

   Roger Hult

   Date: 20010406
   Publisher: CBA Licentiate Thesis No. 5, 24 pages, 2001
   Supervisor: E. Bengtsson
   Opponent: Associate Prof. Arvid Lundervold, Dept. of Physiology, University of Bergen, Norway
   Abstract: This thesis deals with automatic segmentation of the human brain cortex from magnetic resonance images (MRI). In images of the brain it is often important to segment the cortex from non-cortex tissues such as eyes and membranes of the brain. The skin, too, is in the way of viewing the brain. It is not trivial to segment the cortex of the brain as it is connected to extra brain tissue through, for example, nerves, and the connecting tissue often has the same grey level as grey substance or white substance that reside in the brain. There are also applications of the segmentation such as visualisation of activity studies using volume rendering. Today are the volume-images often converted to a set of transparent prints, but manual interpretation may take hours and does not always lead to the same result on the same data set. The reproducibility is important to keep subjectivity to a minimum. In the thesis, one way of converting segmented volume data into a geometric representation is described. The output is used for surface rendering.

2. **Contributions to Computer Aided Image Analysis in Medical Microscopy**
   Mikael Vondrus
   Date: 20011101
   Publisher: CBA Licentiate Thesis No. 6, 17 pages, 2001
   Supervisor: E. Bengtsson
   Opponent: Professor Fritz Albregtsen, Dept. of Informatics, University of Oslo, Norway
   Abstract: Image analysis is a tool with a lot of potential for laboratories and medical institutes working with microscopy for research as well as clinical purposes. However, before it can be fully used in automated systems there are issues that must be addressed. (1) Specimen preparations. (2) Image storing and image coding. (3) Selecting the regions of interest. (4) Image segmentation. (5) Image quantification. This thesis deals with three of these areas.
   The first part deals with segmentation and image storing. The application is called *The Virtual Microscope*, a telemedical application. A virtual microscope is a software connected to a database server, where specimen slides are stored digitally, simulating the functionality of a real microscope. This means it must be able to simulate scanning through a whole specimen without image flickering and change magnification and focus levels. A slide scanned at high resolution, at multiple focal levels and in colour requires several hundreds of Gigabytes in storing capacity unless some compression technique is used. We have proposed a compression algorithm where image segmentation is used as a pre-processing step to highlight the location of cells in the urinary bladder. The algorithm stores only the parts of the image containing cells and not the background.
   The next part deals with segmentation and image quantification. Images from prostate tissue stained with a specific antibody to highlight the blood vessels are analysed. Slides are routinely screened manually by cytotechnologist and histopathologists both when searching for abnormalities and when grading malignancy. The conventional way to grade prostate cancer is according to Gleason grade. Using additional information is of great interest. Such information is the density and distribution of blood vessels in the tumour. Our contribution is a method that tries to assess the tissue structure by observing spatial relations between blood vessels.
   The last part also deals with segmentation, but instead of using a transmission light microscope, images from CHO-cells stained with calcein were taken with a flourescence microscope and later segmented. We have developed a sequence of processing steps combined with a statistical quality measure which is used to decide whether an object looks like a cell or not. Drug companies spend many years on research for a new drugs. Therefore, the requirement for high throughput screening is crucial and demands fast and reliable segmentation algorithms.

4.3 Dissertations

1. **Multispectral Image Analysis for Extraction of Remotely Sensed Features in Agricultural Fields**
   Anna Rydberg
   Date: 20011109
   Publisher: Acta Universitatis Agriculturae Sueciae. Agraria 296. ISBN 91-576-5803-X, 55 pages, Uppsala 2001
   Supervisor: G. Borgefors
   Opponent: Professor Jussi Parkkinen, Dept. of Computer Science, University of Joensuu, Finland
   Committee:
   Professor Josef Bigun, IDE, Halmstad University
   Associate Prof. Irene YH Gu, Dept. of Signals and Systems, Chalmers University of Technology, Göteborg
   Associate Prof. Börje Lindén, JVSK, SLU, Skara
   Keywords: field boundaries, precision agriculture, crop characteristics, image analysis, edge and line detection, segmentation, shape, spectral similarity, remote sensing
   Abstract: Remotely sensed images have been used for a long time in agriculture for measuring different crop characteristics. Often, different types of interactive classification systems are used when processing satellite data. Automated extraction of agricultural features from remotely sensed images is of interest in many applications in agriculture, such as, surveillance, precision agriculture, and crop prediction, to mention a few.
   In this thesis, new and existing methods for automated delineation of agricultural field boundaries are developed and evaluated. The different characteristics of field boundaries in remotely sensed images make

it necessary to use several segmentation techniques in order to be able to detect the various boundaries. Therefore, an integrated method for agricultural field delineation is suggested. A multispectral edge and line detection method is presented and combined with multispectral unsupervised segmentation. Spectral similarity as well as shape properties are considered when merging over-segmented regions.
Site-specific spatial relations of growing conditions within a field are also investigated. Site-specific information is of interest for deciding management practices in precision agriculture.
Satellite images can be useful for investigating the possibility of site-specific crop management. However, the within-field variance makes automatic delineation of field boundaries difficult. The proposed method for boundary delineation detects around 80% of the field boundaries in images from several sensors with different resolutions, which is good considering this is an automated method. Due to the fact that the accuracy is data dependent and that presentation of figures on accuracy for boundary delineation is rare in the literature, comparison to other methods is difficult. To be of real use in precision agriculture the accuracy on the boundary location has to be higher, but for per-field classification these boundaries are useful.

2. **Representing and Analyzing 3D Digital Shape Using Distance Information**

   Stina Svensson

   Date: 20011123
   Publisher: Acta Universitatis Agriculturae Sueciae. Silvestria 211. ISBN 91-576-6095-6, 63 pages, Uppsala 2001
   Supervisor: G. Borgefors
   Opponent: Professor Annick Montanvert, L'Institut National Polytechnique de Grenoble, Saint Martin d'Hères, France
   Committee:
   Docent Stefan Carlsson, Dept. of Numerical Analysis and Computing Science, KTH (Royal Institute of Technology), Stockholm
   Professor Gösta Granlund, Dept. of Electrical Engineering, Linköping University
   Professor Christer Kiselman, Dept. of Mathematics, UU
   Keywords: image analysis, volume images, shape description, distance transformation, multiresolution representation, decomposition, skeletonization, fibre network, paper structure
   Abstract: The increase in number and decrease in cost for devices giving digital three-dimensional (3D) images have implied that the number of application areas where 3D images are used has increased lately. In fact, 3D images are important in many medical and industrial applications. Using a computer for analyzing images facilitates quantitative studies of image data. This is even more relevant when dealing with 3D images as they contain huge amounts of data and cannot be directly inspected by humans.
   Many basic image analysis tools used for 2D images are not yet fully developed for 3D images. A goal would be to be able to use all methods introduced for 2D images also for 3D images. With this thesis, we want to fill part of this gap. We deal with algorithms used when the interesting part of the image, the object, has already been identified.
   We present theoretical results on optimization done for computing distances in the image, giving results more stable under rotation without loss of computation simplicity. We also present various shape analysis methods using distance based algorithms. The shape analysis methods included are multiresolution representations of the object, where the object is represented by images at different resolutions, a decomposition scheme for the object, where the object is decomposed into simpler parts, and skeletonization of the object, where the object is represented by a structure of lower dimension.
   Finally, distance based methods are applied to 3D images of paper. The aim is to have a deeper understanding of the 3D geometrical structure of the fibre network and of its effect on the optical and mechanical properties of paper.

3. **Atlas-Based Fusion of Medical Brain Images — Methods and Applications**

   Roger Lundqvist

   Date: 20011130
   Publisher: Acta Universitatis Upsaliensis. Comprehensive Summaries of Uppsala Dissertations from the Faculty of Science and Technology 673, ISBN: 91-554-5180-2, 62 pages, Uppsala, 2001
   Supervisor: E. Bengtsson
   Opponent: Professor Hans Knutsson, Dept. of Biomedical Engineering, Linköping University Hospital
   Committee:

Docent Kerstin Malmqvist, School of Information Science, Computer and Electrical Engineering, Halmstad University
Docent Björn Gudmundsson, Media Group, ITN, Campus Norrköping, Linköping University
Docent Mats Bergström, PET Centre, UU Hospital
Abstract: This thesis focuses on the development of methods for fusion of information from medical brain scans. The concept of medical image fusion refers to the process of extracting and utilising information from several scans simultaneously in the analysis and diagnosis of patients.
One very important part of the fusion process is the image registration, which is used to find a mapping or transformation of points from one image to the corresponding points in another image. This can, for example, be used to correct for relative movements between patient examinations, thus, making direct comparisons between different scans possible. Furthermore, the registration can be used to map images from different individuals into a common standard anatomy. This is important, since it enables comparisons between the individuals and also between whole groups of individuals. In the thesis, both methods to be used for registration between scans from the same individual and for scans from different individuals are presented.
Another part of the thesis is directed towards analysis of brain scans. Most of the methods are based on a computerised brain atlas, which defines a standardised mapping of the brain into sub-regions. These regions are either anatomical or functional and can be used for a more detailed analysis of the brain scan. The presented methods cover general methods for comparisons of single patients with groups of individuals, methods for feature calculations from brain atlas defined regions, and methods for extraction of more advanced features for automatic classification of brain scans.
Furthermore, image visualisation is always an important part in medical imaging. This is because the constantly increasing amount of medical information demands more advanced visualisation techniques to enhance and aid the interpretation of the data. The methods presented in this thesis are focused on combined visualisation of multiple brain scans, which is useful when scans expressing different types of information are available. For instance, a combined visualisation can be helpful to detect anatomical regions of specific functional importance in the brain.

4. **Digital Image Analysis for Wood Fiber Images**

Mattias Moëll

Date: 20011214
Publisher: Acta Universitatis Agriculturae Sueciae. Silvestria 225. ISBN 91-576-6309-2, 26 pages, Uppsala 2001
Supervisor: G. Borgefors
Opponent: Dr Robert Evans, CSIRO, Melbourne, Australia
Committee: Professor Björn Kruse, ITN, Campus Norrköping, Linköping University
Dr Örjan Sävborg, Stora Enso, Falun
Dr Lars Olsson, STFi, Stockholm
Keywords: digital image analysis, confocal microscopy, wood cell measurements
Abstract: The thesis contributes to the field of digital image analysis for applications where fibers in images of wood are analyzed.
Segmentation methods, i.e. the classification of a picture element (pixel) as either cell-wall or lumen, have been investigated. The accuracy of the segmentation process is crucial, since measurements are performed on the objects created by the segmentation. Thus, the better the cell wall classification is the higher the accuracy of the measurements becomes. For good contrast confocal microscopy images, automatic segmentation methods produced excellent results. Images of containing shading artifacts, due to inferior sample preparation, may in severe cases need shading correction to improve segmentation results. Different shading correction methods have been evaluated.
Different morphological characteristics of the wood fibers, which can be measured on cross-sections of wood, significantly affect the properties of wood products. An image analysis system has been developed to automatically measure radial, and tangential lumen diameter, and radial cell wall thickness. A comparison to manual measurements indicated stability and generality of the automatic image analysis method.
A rapid digital image analysis method for compression wood detection has also been implemented. Compression wood detection is of importance, since compression wood affects the overall quality of construction timber and paper quality. Although the method is species dependent, it is considered as a good supplement to wood grading criteria and to other compression wood detection methods.

5 Research

The CBA is conducting a whole range of projects ranging from basic image analysis research to direct application work. By keeping close touch both with the theoretical front line research and with real life application projects, we believe that we make the best contribution to our field. In line with the stated goal for CBA, we have given priority to applications in the fields of biomedicine and the environmental sciences. We have also a number of projects relevant for the forest industry. Most of the application projects are carried out in close cooperation with researchers form other research areas. In Section 5.2 we list the 21 international and 49 national groups with which we have had some operation in 2001. Many are new contacts during the year.

In this section, we list our current 44 research projects and provide a short description of each. We start with basic research projects and continue with applications, loosely grouped by the subjects medicine, remote sensing, industry, and "miscellaneous." Note that even though nine projects were completed during the previous year, we have increased the number of projects, thanks to 15 newly started projects.

For each project we list who at CBA is involved, where the funding comes from, when the project started (and finished), and who our cooperation partners outside CBA are.

5.1 Current research projects

1. **Estimation of intensity non-uniformities in 2D and 3D microscope images**
   Joakim Lindblad
   Funding: UU TN-faculty
   Period: 0001–
   Abstract: Intensity non-uniformity (INU), also commonly referred to as shading artifacts, is a common problem in computerized image analysis. Although the INU has limited impact on visual interpretation, it may have a negative effect on image segmentation as well as the interpretation of image intensity values. There exists a range of methods to perform correction of intensity non-uniformities. This project is aimed both at evaluating which methods performs best and under what conditions, and towards finding possible improvements to the existing methods. Although trying to stay general the project is biased toward the applicability to microscope images, mainly of fluorescence stained cells. Under the scope of this project a method to reduce the parameter space of a B-spline based iterative shading estimation algorithm has been suggested and evaluated. The results of this evaluation were presented at the 12^{th} SCIA conference in Bergen, Norway.

2. **Methods to perform automatic selection of optimal or near optimal threshold values**
   Joakim Lindblad
   Funding: UU TN-faculty
   Period: 0001–
   Abstract: The simplest and by far most popular method of separating data into different classes is by thresholding. Although not very elaborate and often too abrupt, it is robust and performs well in many different situations. The problem of selecting thresholds is very general and applicable in a vast range of problems. Still there exist no satisfying general solution to the threshold selection problem. This project addresses the task of finding robust all purpose methods for selecting good thresholds in a general distribution. Inspired by statistics, the use of Kernel Density Estimates (KDE) to threshold distributions at locations of high second derivative has been investigated and shown to be fruitful. The difficult problem still to be solved relates to optimal selection of the width of the kernel function for the estimate. The KDE approach was presented at the SSAB conference in Halmstad, March 2000.

3. **Genetic snakes**
   Lucia Ballerini
   Period: 0107–
   Abstract: Genetic Snakes are active contour models, also known as snakes, with an energy minimization

procedure based on Genetic Algorithms. Genetic Snakes have been proposed to overcome some limits of the classical snakes and successfully applied to medical and radar images. During 2001, they have been extended to colour images and applied to beef meat images. The purpose of this project is to extend the Genetic Snakes model in several directions. First of all, we plan to extend the genetic optimization not only to the positions of snakes, but also to the weights of the energy function. Another interesting extension of genetic snakes could be the evolution of the functionals that control the snake behaviour, i.e., the internal energy determined by the elasticity and rigidity of the snake, and the image energy representing the characteristics of the image (intensity, gradient, *etc.*). Another extension of genetic snakes will be to formulate the snakes model with a multi-scale approach. Finally, an extension to 3D of all the above mentioned methods could be studied.

4. **Modelling of natural objects**
   Felix Wehrmann, Ewert Bengtsson
   Funding: UU TN-faculty
   Period: 9912–
   Abstract: This project started under the scope of the general idea of model-based segmentation. A large number of images, especially from the medical sector, lack a proper description of the objects the image analyst is interested in. Often, this leads to poor results of automated segmentation procedures, if any. Incorporating information about the shape of an object is one possible completion of an object description. However, models that provide shape descriptions usually lack the power to compensate for the variation nature supplies us with. As an example, we could ask ourselves, which features make us easily recognize and localize a brain in a medical 3D image, a task which has automated solutions only in specific cases.
   With the intention to compensate for natural variation, we applied a number of common concepts to the problem. In particular, orthogonal transforms, such as PCA and ICA, have been inspected in an attempt to derive the characteristic correlations between similar shapes. In a second stage, artificial neural networks were applied, however, still not covering the essential features.
   Therefore, our present purpose is to involve a stochastic factor into the concept by means of Markov random fields, and so to overcome some of the limits we encountered earlier.

5. **Accurate and precise size estimators for digitized 2D and 3D objects using local computations**
   Joakim Lindblad, Ingela Nyström
   Funding: UU TN-faculty
   Period: 0012–
   Partners: Jayaram K. Udupa, MIPG, University of Pennsylvania, Philadelphia, USA
   Abstract: Information is irrevocably lost in the process of digitizing a continuous object of the real world to fit the digital world of the computer. Therefore, feature measurements of digitized objects can be no more than estimates. Good estimators are those that approach the corresponding feature value of the continuous original object. The possibility to use only local computations is a desirable property in computerized image analysis, both to keep the complexity level at a minimum, and to enable for parallelism in various ways. This project aims at finding good local estimators for size related measures of digitized objects, i.e., perimeter and area of 2D objects, and surface area and volume of 3D objects. Statistical validation of the estimators have been performed on large numbers of computer generated digitized objects. The breakdown behaviour at very low resolution, as well as the asymptotic behaviour at high resolution have been studied.
   The 2D estimators were presented at the SSAB 2001 conference in Norrköping. A surface area estimator with improved precision and accuracy obtained by optimizing the area contribution locally, will be presented at the DGCI 2002 conference in Bordeaux. The work on enclosed volume of triangulated surfaces, which can be computed efficiently, in the same elegant way similarly to digital surface integration, simultaneously with surface area computation, will be presented at SPIE Medical Imaging 2002.

6. **Global shape description in 2D and 3D by polynomial expansion**
   Ola Weistrand, Gunilla Borgefors
   Funding: TFR; UU TN-faculty
   Period: 9701–
   Partners: Christer Kiselman, Dept. of Mathematics, UU; Örjan Smedby, Dept. of Medicine and Care, Linköping University Hospital
   Abstract: Shape description derived from volume images is usually local, e.g., finite elements, surface facets, and spline functions. This can be a severe limitation on usefulness, as comparison between different

shapes becomes very difficult. In 2D, Fourier descriptors is a successful and often used global descriptor with adaptable accuracy. This concept cannot be immediately generalized to 3D because it relies heavily on the existence of an ordering of the boundary pixels. The aim of this project is to overcome this problem and develop methods for global shape description in 3D. At the moment we study a limited class of objects, those that are homotopic to the sphere. By recursively morphing a sphere to the surface of the object, a parametrization of the object is obtained from a parametrization of the sphere. The method is computationally attractive. Using the object parametrization we can approximate coordinate functions using a linear combination of spherical harmonics, that is a complete orthonormal set of functions on the unit sphere. By aligning the coordinate system along the principal axis of the object we hope to obtain approximately invariant coefficient for objects differing only by a combination of translations and rotations. An example of approximations of an object using this approach is found in Figure 2.

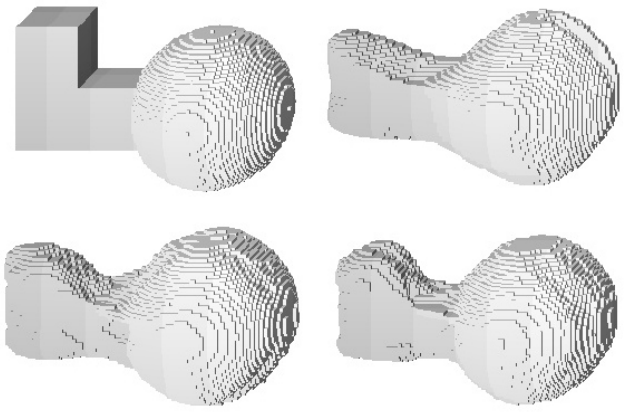


Figure 2: Approximations of an object homotopic to the sphere. Original on top-left. The degrees of the spherical harmonics are 5, 10, and 15, respectively. The number of surface voxels is approximately 15,000.

7. **Decomposition of 3D objects**
   Stina Svensson
   Funding: SLU S-faculty; CNR Italy
   Period: 9801–
   Partners: Gabriella Sanniti di Baja, Istituto di Cibernetica, CNR, Pozzuoli, Italy
   Abstract: Object, or shape, representation is an essential part of image analysis, especially in object recognition. One way of representing an object is to use decomposition into significant parts. Object recognition is thereby a hierarchical process where each part is analysed and recognised individually. Object parts can be obtained in different ways. We use the distance transform of the object and identify therein suitable "seeds" corresponding to the regions into which the object will be decomposed. Starting from the seeds, the object components are obtained by a region growing process. This originates a decomposition into nearly convex parts and elongated parts (i.e., necks and protrusions). During 2002, this resulted in a publications in a proceedings book of an international conference.

8. **Fuzzy shape analysis in 2D and 3D**
   Nataša Sladoje (Matic), Ingela Nyström, Gunilla Borgefors
   Funding: SLU S-faculty, UU TN-faculty
   Period: 0109–
   Abstract: When binary segmentation of a grey-level image is performed, much of the data is destroyed. Moreover, it is often difficult to obtain acceptable segmentation results in the presence of blurring, noise, and background variations.
   It seems that many of these problems could be solved by introducing fuzzy, instead of crisp, segmentation. This means that the image is not first binarized into object and background, but the analysis is performed directly on the original grey-level image. As a consequence, it becomes important to develop shape description methods, as well as other image analysis methods, that can handle fuzzy segmented images.

The aim of this project is to first create the foundation, since very little has been done to date on shape analysis when segmentation is fuzzy. By now, different approaches of applying fuzzy set theory to the segmentation procedures are analysed, as well as different ways to extend the main binary shape analysis tools (e.g., distance transform, medial axis, notion of convexity, descriptors like perimeter and area of a shape) to fuzzy segmented images. As the next step, these results will be used for further development of the fuzzy shape description methods.

9. **Digital distance transforms in 2D, 3D, and 4D images**
   Gunilla Borgefors, Ida-Maria Sintorn, Stina Svensson
   Funding: SLU S-faculty
   Period: 9309–
   Abstract: In a distance transform (DT), each picture element in an object is labelled with the distance to the closest element in the background. Thus the shape of the object is "structured" in a useful way. Only local operations are used, even if the results are global distances. DTs are very useful tools in many types of image analysis, from simple noise removal to advanced shape recognition. We have investigated DTs since the early 1980's.
   Weighted DTs in 3D have previously been investigated, using information from a $3 \times 3 \times 3$ neighbourhood of each voxel. Now research is concentrated on $5 \times 5 \times 5$ neighbourhoods, where the complexity of the digital geometry poses a real challenge. In a $5 \times 5 \times 5$ neighbourhood, there exists six local distances, denoted a to f in the order of increasing Euclidean distance, compared to three local distances (a, b, c) in a $3 \times 3 \times 3$ neighbourhood. During 2001, one paper was published where we presented optimal local distances when one step is added, compared to the $3 \times 3 \times 3$ case. Moreover, we have performed a study of optimal local distances using from one to six of the local distances, all from the $5 \times 5 \times 5$ neighbourhood. The balls for the optimal local distances for DTs $\langle a \rangle$, $\langle a, c \rangle$, $\langle a, b, c \rangle$, $\langle a, b, c, e \rangle$, $\langle a, b, c, d, e \rangle$, and $\langle a, b, c, d, e, f \rangle$ are shown in Figure 3. The results were presented in the PhD thesis of Stina Svensson, see Section 4.3. Among these, the results presented for DTs using five and six local distances were new.
   More and more applications are moving towards 4D imagery (e.g., a sequence of volume images). Optimal DTs for weighted DTs in $3 \times 3 \times 3 \times 3$ have been computed. They will be published in "Pattern Recognition Letters" in 2002.
   In medical and industrial volume images, the picture elements are often rectangular boxes rather than cubes, because the images are created as a stack of "slices." It would be preferable to work directly in such grids, rather than interpolating the image to a cubic grid. However, DT based methods (among others) are not directly applicable non-cubic grids. Therefore, we have investigated DTs in such grids. Last year, we looked at 3×3 neighbourhoods in rectangular grids in 2D, where the pixels are $1 \times \Lambda$. This year we have extended the optimizations to $3 \times 3 \times 3$ neighbourhoods in 3D grids with elongated voxels, sized $1 \times 1 \times \Lambda$ (two sides are equal to one and the third is larger than one). The expansion to 3D gives rise to four types of regular DTs of which one was further investigated. The results show that the error grows very rapidly with increasing Λ. The use of these DTs are therefore only recommended when either Λ is small or only relative distances and not true distances are needed.

10. **Distance transforms for objects with fuzzy border and their applications in shape representation**
    Gunilla Borgefors, Stina Svensson
    Funding: SLU S-faculty
    Period: 0110–
    Abstract: In most applications, the input data is a grey-level image. The segmentation process, i.e., the process to separate the objects from the background, is often difficult. Thus, it is of interest to work directly with the grey-level images. We have recently started extend bi-level methods we have developed to deal with objects in grey-level images, called *grey-level object*.
    For grey-level objects, we can think of a number of different situations. One reflects an object where the segmentation is rather easy, except for the voxels placed in the border of the object. This is the case for the 3D images of fibres in paper (see Project 41) we are using, where the border of the fibre wall is fuzzy. Assigning the voxels in the border to belong either the object or to the background in a strict way will give an analysis of the object which is noise sensitive. It is possible to decide in what range of grey-levels the border is placed. The result of a bi-level skeletonization algorithm would be completely different if all voxels in the range would be assigned to the object compared to if all would be asigned to the background. Instead the values can be used to describe to what degree the voxels belong to the object and algorithms can be developed taking this into account. By this, we can have a more stable analysis of the object. The project

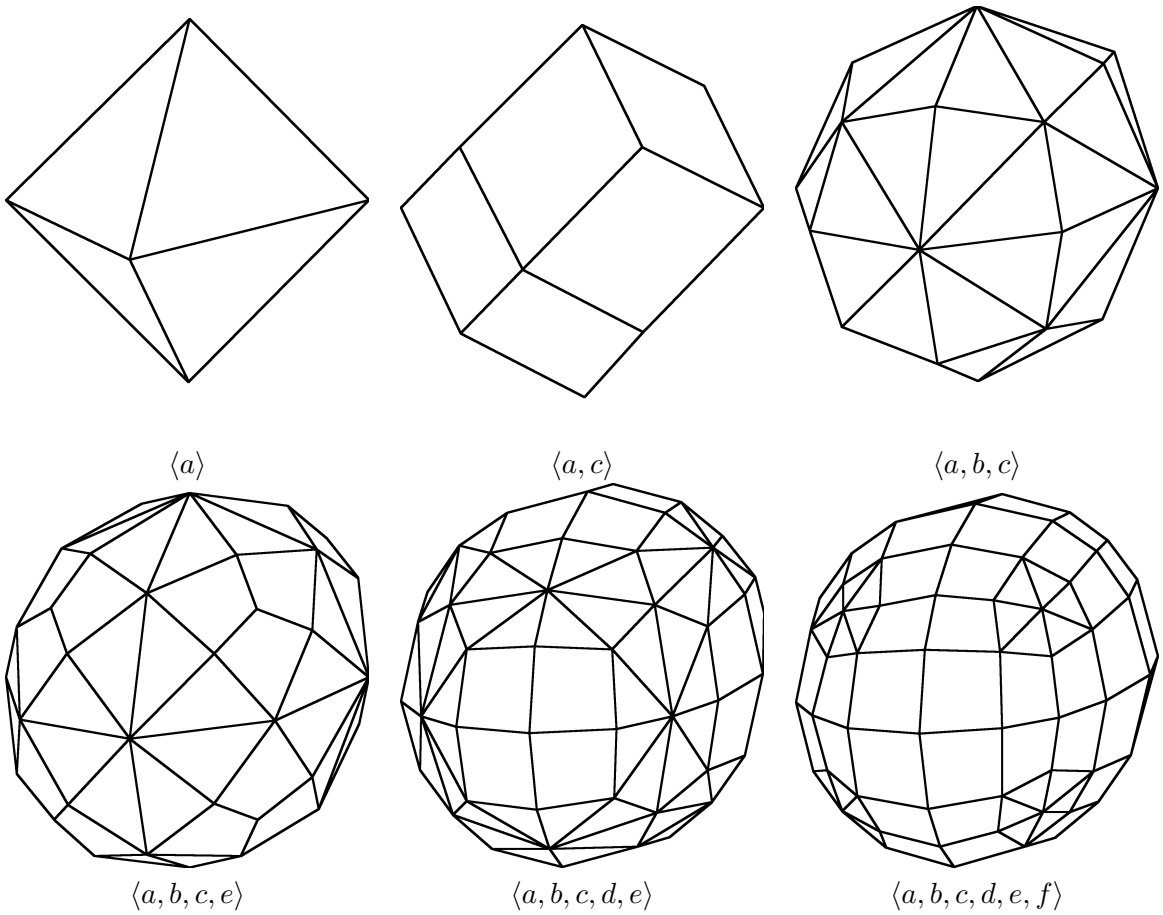


Figure 3: Balls obtained using optimal local distances optimized for each combination of local distances.

is in an early stage but shows good results for skeletonization of 2D objects.

11. **Multiresolution skeletonization in 2D**
Gunilla Borgefors
Funding: SLU S-faculty
Period: 9701–0111
Partners: Giuliana Ramella, Gabriella Sanniti di Baja, Istituto di Cibernetica, CNR, Pozzuoli, Italy
Abstract: Multiresolution structures have proved very useful in image analysis. Depending on the type of analysis performed, in a multiresolution structure the "optimal" resolution can always be used, thus simplifying and speeding up the process. In this work, we concentrate on creating and using multiresolution skeletons. In one approach, we start from a binary image, and build a multi-valued resolution pyramid, in such a way as to preserve shape and topology properties satisfactorily at all resolution levels. This multi-valued pyramid is then used as input data to a grey-level skeletonization algorithm. In this way, a multiresolution skeleton is computed. This work was published in "Pattern Recognition Letters" in May 2001.
In another approach an original pattern is recorded in a binary AND-pyramid to transform it into a multi-scale data set. Skeletonization is applied at all resolution levels and the obtained set of single-scale skeletons constitutes a multi-scale skeleton of the pattern. This initial skeleton pyramid is first analysed bottom-up (i.e., from higher to lower resolution), so that connectedness information can be transferred to smaller resolution levels, where the skeleton subsets corresponding to a single branch could consist of more than one component. The pyramid is then analysed top-down, to establish a parent-child relation between components at successive pyramid levels. As a result, skeleton subsets are suitably ranked, based on their permanence in the skeleton at the various scales, and a hierarchical decomposition of the skeleton is ob-

tained at *all* pyramid levels in accordance with human intuition. This work was published in IEEE PAMI in November 2001.

12. **Skeletonization of volume images**
Ingela Nyström, Stina Svensson, Gunilla Borgefors
Funding: UU TN-faculty, SLU S-faculty
Period: 9501–
Partners: Gabriella Sanniti di Baja, Istituto di Cibernetica, CNR, Pozzuoli, Italy
Abstract: Skeletonization (or thinning) denotes the process where objects are reduced to structures of lower dimension. Skeletonization reduces objects in 2D images to a set of planar curves and objects in volume (3D) images to a set of 3D surfaces. In volume images, skeletonization might furthermore compress the skeleton to a set of 3D curves. Skeletonizing volume images is a promising approach for quantification and manipulation of volumetric shape, which is becoming more and more essential, e.g., in medical image analysis.
We are working with two different approaches for reducing an object to a surface skeleton. The first approach is based on the idea to iteratively thin the distance transform of an object, layer by layer until either an anchor-point is reached or the connectivity breaks. Our definition of an anchor-point is a centre of a maximal disc/sphere, i.e., a "maximum" in the distance transform. The goal is that any (2D or 3D) distance transform could be used. Thus, it would be possible to choose the best distance transform according to the shape of the object. The skeletons produced fulfill the skeletal properties: they are topologically correct, centered within the object, thin, and fully reversible. The last property is rare for 3D skeletons. The algorithm is simple to implement and is not unduly computationally heavy. For 3D objects, an additional criterion compared to the 2D case needs to be introduced. This is necessary to preserve the shape of the object and to obtain a surface skeleton, instead of a mixture of surfaces and "combs of curves". The criterion differs depending on the distance transform. During 2002, an attempt of creating a general framework for different distance transforms was presented in the PhD thesis of Svensson, see Section 4.3.
The second approach is to mark skeletal voxels directly on the distance transform of the object. This method was introduced for 2D images in 1985, but has not been developed for 3D images until now. The idea is to simulate the iterative process using the distance transform. For a reasonable sized object, the skeleton can be found in a smaller number of scans than in an iterative method.
To further reduce the surface skeleton to a curve skeleton, we have developed a method based on the detection of curves and of junctions between surfaces in the surface skeleton. The surface skeleton is iteratively thinned while keeping voxels placed in curves and in (some of the) junctions and voxels necessary for topology preservation. The algorithm can be applied even if the surface skeletons are two-voxel thick (at parts), which is often the case. This is generally not true for other algorithms. The curve skeletonization algorithm was published in a proceedings book of an international conference. Moreover, to show the use of the new curve skeletonization algorithm we have applied it to MRA images, see Project 20.

13. **Medial representation of grey-level images**
Ingela Nyström, Stina Svensson
Funding: SLU S-faculty, UU TN-faculty
Period: 0109–
Partners: Gabriella Sanniti di Baja and Carlo Arcelli, Istituto di Cibernetica, CNR, Pozzuoli, Italy
Abstract: In most applications, the input data is a grey-level image. The segmentation process, i.e., the process to separate the objects from the background, is often difficult. Thus, it is of interest to work directly with the grey-level images. We have recently started to extend our bi-level skeletonization algorithms to deal with objects in grey-level images, called *grey-level objects*.
For grey-level objects, we can think of a number of different situations. One is where it is reasonable to assume that the most important regions of the grey-level object consist of the voxels with the highest grey-level. This can be the case for magnetic resonance angiography, imaging the blood flow in the vessels. The distribution of grey-levels in the vessel may not be symmetric, i.e., the "centre-of-mass" is not centrally located. By using a representation scheme that is adjusted to the regions where voxels with the highest grey-levels are placed, a more reliable analysis can be obtained than if only the distance from the border of the object is considered. It also implies that the segmentation process will not be equally crucial. A region of interest selection including the blood vessel together with a decision on the highest grey-level in the background that can exist is needed. A first study shows good results for skeletonization of 3D grey-level

objects.

14. **Efficient algorithms for computer graphics**
Anders Hast, Ewert Bengtsson
Funding: Dept. of Mathematics, Natural Sciences, and Computing, University College of Gävle; The KK-foundation
Period: 9911–
Partner: Tony Barrera, Cycore AB
Abstract: Computer graphics is increasingly being used to create realistic images of 3D objects. Typical applications are in entertainment (animated films, games), commerce (showing 3D images of products on the web which can be manipulated and rotated), industrial design, and medicine. For the images to look realistic high quality shading and surface texture and topology rendering is necessary. Many fundamental algorithms in this field were developed already in the early seventies. The algorithms that produce the best results are computationally quite demanding (e.g., Phong shading) while other produce less satisfactory results (e.g., Gouraud shading). In order to make full 3D animation on standard computers feasible high efficiency is necessary. We are in this project reexamining those algorithms and are finding new mathematical ways of simplifying the expressions and increasing the implementation speeds without sacrificing image quality. See Figure 4. The project is carried out in close collaboration with Barrera at Cycore AB. During 2001 the work led to three international conference presentations plus a couple of submissions to international journals.

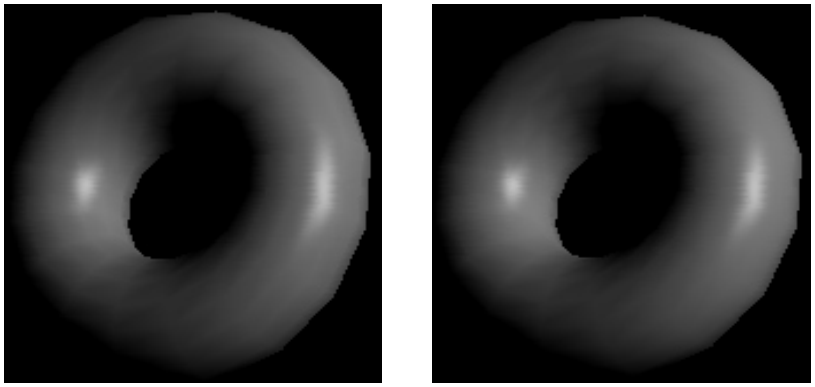


Figure 4: Shading examples: the hybrid shaded torus *(left)* shows more mach bands, while the Euler shaded torus *(right)* shows better diffuse shading, but at higher computational cost. Both have high quality specular reflections based on our methods.

15. **Plenoscope research**
Fredrik Bergholm
Funding: SSF; UU TN-faculty
Period: 0108–
Partners: Jens Arnspang, Knud Henriksen, Dept. of Computer Science (DIKU), University of Copenhagen, Denmark
Abstract: Plenoscope is an optical invention (SE00/00004) for which we, the inventors, currently pursue patent applications in Europe, America, and Japan, and Swedish patent has been granted. The interesting aspect about plenoscopes, which — crudely — may be described as a lens system equipped with obstacles in the vicinity of the focal plane of the ocular, is that an ordinary camera, video camera, microscope etc. may be converted to a kind of 3D-camera by placing plenoscope in front of the conventional lens system. Thereby, a photographic image with 3D-dependent distortions is obtained. Using image analysis, these distortions may, in principle, be translated into a depth map + ordinary photographic image, alternatively, into a (real time) 3D-visualisation.
Fredrik Bergholm has invented the plenoscope together with Jens Arnspang and Knud Henriksen. Plenoscopes have been used in microscopes, cameras and telescopes showing optically promising results, and

decoded depth differences for fractions of mm in microscopes and detected 50m-depth differences at the distance of 1.5 km, in a plenotelescope.
Plenoscopy represents one of the few really new image creating devices and methods which have been discovered in recent years (through Swedish/Danish university cooperation). The scientific challenge lies in finding out with how high precision the inverse problem (depth-from-plenoscope-image) may be solved by image analysis, refine the optics, and develop a transparent theory for the inverse problem. Image matching in plenoscopy is far more local compared to stereo matching, and plenoscopy seems to be possible analyse mathematically in detail, in a reasonably image independent general fashion. Current work aims at building up the theory behind usage of plenoscopes for depth recovery, and describe image formation. Experiments with microscopes are planned. This project is still in a start-up phase, with only 1–2 man-months spent on theory development, and equipment planning.

16. **Fusion of 3D medical images**
Roger Lundqvist, Xavier Tizon, Ewert Bengtsson, Gunilla Borgefors, Lennart Thurfjell
Funding: Swedish Foundation for Strategic Research, VISIT program
Period: 9707–
Partners: Örjan Smedby, Dept. of Medicine and Care, Linköping University; UU Hospital; Dept. of Nuclear Medicine and Dept. of Neuroradiology, Karolinska Hospital, Stockholm; Dept. of Nuclear Medicine, The Prince of Wales Hospital, Sydney, Australia
Abstract: This is a long-term project where the overall objective is to develop methods to support diagnosis based on 3D medical images. The data sets provided by the latest imaging techniques can sometimes be confusing to interpret for the physicians, mainly because of the complexity of the 3D structures visualised and the lack of sufficiently informative visualisation techniques. The images need to be presented to the physicians in such a way that they can be easily and correctly interpreted, but without removing essential information. In particular, we concentrate on the development of new methods for registration, diagnosis, visualisation, and segmentation.

Fusion of brain images
One part of the project is focused on analysis of PET, SPECT, MR, and CT brain images. We have developed voxel-based registration methods, both for rigid registration of data from different examinations of the same patient and for non-rigid registration of data from different individuals.
The rigid registration methods can be used to fuse information acquired from different imaging modalities to improve medical diagnosis. One example is from patients suffering from epilepsy where an examination may contain both SPECT and MR scans and a fusion of the two scans enables accurate determination of the location of the epileptical foci.
Another important part throughout the fusion project has been a computerised brain atlas, which maps the human brain into anatomical and functional regions. During 2001, improved methods for atlas-based analysis and also more accurate image registration methods have been developed.
The brain atlas technique has also recently been used in a project aiming to quantify the effects from carotid endarterectomy on patients suffering from carotid artery stenosis. Selected vascular brain atlas regions were used to measure the differences between preoperative and postoperative SPECT scans. Finally, the measured differences were correlated to other observed variables describing the outcome of the operation. Previously, the brain atlas has also been used for discrimination from SPECT scans between patients suffering from Alzheimer's disease and normal controls subjects.
Moreover, during the last year improved methods for combined 3D visualisation of volume images has been developed. The new methods enables visualisation of information from different imaging modalities together in the same rendered image. Furthermore, methods has been developed to incorporate atlas structures into the 3D visualisation, which enables more accurate localisation of different features in the image data. See Figure 6.
In November 2001 this work was presented and defended as a PhD thesis by Lundqvist. See Section 4.3.

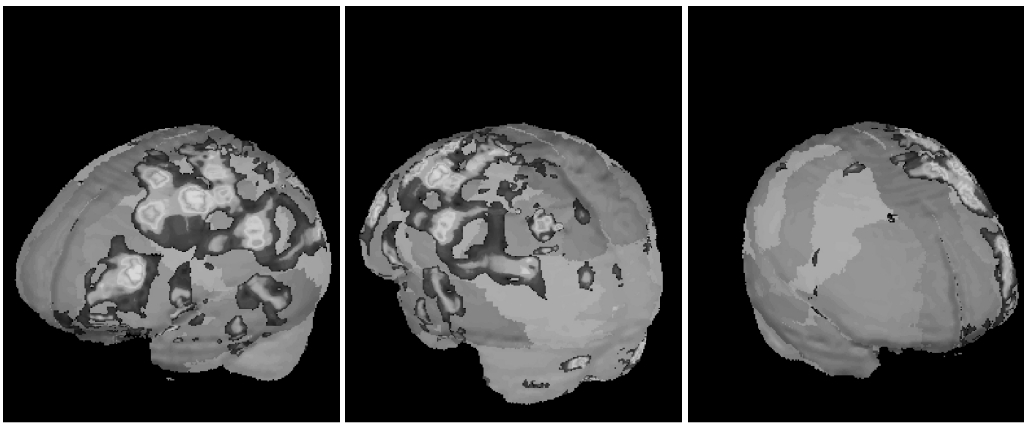


Figure 5: An atlas-labelled rendering of an image expressing differences in blood perfusion between two different groups of individuals. The high intensity values on the brain surface correspond to regions where the perfusion is decreased relative to a normal control group. Moreover, a number of vascular atlas structures are visible at the brain surface, which can be used to better localise the areas where the decreased perfusion is located.

Arteries-veins separation in magnetic resonance angiography images
Another part of the project aims at selecting a subset of volumetric data, and to present it in such a way as to make diagnosis easier. As an example, in magnetic resonance angiography (MRA), it is of great interest to be able to separate arteries from veins. This problem is not trivial, because the vessels can lie in close parallel throughout the image. Our algorithm extends the concept of binary connectedness by using a grey-level connectedness approach using fuzzy sets. We join together voxels that have high "hanging-togetherness", i.e., which form a coherent set in terms of grey-level variation. As a start set we use markings set by the operator. A journal paper on the general principles has been accepted for publication. An illustration is found in Figure 7. Good user interaction possibilities, portability and reusability are important concerns in this project, and that is why we chose to use public domain packages: the Visualization Toolkit (VTK) and the Insight Segmentation Toolkit.

Figure 6: Volume rendering of fuzzy connectedness segmentation performed on blood vessels of the neck and head. We can visualize carotid and vertebral arteries, after removal of the unwanted vessel structures (the jugular veins have been removed).

17. **3D medical image analysis based on a computerised brain atlas**
Roger Hult, Ewert Bengtsson, Lennart Thurfjell
Funding: NUTEK, UU TN-faculty
Period: 9501–0104
Partners: Depts. of Neuroradiology and Clinical Neurophysiology, Karolinska Institute and Hospital, Stockholm; Dept. of Physics, Stockholm University; PET Centre, UU

Abstract: The objective of this project is to develop new tools for analysis and visualisation of neuroimaging data. These tools are partly integrated in a computerised brain atlas. The work during the last years has been focused on segmentation of MR images and visualisation of functional information on the segmented volumes. A segmentation method based on connectivity analysis and morphology has been developed. The goal is to have a robust three-dimensional method for segmentation of the brain in MRI data. See Figure 7. The project is carried out in close collaboration with the medical partners. Several articles were presented at international reviewed conferences and a licentiate thesis was presented in April 2001 by Hult. See Section 4.2.

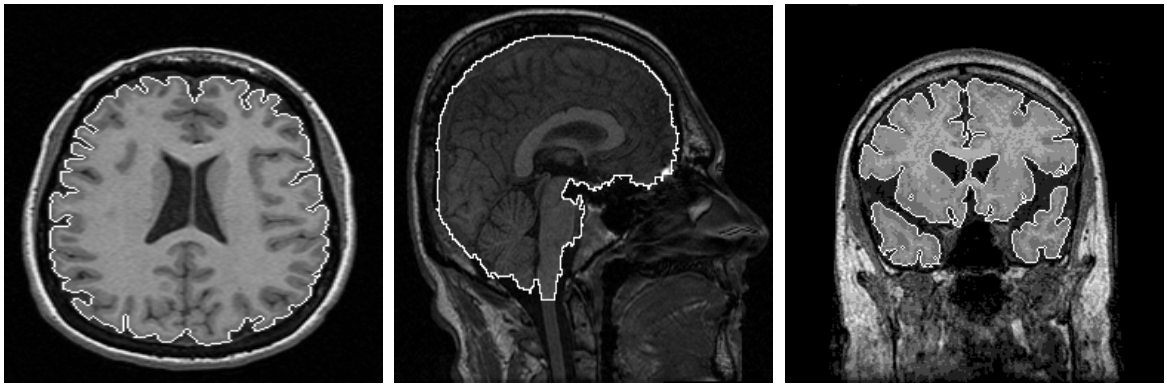


Figure 7: *Left:* A segmented slice from a T1 weighted Transversal MRI data set. *Middle:* A segmented slice from a T1 weighted Sagittal MRI data set. *Right:* A segmented slice from a T1 weighted Coronal MRI data set.

18. **3D medical image analysis of MRI images of the brain for psychiatric research**
Ewert Bengtsson
Period: 0105–
Partners: Roger Hult, Håkan Hall, Ingrid Agartz, Dept. of Clinical Neuroscience, Karolinska Institute and Hospital, Stockholm; Stefan Arnborg, NADA, KTH, Stockholm
Abstract: This is part of a larger project with the objective to perform research on the brain to find new solutions and treatments for brain diseases. The project HUBIN (Human Brain Informatics) is an interdisciplinary project that for the time being is focusing on schizophrenia and started in 1998. Within HUBIN there are several projects and the aim for the image analysis project is to be supportive in using the software BRAINS2. Tools for segmenting structures in the brain are also being developed and implemented in the BRAINS2 software. The software uses ANN (artificial neural networks) to segment structures in the brain. The project is carried out in close collaboration with the medical partners.

19. **Simultaneous visualisation of 3D anatomical and multidimensional physiological information - with application to positron emission tomography**
Pascha Razifar, Ewert Bengtsson
Period: 200110–
Funding: PET Centre, UU; UU TN-Faculty
Partners: Mats Bergström, Harald Schneider, PET Centre, UU
Abstract: Within this project existing methods for visualising 3D anatomical information and methods for visualising multidimensional features as scatter plots etc. will be extended and integrated into a coherent tool for interactive exploitation of these highly complex data. One concept that will be investigated is how the anatomical information can be visualised in the clusters pace through spectral and temporal methods. The work will be based on sequences of PET images from various tracer studies.
The motivation for this work is the highly complex data sets that are obtained from PET studies and which are difficult to fully interpret with currently available tools. New ways of interacting with the data that preserves the anatomical context at the same time as it allows flexible exploitation of the many feature dimensions should have a potential of providing most useful tools. The project was defined during the second half of 2001 and is thus in an early phase.

20. **Skeletonization applied to magnetic resonance angiography images**
Ingela Nyström, Stina Svensson
Funding: UU TN-faculty, SLU S-faculty
Period: 9703–
Partners: Örjan Smedby, Dept. of Medicine and Care, Linköping University Hospital
Gabriella Sanniti di Baja, Istituto di Cibernetica, CNR, Pozzuoli, Italy
Abstract: For interpretation and analysis of magnetic resonance angiography (MRA) images, the 3D overall tree structure and the thickness of the blood vessels are of interest. One way to obtain this shape information of the vascular system is by utilizing the curve skeleton of the blood vessels as they are thin elongated objects and, hence, well suited for reduction to curve skeletons. Positions for possible artery stenoses may be identified by locating local minima in the curve skeletons, where the skeletal voxels are labelled with the distance to the original background.
MRA images are usually presented as maximum intensity projections (MIP), and the choice of viewing direction is then critical for the detection of stenoses. We use a method which visualizes variations in vessel width independent of viewing direction. Each voxel in the curve skeleton is surrounded with a sphere of radius corresponding to the distance value, i.e., half the minimum diameter of the blood vessel at that level. The method has been presented in an international journal this year.
We have verified our novel approach to curve skeletonization (see Project 12) based on the detection of junctions and curves in the surface skeleton on thoracic data sets. This procedure results in a good description of the tree structure of the vessels, represented with a much smaller number of voxels. See Figure 8. This representation is suitable for further quantitative analysis, e.g., measurements of vessel width and length. The work was presented at an international conference.

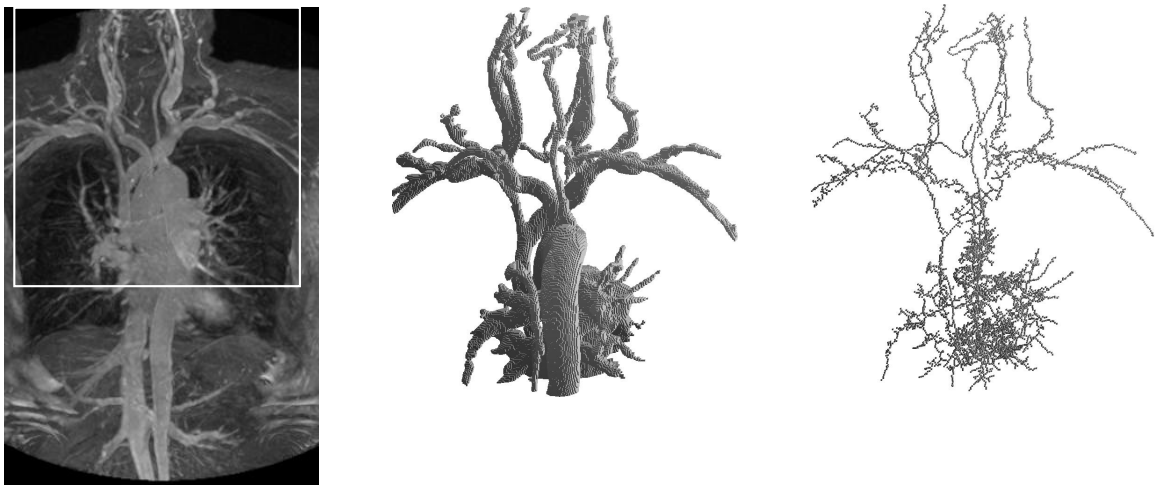


Figure 8: MIP of a thoracic MRA image (left). Rendered 2D projections of the segmented vessels (middle) and the corresponding curve skeleton (right).

21. **Classification of blood flow images of rat brains with fuzzy C-Means clustering**
Xavier Tizon, Gunilla Borgefors
Funding: Swedish Foundation for Strategic Research, VISIT programme
Period: 0103–
Partners: Anders Ericsson, Dept. of Oncology, Radiology, and Clinical Immunology, UU Hospital
Abstract: Stroke, often called “brain attack,” occurs when a blood clot blocks a blood vessel or artery, or when a blood vessel breaks, interrupting momentarily blood flow to an area of the brain. To study the recovery of the brain after stroke, we induce surgically a transient ischemic attack on a series of rats. We then perform Diffusion Weighted Imaging of the rat brains during the few minutes following the stroke, and after a certain period of recovery time. Segmentation of the infarcted region is done using a fuzzy C-Means algorithm, see Figure 9.

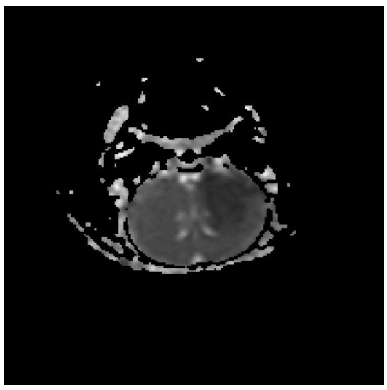
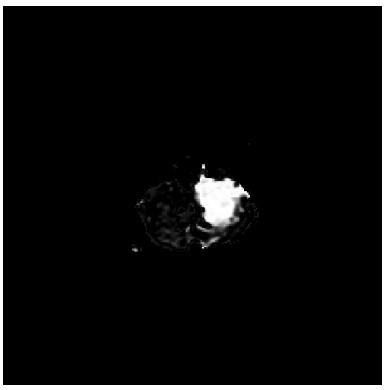



Figure 9: (a) The Apparent Diffusion Coefficient (ADC) map of the rat brain. Notice the somewhat darker zone in the right part of the brain. This is the infarct. (b) A false colour mapping of the membership functions of each image point with respect to the infarct. We can this way visualize the fuzzy nature of the segmentation process.

22. **Liver cancer grading by segmentation of liver metastasis**
Xavier Tizon, Gunilla Borgefors
Funding: Swedish Foundation for Strategic Research, VISIT programme
Period: 0108–
Partners: Sven Nilsson, Dept. of Oncology, Radiology, and Clinical Immunology, UU Hospital
Abstract: The liver is a common site of metastatic disease. The diagnosis of liver metastases in patients at high risk is straightforward, but estimating the gravity is more problematic. We investigate the use of CT scans, see Figure 10. The first problem is to segmenting the liver itself in the CT scan, the second is segmenting the metastases in the liver to evaluate their relative volume. In this pre-study, we investigated the possible methods available to us. The algorithms have to be 3D in nature, but are allowed to include some basic user interaction. Further work implies the use of level-set methods, and/or fuzzy topological algorithms. Our intention is to use the Insight package (see Project 16) to code the chosen algorithm.

Figure 10: Liver metastasis as seen on a CT scan slice of a patient.

23. **Computerized wound image analysis**
Ewert Bengtsson, Bo Nordin
Partners and Funding: CWA Institute AB, Västra Frölunda
Period: 9502–
Abstract: When an open wound is healing a necessary first step is for yellow and black inflammatory and necrotic areas to be cleared and red granulation tissue will become visible before the reepitalisation can take place. Based on this the wound healing process can be monitored through a quantitative analysis of colour photographs of the wounds taken at regular time intervals. This quantitative evaluation of the healing process is of particular interest to pharmaceutical companies developing new wound treatment compounds. Already in 1988–1990, we developed a hardware/software system for this purpose and a new version was

implemented in 1995–1996 and finally in 1998–1999 we added the possibility of working with digital images (rather than scanning colour photographs). Currently, we are discussing the possibility of extending the system to also work with other types of medical colour images.

24. **Quantification of microvessels in the prostate**
Mikael Vondrus, Ewert Bengtsson
Funding: UU TN-faculty
Period: 9901–
Partners: Christer Busch, Dept. of Pathology, University Hospital, Tromsø, Norway; Kenneth Wester, Per-Uno Malmström, Depts. of Surgical Sciences and Genetics & Pathology Experimental Urology, The Rudbeck Laboratory, UU
Abstract: Quantification of microvessel density in prostatic carcinoma is often done by calculating the number of and/or the area outlined by the endothelial cells. The result is expressed in relation to the quantified tumour area. Automatized image analysis quantification of microvessel density has proven to correlate well with manual quantification done by a pathologist. We have observed that the microvessel-pattern is highly dependent on the tissue architecture, which in turn depends on the distribution and size of the prostate glands. This indicates that, besides microvessel density, also microvessel pattern may be of prognostic importance in prostate cancer diagnostics. In this project, a new approach to microvessel quantification is tested and evaluated in comparison to malignancy grading and classical microvessel density. In May 2001 some preliminary results from this research was presented as an invited paper at the International congress of Cytology in Amsterdam. The results were also included in Vondrus licentiate thesis presented in October 2001 (see Section 4.2).

25. **Segmentation and analysis of biological 3D shapes**
Carolina Wählby, Ewert Bengtsson
Funding: Swedish Foundation for Strategic Research, VISIT program
Period: 9806–
Partners: F. Erlandsson and A. Zetterberg, Dept. of Oncology/Pathology, CCK, KI, Stockholm
Abstract: Shape and distribution of various subcellular structures and components can be observed by immunostaining and insitu-hybridization of fluorescent markers followed by fluorescence microscopy in three dimensions. The 3D images are acquired by making non-invasive serial optical sections of the object. Studies of the distribution of signaling-factors involved in the cell cycle control indicate that minor changes in the signaling systems are the first signs of cancer transformation and tumour formation. Understanding the 3D organization of normal and transformed cell-nuclei is therefore of great interest as a new approach to understanding the pathways of cancer.
A new technique for sequential immunofluorescence staining has been developed in cooperation with the Dept. of Oncology/Pathology, Div. of Tumour Cytology, CCK, Karolinska Hospital and Institute. New methods for analysis of these multi-dimensional data are currently tested. The methods include image registration, semi-automatic segmentation, and normalization. The aim of the project is to examine the relationships between changes in the signaling systems within individual cells, either in culture or in sections of tumours. A second part of this project is carried out in Tomas Gustavsson's research group at the Dept. of Signals and Systems, Chalmers University of Technology, Göteborg.

26. **Algorithms for segmentation of fluorescence labelled cells**
Carolina Wählby, Joakim Lindblad, Mikael Vondrus, Ewert Bengtsson
Funding: Amersham Biosciences, Uppsala and Cardiff, UK; UU TN-faculty; SSF through the VISIT programme
Period: 9902–
Partners: Lennart Björkesten, Amersham Biosciences, Uppsala; Stuart Swinburne, Alla Zaltsman, and Dietrich Ruehlmann, Amersham Biosciences, Cardiff, UK
Abstract: The interaction with and effect of potential drugs on living cells can be observed by fluorescence microscopy. Automated methods for feature extraction from fluorescence microscopy images of cells can be used as a tool in the drug discovery process. The cell nucleus has a well-defined shape and is relatively easy to detect. The cytoplasm is however more complex. The first goal of this project was to develop a fully automatic method for cytoplasm segmentation. The present algorithm, inspired by literature and previous experience, consists of an image pre-processing step, a general segmentation and merging step followed by a quality measure and a splitting step. By training the algorithm on one image, it is made fully automatic

for subsequent images created under similar conditions. See Figure 12. This method was presented at an internal Amersham Pharmacia Biotech R&D conference in Uppsala in late 1999. During 2000 the algorithms were improved through a more elaborated shape analysis and a more consistent feature extraction and quality evaluation step. The results were documented in a journal paper that was submitted for publication in mid 2001. Further developments, mainly aimed at efficiency and increase of speed, were made during 2001.

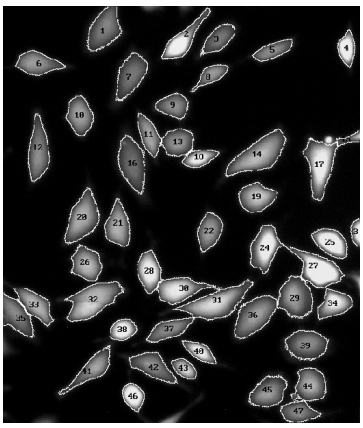


Figure 11: Fluorescence microscopy image of cells growing on a surface and the result of the segmentation algorithm.

27. **Segmentation and classification of Human Cytomegalo Virus**
Ida-Maria Sintorn, Gunilla Borgefors
Funding: SLU S-faculty
Period: 0111–
Partners: Mohammed Homan, Centre for Molecular Medicine, Karolinska Hospital, Stockholm
Abstract: Human Cytomegalo Virus (HCMV) is a rather unknown virus belonging to the herpes virus family. The goal of this project is to segment, classify, and describe virus particles at three different maturation stages from transmission electron microscopy (TEM) images of an infected cell nuclei. The virus particles are to be classified as immature, in between, or mature. See Figure 12. The segmentation is done by template matching for one class at a time. The templates were produced from the images of a number of typical particles of each class. Each class is then described by producing a normalized mean radial grey-tone profile from the particles segmented to each class, i.e., the mean grey-level for all pixels at the same distance from the particle edge was computed for all distances.

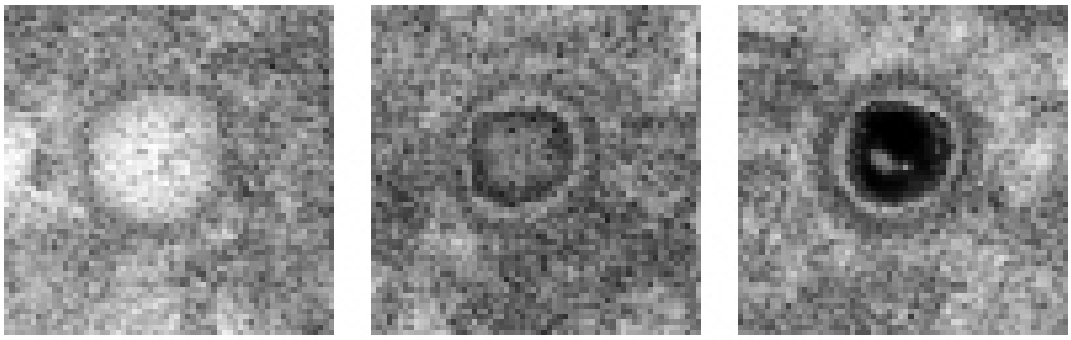


Figure 12: HCMV particles in three stages: immature *(left)*, in between *(middle)*, and mature *(right)*.

28. **3D image reconstruction and analysis of HIV-1**
Ingela Nyström, Ida-Maria Sintorn
Funding: UU TN-faculty
Period: 9906-
Partners: Stefan Höglund, HIV structure group, Dept. of Biochemistry, UU

Abstract: Sample specimens of HIV-1, and HIV-1 treated with the tripeptide GPG, are studied in series of different tilt angles from $+60^\circ$ to -60° with a goniometer in transmission electron microscopy (TEM). A tilt series consists of 25–40 electron micrograph projections. Each of these is digitized. Thereafter, the digital images are aligned, using the coordinates of (some of) the added gold particles (10 nm) as reference points. The 3D reconstruction is made as a series of 2D reconstructions, each a combination of the radius-weighted Fourier transform of one pixel line of each micrograph. The 3D reconstructions are typically of size $256 \times 256 \times 80$ voxels (appr. 5 Mbyte). The goal of the project is to achieve 3D reconstructions of intact and GPG treated single HIV-1 particles for comparison and quantitative analysis through, e.g., convex hull computations. During 2001, we received a number of reconstructions of intact HIV-1 particles of different quality. These must be segmented, and the segmentation results verified, before further analysis.

29. **Automated segmentation of remotely sensed images over agricultural fields**
Anna Rydberg, Gunilla Borgefors
Funding: SLU JLT-faculty
Period: 9602–0112
Abstract: In this project, multispectral segmentation methods for extraction of remotely sensed features in agricultural fields have been developed. An increasing number of satellites, and other sensors, provide more and more information, which creates a need for interactive or even automated analysis of remotely sensed images. Automated extraction of agricultural features from remotely sensed images is of interest in many applications in agriculture, e.g., surveillance, precision agriculture, and crop prediction, to mention a few.
A multispectral segmentation method for automated delineation of agricultural field borders has been developed. Different phenological stages of the crops can sometimes make it difficult to separate different crops by spectral information alone. Multispectral information from different dates is therefore essential, in order to separate areas with similar spectral characteristics. On the other hand, the use of images from different timing introduces the problem of different solar illumination and atmospheric affects, making it hazardous to compare spectral characteristics from one date to another. To achieve good segmentation, it is advantageous to integrate several techniques in order to improve the result of the segmentation. Information from several spectral bands (and/or different dates) can be used for delineating field borders with different characteristics. As a first step in this project, a multispectral edge and line detector is developed. A region growing procedure, which detects additional boundaries, follows this step. This results in an over-segmented image, but over-segmentation is preferable since it is much easier, at a later stage of the process, to merge small regions into a correct region than to split a region. The segmentation is followed two merging procedures, one procedure merging small regions with similar spectral characteristics, and one procedure merging regions according to their shape. A priori knowledge about field shape and size should be taken into account if possible.
This project resulted in Rydberg's PhD thesis, defended in November 2001. See Section 4.3. Results were also presented at the IMVIP 2001 conference in Maynooth, Ireland and at the ICIAP 2001 conference in Palermo, Italy, and some results were presented in the November issue of the journal IEEE Trans. of Geoscience and Remote Sensing.

30. **Automated analysis of forest using high resolution CIR aerial images**
Mats Erikson, Gunilla Borgefors
Funding: SLU S-faculty
Period: 9508–
Partners: Tomas Brandtberg, Dept. of Geology and Geography, West Virginia University, Morgantown, USA
Abstract: The main goal of the project is to develop methods for computerised analysis of high spatial resolution remotely sensed data, i.e., digitised aerial photographs and laser scanning data. A set of 50 research aerial images (digitised colour-IR film), with resolution approximately 10 cm (flight height 600 m, focal length 300 mm) to make the individual tree crowns clearly visible is used. Interesting image features: number and positions of trees, horizontal tree crown area, tree height, and features related to the individual tree species, such as colour and structure (texture). A new fuzzy segmentation method that preserves the structure of the tree crowns has been developed. During the year this has been further developed and also presented at SCIA 2001 in Bergen. In the autumn the method has been evaluated against a manual interpretation of the material. This evaluation included over 8,000 individual trees. The new method was shown to perform better than previous segmentation methods. A journal paper of the evaluation will soon be submitted.

31. **Finding stems in young forests using horizontal laser scanning**
Mats Erikson, Gunilla Borgefors
Funding: SLU S-faculty
Period: 0108–
Partners: Karin Vestlund, Dept. of Forest Management and Production, SLU
Abstract: This is a pilot project on finding stems in horizontal laser images in the forest. See Figure 13 for example image. The goal is to investigate if such images are suitable for automatically selecting trees for cutting by a thinning robot. The image analysis task is to locate and identify young trees in depth images and also find various features to determine if the tree should be cut or not.

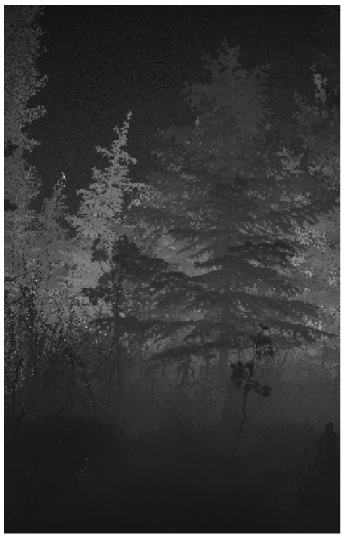


Figure 13: Laser image showing the distance to the objects in the direction away from the laser.

32. **New techniques for information extraction from remotely sensed hyperspectral images**
Hamed Hamid Muhammed, Tommy Lindell, Ewert Bengtsson
Funding: UU TN-faculty, Swedish National Space Board
Period: 0001–
Abstract: Many different substances can be characterised and recognised by their spectral signatures. The benefit of hyperspectral imagery is that a sufficient number of narrow spectral bands is available to be able to accurately determine the spectral response at each pixel in the image. A pixel (or a point spectrum) in a hyperspectral image can be considered as a mixture of the reflectance spectra of several substances that can be found in the (remotely sensed) imaged region. The mixture coefficients correspond to the (relative) amounts of these substances in the studied region. Linear transformation methods can be used to project the hyperspectral data on the basis vectors found by the used transformation. Independent Component Analysis (ICA) and Principal Component Analysis (PCA) have been used to transform the hyperspectral data as a first step to get a new set of data that is more suited for further processing than the original data. The next step is to interpret and use the ICA or PCA results efficiently. This can be achieved by using a new technique called Feature-Vector Based Analysis (FVBA) which has been developed during 2001. The outputs of the transformation step (which are a number of basis vectors and projections of the original data on these vectors) are considered as so called Component-FeatureVector pairs in the subsequent FVBA step. The FVBA task itself is application dependent. But, the common idea of FVBA is to look at the Feature Vectors to understand the corresponding Components. FVBA can be used for four main types of applications. Two of them can directly be distinguished where either well-defined Feature Vectors or well-defined Components are obtained. The other two types of applications are feature extraction and classification. When studying hyperspectral images, the obtained Feature Vectors and the corresponding Components represent the spectral signatures and the corresponding weight coefficients images (the relative concentration maps) of the different constituting substances. During 2001, the work has resulted in two publication at reviewed conferences, one describes FVBA itself, and another one about using FVBA for analysing hyperspectral images. The methods are still under investigation for further development to get better results in addition to trying to construct a fully automatic analysis method.

33. **Remote sensing for change detection and monitoring of Case II and lake waters**
Petra Ammenberg, Tommy Lindell
Funding: Foundation for Strategic Environmental Research (MISTRA), RESE programme
Period: 9701–
Partners: Swedish Meteorological and Hydrological Institute (SMHI), Norrköping
Abstract: The ability to map and monitor water quality parameters in Case II and lake waters is of great environmental interest. Images from spectrographic sensors constitute an important part of such a mapping and monitoring system. The Compact Airborne Spectrographic Imager (CASI) was used to collect images over the archipelago of Stockholm in August 1997. These images have been evaluated in combination with simultaneously collected field data. The work in the archipelago has been concentrated on finding relations between the water quality variables and the reflectance measurements from the field and correlation analysis between field and scanned data (CASI). It is unlikely, though, that the resulting algorithms from these kind of empirical relationships will be sufficiently general to be used in a variety of contexts. In recent years, the focus of lake water monitoring by remote sensing, has shifted towards coupling remotely sensed data to semi-analytical modelling. A simple bio-optical model for the sub-water environment in lakes has been developed. The model is mainly based on oceanographic relationships from the literature. A large historical data set of water quality measurements have been used together with the model to develop algorithms for the retrieval of water quality parameters. The model takes as inputs the concentration of chlorophyll, the concentration of suspended particulate inorganic material (SPIM) and the absorption of colored dissolved organic matter (CDOM) at 420 nm. The output from the model is a reflectance spectrum just above the water surface. From the modelled reflectance, algorithms are derived for chlorophyll, SPIM and CDOM absorption at 420 nm. The algorithms were applied to atmospherically corrected CASI data from Lake Mälaren collected in August 1997. The resulting concentration maps were validated using continuous measurements of fluorescence and beam attenuation, calibrated with water analysis results from 9 water samples. The results from the validation of the CASI algorithms are very satisfying, and the modelled concentrations and absorption coefficients corresponds very well to the ground truth measurements, which is very encouraging for the future work. The first part of the work was carried out by Peter Flink and later finished by Ammenberg in a paper ready for printing in Int. Journal of Remote Sensing 2002.

34. **HYSENS — Hyperspectral remote sensing using a new version of ROSIS**
Tommy Lindell, Petra Ammenberg
Funding: ESA/DLR
Period: 0001–
Partners: Don Pierson, Dept. of Evolutionary Biology, Limnology, UU; Eugenio Zilioli, CNR, Milan, Province Environment Protection Agency of Trent (APPA), Province Ecological Agency of Verone (ECOV) and Regional Environment Protection Agency, Verone, all in Italy
Abstract: ROSIS for Algal Mapping in Lacustrine Environment (ROSALMA). Rosalma is essentially oriented to a double task:

(a) to correlate basic water quality parameters like chlorophyll, suspended sediment concentrations and Secchi disc to the hyperspectral data by using a semi-analytical approach already proved in other geographic conditions and with other hyperspectral devices;

(b) to determine the best optical spectral windows for mapping the macrophyte growth, in order to design a possible operational tool to be used for environmental emergencies of this kind, especially in mapping its spatial distribution.

Lindell participated in the field work in July 2000, in Lake Garda, Italy, and Ammenberg has participated in the work with the data at CNR, Italy.

35. **Industrial plume detection in multispectral remote sensing data**
Petra Ammenberg, Tommy Lindell
Funding: Foundation for Strategic Environmental Research (MISTRA), RESE programme
Period: 0001–
Partners: Marcus Liljeberg, IVL - Swedish Environmental Research Institute, Stockholm;
Niklas Strömbeck, Dept. of Evolutionary Biology, Limnology, UU
Abstract: Industrial and river outlet plumes are characterised by high concentrations of dissolved and suspended substances. Water samples from the outlet of one paper-pulp industry in the investigated area have

been analysed in laboratory to examine the spectral characteristics of these waters. An increase in absorption by dissolved substances was found around 550 nm, compared to more natural waters. The spectral characteristics have also been investigated using multispectral remote sensing data from the corresponding area. Spectral differences between industrial and riverine outlets were found around 450 to 550 nanometers in the electromagnetic spectrum. The remote sensing data were used to create reference spectra for different types of water. These spectra served as input to the Spectral Angle Mapper (SAM) algorithm to classify additional remote sensing data, along the east coast of Sweden, in an attempt to locate and map the extent of industrial plumes. See Figure 14. This work was presented at the workshop Bio-optical Modeling and Remote Sensing of the Baltic Sea, Stockholm University, in November 2001. As a result of the workshop, a special issue of the Int. Journal of Remote Sensing, is planned for by the organising committee. The above mentioned paper will be submitted for publication to this special issue.

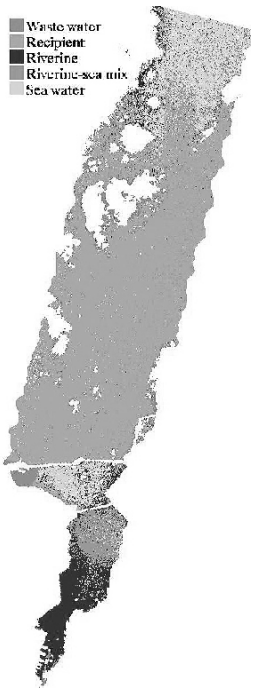


Figure 14: Classified remote sensing image from Norrsundet.

36. **Acquisition of hyperspectral data under the ocean surface**
Julia Åhlén, Tommy Lindell, Ewert Bengtsson
Funding: Dept. of Mathematics, Natural Sciences, and Computing, University College of Gävle; The KK-foundation
Period: 0102–
Abstract: The examination of image processing techniques for dealing with image enhancement in underwater conditions is important for scientists involved with marine environments. One application could be a study of archaeological sites in various oceans of the world. Generally, historical objects found under the water have to be analysed directly with photography. Another application is a different approach to study problems observed on corals such as bleaching. Prominent blue colour of clear ocean water, apart from sky reflection, is due to selective absorption by water molecules. Due to this nature of underwater optics, red light diminishes when the depth increases, thus producing blue to grey like images. In fact all red light is gone when reaching 3 m of depth. So far very few studies have been done on multi spectral or hyperspectral data taken under the water. Such studies could develop techniques to efficiently reduce the negative effects of scatter and light absorption. These effects often result in bluish images. In this project we are investigating how multi or hyperspectral data can be utilized to give us better colour information in underwater images. Initially we are looking at what techniques are available for creating an image acquisition system that could give multi- or hyperspectral data. Approaching the issues of enhancement for underwater images from the perspective of colour constancy is one of the approaches that are being investigated.

37. **Detecting COral Reef Bleaching from Optical Satellites — a pilot and demonstration project (CORBOS)**
Petra Ammenberg, Tommy Lindell
Funding: Foundation for Strategic Environmental Research (MISTRA), RESE programme
Period: 0001–
Partners: Swedish Meteorological and Hydrological Institute (SMHI), Norrköping
Abstract: Recent dramatic bleaching events on coral reefs have enhanced the need for global environmental monitoring. This project investigated the value of present high spatial resolution satellites to detect coral bleaching using a change detection technique. We compared an IRS LISS-III image taken during the 1998 bleaching event in Belize to images taken before the bleaching event. The sensitivity of the sensors was investigated and a simulation was made to estimate the effect of sub-pixel changes. A manual interpretation of coral bleaching, based on differences between the images, was performed and the outcome were compared to field observations. The spectral characteristics of the pixels corresponding to the field observations and the manually interpreted bleachings have been analysed and compared to pixels from unaffected areas. See Figure 15. This work was presented at the 9th Int. Coral Reef Symposium Bali, Indonesia, in October 2000 and further improved and accepted for publication in the proceedings 2002.

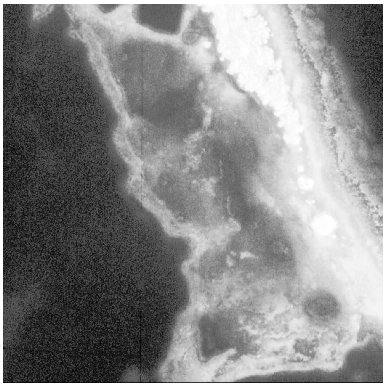


Figure 15: Image from the new satellite IKONOS, which from over 600 km height is scanning the world in 1–4 m resolution. The image shows a pancromatic 1 m resolution image over the barrier coral reef in Belize, Central America.

38. **Digital video and colour camera in remote sensing of water**
Tommy Lindell
Period: 0001–
Partners: CNR, Milan, Italy
Abstract: Test of the usefulness of air-borne digital camera and video for mapping water variables. Lindell has been constructing a holder for the digital video/camera for small aircrafts. He has collected images from Lake Erken, Mälaren, and from coral bottoms in Bisceyne National Park.

39. **Wood fibre morphology**
Mattias Moëll, Gunilla Borgefors
Funding: Wood and Wood Fiber graduate school; SLU S-faculty
Period: 9509–
Partners: Lloyd L. Donaldson, Forest Research New Zealand Ltd., Rotorua, New Zealand;
Minoru Fujita, Graduate School of Agriculture, Kyoto University, Japan
Abstract: The morphology of wood fibres is of great importance to the mechanical properties of pulp and paper. For the forest industry to be able to produce new products, renew processes, and to maximise the use of the wood fibre potential, more knowledge of the fibre morphology is needed. The project concentrates on analysis of fibre cross-sections in confocal microscopy images of transverse sections of wood. The aim is to measure as many parameters as possible, such as: cell wall width, radial/tangential lumen width, fraction of cell wall area, and degree of compression wood. A fully automatic image analysis method has been developed. Each individual fibre is measured, and the measures are averaged along the wood section. Ray cells and resin canals are detected and does not affect the fibre measurements. The same method can be used for different wood species by changing a few parameters. In the fall of 1998 a collaboration with

Forest Research New Zealand Ltd. was introduced, to study and compare segmentation methods of confocal images of transverse sections of wood. This co-operation has led to one manuscript on segmentation being published. It is shown that the fastest and simplest automatic segmentation methods can be used, and that automatic segmentation removes the possible bias of manual segmentation. A second paper, focusing on shading correction methods for poorer quality images, will be submitted in 2002. Moëll spent the Autumn of 2000 at Graduate School of Agriculture, Kyoto University, Japan, to study wood fibre analysis using FFT-methods. A paper on compression wood detection using FFT-methods has been submitted. In December 2001 Moëll successfully defended his PhD thesis. See Section 4.3.

40. **Analysis of AFM images of wood fibers using image analysis algorithms**
Carolina Wählby
Funding: UU TN-faculty
Period: 200101–08
Partners: Jesper Fahlén, STFI, Swedish Pulp and Paper Research Institute, Stockholm
Abstract: The arrangement of wood polymers within the fiber wall is of high interest for understanding its properties. AFM (Atomic Force Microscopy) images in combination with image analysis algorithms originally developed for cell segmentation were used to obtain more information regarding the arrangement of the cellulose aggregates, i.e., the fibrils, in the secondary cell wall layer of spruce wood. The work resulted in a presentation at the 11th International Symposium on Wood and Pulping Chemistry (ISWPC), Nice, France in June 2001 with the title "Cross section structure of the secondary wall of wood fibers as affected by processing" by J. Fahlén and L. Salmén.

41. **3D tracking of fibers in paper**
Mattias Aronsson, Stina Svensson, Gunilla Borgefors
Funding: Swedish Foundation for Strategic Research, VISIT programme, SLU S-fak
Period: 9710–
Partners: Björn Kruse, Arash Fayyazi, Dept. of Science and Engineering, Linköping University, Campus Norrköping; Örjan Sävborg, Olle Henningsson, StoraEnso Research, Falun; Carl-Henrik Ljungqvist, Dept. of Chemistry, Karlstad University; Institute of Optical Research (IOF), Kista
Abstract: Using image analysis on paper samples can increase the understanding of how individual fibres build up the paper and what effect different types of fibre networks have on paper properties. This network of fibres is a very complicated structure and creating images of it is a challenging problem. It is essential to use 3D volume images, since 2D images cannot capture enough information of the fibre network. Fibres are thin, so the resolution must be in the micrometer range, to enable accurate measurements. Our main concern is developing the necessary image building and analysis tools to enable a practical process method for creating volume images of paper samples, and then use these images to measure various properties of the fibre network.
The main data set used is a series of 2D scanning electron microscopy (SEM) images created at StoraEnso Research, Falun. A new technique for SEM-artifact attenuation has been developed, which is based on weighted distance transforms (Project 9). We can now pre-process the 2D fibre images to attenuate at least some of the background inhomogeneities, thereby enhancing the robustness of the following segmentation. The results were presented at the SCIA 2001 in Bergen.
We have now created a rather large digital volume of a paper sample from the original data set. Using this digital volume image, we have begun to investigate possible measures of the fibres and fibre network. First, the individual fibres were labelled in a subset of the volume. See Figure 14. A series of 3D fibre measurements were implemented and evaluated on this subset.
Especially we wanted to emphasize the advantages of using information that can be extracted from the distance transforms computed for the fibre wall and fibre lumen. For efficient computations, medial representations of 3D fibre objects — a surface for the fibre wall and a curve for the fibre lumen — were used. The medial representations were computed by iterative thinning of the distance transforms. Initial results were presented at the CVPR conference in Hawaii, USA. We are adding more measurement techniques, based on the same representation, measurements which should be of interest to pulp and paper researchers.

Figure 16: Labelled fibres in the 3D data set.

42. **Image analysis methods for food quality measurements**
Lucia Ballerini, Gunilla Borgefors
Funding: Foundation for Strategic Environmental Research (MISTRA), FOOD21 programme
Period: 9908–
Partners: Dept. of Food Science, SLU, Uppsala; Wallenberg Laboratory, Sahlgrenska University Hospital, Göteborg
Abstract: FOOD 21 is a broad scientific project, aimed to develop sustainable food production methods. So far, image processing methods have been successfully applied to meat images in order to determine the percentage and the distribution of various substances. Specifically, we have been working with camera photographs and Magnetic Resonance images of meat. Segmentation algorithms have been optimised for these kinds of images, in order to classify different substances as muscle, fat and connective tissue.
During 2001, we proposed a method to separate connective tissue from meat based on Genetic Snakes (see Project 3). Fat and connective tissue present almost the same colour and therefore they are almost indistinguishable by any colour segmentation techniques.
Moreover, we developed a method to measure homogeneity of fat distribution. Indeed, fat distribution is an important criterion for meat quality evaluation and its expected palatability. This method is simple and accurate and gives a description of feature distribution and a measure of homogeneity, depending on both size and spatial organization of features, without requiring any individual measure of them.
We propose a new method to predict fat content in meat images based on fractal theory. Results seem very promising. A very good correlation has been obtained between the mean fat content measured by chemical analysis and the Hurst coefficient estimated by the proposed method.
A survey has been carried out to understand the choice of consumers when buying beef meat and compare preferences to features measured by image analysis. A web form has been prepared to ask "customers" to choose meat (`http://www.cb.uu.se/~lucia/meat`), and some preliminary results have been collected.

43. **The development of a general image analysis software platform**
Bo Nordin, Ewert Bengtsson
Funding: UU TN-faculty
Period: 8807–
Partners: Diascan AB, Uppsala; Wallac Oy, Åbo, Finland
Abstract: In recognition of the need in image analysis research to have a good platform for interactive work with digital images we several years ago started a project with the aim of developing such a platform. The project originally involved some 10 man years of work which would have been impossible to finance by regular research money. But through a cooperation with a group of companies we coordinated our interests of obtaining a good software platform for research with their interest in development of a new software product. Unfortunately, the companies never actively turned the resulting system, which was given the name IMP, into a product. At CBA, however, the IMP system has been used as a software basis for most of the teaching and research in image analysis for the last decade.
Some years ago, we started a major revision of the system as a "background task" for Bo Nordin. The main goal was to reprogram the core system in C++ to make it easier to maintain and extend. Some new functionality has also been added to the system. A preliminary version of the new program, IMP++, was released in 1999. Since then we have had discussions with the involved companies about this new software which only to a limited extent is based on the original IMP project. These have not yet come to a conclusion

and it is likely that we during the coming year will rewrite the remaining parts of the system and thus in the end have a completely new platform for our research.

44. **Development of an image input facility**
Per Bengtsson
Funding: CBA funds
Period: 200106–12
Abstract: IMP, the general image analysis platform used at CBA, has an image input facility based on a frame-grabber on a DEC 25 workstation. Since that workstation is very old and no longer in active use and similar frame-grabbers are no longer available on more modern workstations there has for some time been a need to develop a more modern image input facility for IMP. Ideally such a facility should provide dynamic live-images as well as high quality digitized images and do this at low cost. An additional requirement is that light microscopy images can be digitized.
In this project such an image input facility was developed based on a digital camera for the consumer market, a Nikon Coolpix 800 interfaced to the computer through a low cost frame-grabber card for live, low quality video images and through the USB port for control and acquisition of full resolution digitized images. Through a special adapter the camera can also be mounted on a microscope for microphotography. The software was developed in the C++ language for the Linux operating system and based on the IMP++ image analysis software version. Images of varying resolution and compression can be obtained and several camera parameters can be controlled through the program interface.

5.2 Cooperation partners

CBA has extensive cooperation with other research groups, locally as well as nationally and internationally. Our research philosophy is that good application work in image analysis requires good competence both in image analysis technology and in the specific application field. We have, and are constantly building, the highest possible expertise in image analysis within our CBA and are seeking the expertise in the applications through close cooperations with other researchers. We are also trying to bring our results out from the research situation into real world use. In order to achieve this, we are cooperating with several companies, local and central government agencies, and hospitals.

The names of our cooperation partners can be found in various places in this report, but to give an overview, we list below the partners with whom we had direct project cooperation during 2001.

International

Amersham Biosciences, Cardiff, UK

Norwegian Institute for Water Research, NIVA, Oslo, Norway

Norwegian Pulp and Paper Research Institute, Trondheim, Norway

Prince of Wales Hospital, Sydney, Australia

The Queen Elizabeth Hospital, Adelaide, Australia

Dept. of Computer Science (DIKU), University of Copenhagen, Copenhagen, Denmark

Wallac Oy, Åbo, Finland

Dept. of Electronics and Telecommunications, University of Florence, Firenze, Italy

Istituto di Cibernetica, National Research Council, Milan, Italy

Istituto di Cibernetica, National Research Council, Pozzuoli (Napoli), Italy

Province Environment Protection Agency of Trent (APPA), Italy

Province Ecological Agency of Verone (ECOV), Italy

Regional Environment Protection Agency, Verone, Italy

Graduate School of Agriculture, Kyoto University, Japan

Medical Image Technology Laboratory (MITL), Inje University, Kim-Hae, Korea

Centro de Inteligencia Artificial, ITESM, Monterrey, Mexico

Forest Research Insitute (FRI), Rotorua, New Zealand

Dept. of Pathology, University Hospital, Tromsø, Norway

Dept. of Geology and Geography, West Virginia University, Morgantown, USA

Dept. of Radiology, University of Pennsylvania, Philadelphia, PA, USA

Faculty of Engineering, University of Novi Sad, Yugoslavia

National

Amersham Biosciences, Uppsala

Banverket, Gävle

Bergström Instruments AB, Stockholm

CC Systems AB, Uppsala

CelsiusTech Electronics, Järfälla

CWA Institute AB, Västra Frölunda

Cycore AB, Uppsala

Diascan AB, Uppsala

Electrolux AB, Stockholm
Ericsson Radio Systems, Media Lab, Kista
IVL - Swedish Environmental Research Institute, Stockholm
ReachIn AB, Stockholm
Sensys Traffic AB, Jönköping
StoraEnso Research, Falun
Vattenfall, Stockholm
Institute of Optical Research (IOF), Kista
Swedish Meteorological and Hydrological Institute (SMHI), Norrköping
Swedish Pulp and Paper Research Institute (STFI), Stockholm
Dept. of Biochemistry, UU
Dept. of Diagnostic Radiology, UU Hospital
Dept. of Earth Sciences, UU
Dept of Genetics and Pathology, UU
Dept. of Information Technology, UU
Dept. of Limnology, Evolutionary Biology Centre, UU
Dept. of Mathematics, UU
Dept. of Oncology, Radiology, and Clinical Immunology, UU Hospital
Dept. of Surgical Sciences, The Rudbeck Laboratory, UU
Dept. of Urology, UU
PET Centre, UU Hospital
The Industrial Liaison Office, UU
Uppsala Learning Lab, Uppsala
Dept. of Agricultural Engineering, SLU, Uppsala
Dept. of Food Science, SLU, Uppsala
Dept. of Forest Management and Production, SLU
Centre for Molecular Medicine, Karolinska Hospital, Stockholm
Dept. of Clinical Neurophysiology, Karolinska Institute/Hospital, Stockholm
Dept. of Hospital Physics, Karolinska Institute, Stockholm
Dept. of Neuroradiology, Karolinska Institute/Hospital, Stockholm
Dept. of Oncology-Pathology (CCK), Karolinska Institute/Hospital, Stockholm
Dept. of Physics, Stockholm University, Stockholm
Dept. of Psychiatry, Karolinska Hospital, Stockholm
NADA, KTH, Stockholm
Dept. of Mathematics, Natural Sciences, and Computing, University College of Gävle
Dept. of Chemistry, Karlstad University
Dept. of Medicine and Care, Div. of Medical Radiology, Linköping University Hospital, Linköping
Dept. of Biomedical Engineering, Linköping University Hospital, Linköping
Dept. of Science and Engineering, Linköping University, Campus Norrköping
Dept. of Signals and Systems, Chalmers University of Technology, Göteborg
Wallenberg Laboratory, Sahlgrenska University Hospital, Göteborg

6 Publications

Our research results are published in many different ways. The list covers papers with a publication date during 2001. As can be seen from the lists in the following sections we have published ten journal articles, 27 papers in refereed international conference proceedings, of which seven were presented at the 12^th Scandinavian Conference on Image Analysis in Bergen, Norway, and 15 non-refereed conference papers, of which five were presented at SSAB 2001 (the annual Swedish Symposium on Image Analysis). We also have our own report series, but little was published there this year.

6.1 Journal articles

1. **Titta inuti papper — Looking inside Paper**
   Authors: M. Aronsson, K.-A. Larsson (1)
   (1) freelance journalist, Uppsala
   Journal: Nordisk Papper och Massa, No. 2, pp. 44–45, 2001
   Comment: Popular science article in Swedish.

2. **Image Analysis for the Food Industry: Digital Camera Photographs and Nuclear Magnetic Resonance Images**
   Author: L. Ballerini
   Journal: Electronic Imaging, Vol. 11, No. 2, p. 7, 2001
   Comment: No *Abstract*.

3. **Hierarchical Decomposition of Multi-Scale Skeletons**
   Authors: G. Borgefors, G. Ramella (1), G. Sanniti di Baja (1)
   (1) Istituto di Cibernetica, CNR, Pozzuoli (Napoli), Italy
   Journal: IEEE Trans. on Pattern Analysis and Machine Intelligence, Vol. 23, No. 11, pp. 1296–1312, 2001
   Keywords: skeleton, decomposition, multi-resolution, binary pyramid
   Abstract: This paper presents a new procedure to hierarchically decompose a multi-scale discrete skeleton. The skeleton is a linear pattern representation that is generally recognized as a good shape descriptor. For discrete images, the discrete skeleton is often preferable. Multi-resolution representations are convenient for many image analysis tasks. Our resulting skeleton decomposition shows two different types of hierarchy. The first type of hierarchy is one of different scales, as the original pattern is converted into an AND-pyramid and the skeleton is computed for each resolution level. The second type of hierarchy is established at each level of the pyramid, by identifying and ranking skeleton subsets according to their permanence, where permanence is a property intrinsically related to local pattern thickness. To achieve the decomposition, both bottom-up and top-down analysis, in the sense of moving from higher to lower resolution, and vice versa, are used. The bottom-up analysis is used to ensure that a part of the skeleton that is connected at a higher resolution level is also connected (if at all present) in the next, lower resolution level. The top-down analysis is used to build the permanence hierarchy ranking the skeleton components. Our procedure is based on the use of (3×3) local operations in digital images, so it is fast and easy to implement. This skeleton decomposition procedure is most effective on patterns having different thickness in different regions. A number of examples of decompositions of multi-scale skeletons (with and without loops) will be shown. The skeletons are, in most cases, nicely decomposed into meaningful parts. The procedure is general and not limited to any specific application.

4. **Shape and Topology Preserving Multi-Valued Image Pyramids for Multi-Resolution Skeletonization**
   Authors: G. Borgefors, G. Ramella (1), G. Sanniti di Baja (1)
   (1) Istituto di Cibernetica, CNR, Pozzuoli (Napoli), ITALY
   Journal: Pattern Recognition Letters, Vol. 22, No. 5, pp. 741–751, 2001
   Keywords: shape, grey-level skeleton, multi-resolution, binary pyramid
   Abstract: Starting from a binary digital image, a multi-valued pyramid is built and suitably treated, so that shape and topology properties of the pattern are preserved satisfactorily at all resolution levels. The multi-valued pyramid is then used as input data to a grey-level skeletonization algorithm. In this way, a multi-resolution skeleton is computed, which could be useful in many image analysis tasks.

5. **Statistical Analysis of Hyperspectral Data from Two Swedish Lakes**
   Authors: P. Flink, T. Lindell, C. Östlund
   Journal: Science of the Total Environment, Vol. 268, No. 1–3, pp. 155–169, 2001
   Keywords: CASI, hyperspectral, chlorophyll, PCA, water quality, remote sensing
   Abstract: CASI data has been collected from two lakes in Sweden. In this paper some statistical properties of CASI spectral data have been discussed. Principal component analysis is used for assessing the dimensionality of the data and the principal components were used for making chlorophyll maps. The quality of the reconstruction of the spectra from the principal components was demonstrated. Examples of the accuracy of the radiative transfer code 6S in atmospheric correction applications have been given. Furthermore, the widths and positions of the spectral bands based on the studied dataset were proposed for chlorophyll mapping. Robustness aspects of regression models have been discussed. Algorithms derived from one lake have been used to map water quality parameters in another lake. Algorithms based on principal components, as well as algorithms based on image bands, have been used.
   Comment: Östlund got her PhD and Flink his Licentiate at CBA in 1999.

6. **An Image Analysis Method to Measure Cross-Sectional Tracheid Dimensions on Softwood Increment Cores**
   Authors: M. Moëll, G. Borgefors
   Journal: Wood and Fiber Science, Vol. 33, No. 2, pp. 200–212, 2001
   Keywords: image analysis, confocal microscopy, shape-based thresholding, distance transform, Hough transform, skeletonization, tracheid measurements
   Abstract: Anatomical properties of wood affect the properties of wood products. In this paper an automated image analysis method for measuring cross-sectional tracheid dimensions of softwood cores is presented. The images used were single slice confocal reflected light microscope images. By the use of the proposed method, automatic measurements of radial and tangential lumen diameter, as well as radial cell wall thickness, of almost all individual tracheids are obtainable.

7. **Comparison of Segmentation Methods for Digital Image Analysis of Confocal Microscope Images to Measure Tracheid Cell Dimensions**
   Authors: M. K. Moëll, L. A. Donaldson (1)
   (1) Forest Research New Zealand Ltd., Rotorua, New Zealand
   Journal: IAWA Journal, Vol. 22, No. 3, pp. 267–288, 2001
   Keywords: segmentation, image analysis, tracheid measurements, confocal microscopy
   Abstract: Image analysis is a common tool for measuring tracheid cell dimensions. When analyzing a digital image of a transverse cross-section of wood, one of the initial procedures is that of segmentation. This involves classifying a picture element (pixel) as either cell-wall or lumen. The accuracy of tracheid measurements is dependent on how well the result of the segmentation procedure corresponds to the true distributions of cell-wall or lumen pixels. In this paper a comparison of segmentation methods is given. The effect of segmentation method on measurements is investigated and the performance of each method is discussed. We demonstrate that automated segmentation methods remove observer bias and are thus capable of more reproducible results. The contrast for confocal microscope images is of such quality that one of the fastest and simplest automatic segmentation methods may be used.

8. **Skeletonization of Volumetric Vascular Images — Distance Information Utilized for Visualization**
   Authors: I. Nyström, Ö. Smedby (1)
   (1) Division of Medical Radiology, University Hospital, Linköping
   Journal: Journal of Combinatorial Optimization - Special Issue on *Optimization Problems in Medical Application*, Vol. 5. No. 1, pp. 27–41, 2001
   Keywords: shape representation, 3D skeleton, reverse distance transform, magnetic resonance angiography, stenosis detection
   Abstract: This paper deals with two techniques to represent relevant information from volumetric vascular images in a more compact format. The images are obtained with contrast-enhanced magnetic resonance angiography (MRA). After segmentation of the vessels, the curve skeleton is extracted by an algorithm based on the distance transformation. The algorithm first reduces the original object to a surface skeleton and then to a curve skeleton, after which "pruning" can be performed to remove irrelevant small branches. Applying this procedure to MRA data from the pelvic arteries resulted in a good description of the tree structure of the vessels with a much smaller number of voxels. To detect stenoses, 2D projections such as maximum

intensity projection (MIP) are usually employed, but these often fail to demonstrate a stenosis if the projection angle is not suitably chosen. A new presentation method surrounds each voxel in the distance-labelled curve skeleton of the segmented vascular tree with a ball whose radius represents the minimum vessel radius at that level. Experiments with synthetic data indicate that stenoses invisible in an ordinary projection may be seen with this technique. It is concluded that the distance-labelled curve skeleton seems to be useful for visualizing variations in vessel calibre and in the future possibly also for quantification of arterial stenoses.

9. **Integrated Method for Boundary Delineation of Agricultural Fields in Multispectral Satellite Images**
   Authors: A. Rydberg, G. Borgefors
   Journal: IEEE Trans. on Geoscience and Remote Sensing, Special Issue on IGARSS'00: *Taking the Pulse of the Planet*, Vol. 39, No. 11, pp. 2514–2520, 2001
   Keywords: field boundaries, edge detection, segmentation, merging
   Abstract: Most agricultural statistics are calculated per field and it is well known that classification procedures for homogeneous objects produce better results than per pixel classification. In this study, a multispectral segmentation method for automated delineation of agricultural field boundaries in remotely sensed images is presented. Edge information from a gradient edge detector is integrated with a segmentation algorithm. The multispectral edge detector uses all available multispectral information, by adding the magnitudes and directions of edges derived from edge detection in single bands. The addition is weighted by edge direction, to remove "noise" and to enhance the major direction. The resulting edge from the edge detection algorithm is combined with a segmentation method based on a simple ISODATA algorithm, where the initial centroids are decided by the distances to the edges from the edge detection step. From this procedure, the number of regions will most likely exceed the actual number of fields in the image and merging of regions is performed. By calculating the mean and covariance matrix for pixels of neighboring regions, regions with a high Generalized Likelihood-Ratio test quantity will be merged. In this way, information from several spectral bands (and/or different dates) can be used for delineating field borders with different characteristics. The introduction of the ISODATA classifier compared to a previously used region growing procedure improves the output. Some results are compared to manually extracted field boundaries.

10. **Mapping of the Water Quality of Lake Erken, Sweden**
    Authors: C. Östlund, P. Flink, N. Strömbeck (1), D. Pierson (1), T. Lindell
    (1) Dept. of Limnology, UU
    Journal: Science of the Total Environment, Vol. 268, No. 1–3, pp. 139–154, 2001
    Keywords: CASI, hyperspectral, lakes, water quality
    Abstract: Hyperspectral data has been collected by the Compact Airborne Spectrographic Imager (CASI) and multispectral data by the Landsat TM instrument for the purpose of mapping lake water quality. Field campaigns have been performed on Lake Erken in Sweden during the summer of 1997. Water samples have been collected and analysed in laboratory. Continuously measured variables from a boat, have added a spatial dimension to the ground truth dataset. The data has been used to construct algorithms, based on remotely sensed data, for the retrieval of water quality parameters. The correlation between the continuous data and the collected CASI data has been investigated. Algorithms using both the point sampling results and the continuous data have been developed. Maps based on data from each instrument, showing the distribution of chlorophyll, are presented. Problems of having few water sampling stations, and the potential of using sub-water optics models are addressed as well. Tests were performed on MERIS bands and found useful for mapping chlorophyll and turbidity and algorithms have been suggested for future use with MERIS.
    Comment: Östlund got her PhD and Flink his Licentiate at CBA in 1999.

6.2 Refereed conference proceedings

1. **Integrated Method for Boundary Delineation of Agricultural Fields in Multispectral Satellite Images**
   Author: A. Rydberg
   Conference: International Geoscience and Remote Sensing Symposium (IGARSS'00), Honolulu, Hawaii, USA
   Publisher: IEEE Publications, pp. 1678–1680, 2001
   Abstract: Agricultural field boundary information is important in many agricultural management practices and remotely sensed imagery can present valuable, timely, information about land parcels. This paper presents a multispectral segmentation method for automated delineation of agricultural field boundaries in digital imagery. Edge information from a gradient edge detector is integrated with region growing, where the multispectral information from all selected image bands is utilized in both procedures. In this way, information from several spectral bands (and/or different dates) can be used for delineating field boundaries with different characteristics. This is particularly important for agricultural applications, where multidate information is necessary to differentiate between, for instance, crops at different phenological growing stages. The results show that Landsat TM images are easier to delineate than SPOT images due to lower spectral variance between adjacent pixels.

2. **Colour Image Analysis Technique for Measuring of Fat in Meat: An Application for the Meat Industry**
   Authors: L. Ballerini, A. Högberg (1), K. Lundström (1), G. Borgefors
   (1) Dept. of Food Science, SLU, Uppsala
   Conference: SPIE Electronic Imaging 2001, San José, CA
   Publisher: SPIE, pp. 113–124, 2001
   Abstract: Intramuscular fat content in meat influences some important meat quality characteristics. The aim of the present study was to develop and apply image processing techniques to quantify intramuscular fat content in beefs together with the visual appearance of fat in meat (marbling). Colour images of *M. longissimus dorsi* meat samples with a variability in intramuscular fat content and marbling were captured. Image analysis software was specially developed for the interpretation of these images. In particular, a segmentation algorithm (i.e., classification of different substances: fat, muscle and connective tissue) was optimized in order to obtain a proper classification and perform subsequent analysis. Segmentation of muscle from fat was achieved based on their characteristics in the three-dimensional colour space (RGB), and on the intrinsic fuzzy nature of these structures. The method is fully automatic and it combines a fuzzy clustering algorithm, the Fuzzy c-Means Algorithm, with a Genetic Algorithm. The percentages of various colours (i.e. substances) within the sample are then determined; the number, size distribution, and spatial distributions of the extracted fat flecks are measured. Measurements are correlated with chemical and sensory properties. Results so far show that advanced image analysis is useful for quantify the visual appearance of meat.

3. **Improved Shading Performance by Avoiding Vector Normalization**
   Authors: A. Hast, T. Barrera (1), E. Bengtsson
   (1) Cycore AB, Uppsala
   Conference: Plzen, Czech Republic
   Publisher: University of West Bohemia, Vol. III, pp. 1–7, 2001
   Abstract: Phongs illumination model requires unit length vectors. The surface normal has to be normalized due to the linear interpolation, and if we use single point light sources or a fixed view point, we have to normalize the vectors pointing to the light source and to the viewer. Unfortunately, normalization is a relatively costly operation. One of the main reasons for this is the square root involved. But when we calculate the reflection vector, we actually do not need a normalized normal. This fact can be used in order to get an approximation for the vector we want when we interpolate between normals. The result is faster Phong shading and faster lighting calculations when we are using a single point light source or having a viewer which is not placed at infinity.

4. **Approximated Phong Shading by using the Euler Method**
   Authors: A. Hast, T. Barrera (1), E. Bengtsson
   (1) Cycore AB, Uppsala
   Conference: Eurographics 2001, Manchester, UK

Publisher: Blackwell Publishers Ltd, Oxford, UK, pp. 43–48, 2001
Abstract: After almost three decades and several improvements, Gouraud shading is still more often used for interactive computer graphics than Phong shading. One of the main reasons for this is of course that Phong shading is computationally more expensive. Quadratic polynomial approximation techniques like Bishop's method could reduce the amount of computation in the inner loop to just the double of what is done in Gouraud shading. By using Euler's method we get another quadratic polynomial approximation technique which is just as fast in the inner loop, but it will also give correct intensities on the edges, which we will not get with Bishop's method. By computing the maximum difference over a scan line between Gouraud shading and the proposed method, we could decide if Gouraud will suffice. It is also shown that linearly interpolated normals are normalized by a symmetric function. This means that we could reduce the amount of square roots by the half in Phong shading.

5. **Genetic Snakes for Color Image Segmentation**
Author: L. Ballerini
Conference: EvoIASP 2001, Como, Italy
Publisher: Springer-Verlag, Lecture Notes in Computer Science 2037, pp. 268–277, 2001
Abstract: The world of meat faces a permanent need for new methods of meat quality evaluation. Recent advances in the area of computer and video processing have created new ways to monitor quality in the food industry. In this paper we propose a segmentation method to separate connective tissue from meat. We propose the use of Genetic Snakes, that are active contour models, also known as snakes, with an energy minimization procedure based on Genetic Algorithms (GA). Genetic Snakes have been proposed to overcome some limits of the classical snakes, as initialization, existence of multiple minima, and the selection of elasticity parameters, and have both successfully applied to medical and radar images. We extend the formulation of Genetic Snakes in two ways, by exploring additional internal and external energy terms and by applying them to color images. We employ a modified version of the image energy which considers the gradient of the three color RGB (red, green and blue) components. Experimental results on synthetic images as well as on meat images are reported. Images used in this work are color camera photographs of beef meat.

6. **Optimal Local Distances for Distance Transforms in 3D using an Extended Neighbourhood**
Authors: G. Borgefors, S. Svensson
Conference: International Workshop on Visual Form (IWVF4), Capri, Italy
Publisher: Springer-Verlag, Lecture Notes in Computer Science 2059, pp. 113–122, 2001
Abstract: Digital distance transforms are useful tools for many image analysis tasks. In the 2D case, the maximum difference from Euclidean distance is considerably smaller when using a 5×5 neighbourhood compared to using a 3×3 neighbourhood. In the 3D case, weighted distance transforms for neighbourhoods larger than $3 \times 3 \times 3$ has almost not been considered so far. We present optimal local distances for an extended neighbourhood in 3D, where we use the three weights in the $3 \times 3 \times 3$ neighbourhood together with the $(2, 1, 1)$ weight from the $5 \times 5 \times 5$ neighbourhood. A good integer approximation is shown to be $\langle 3, 4, 5, 7 \rangle$.

7. **Curve Skeletonization by Junction Detection**
Authors: I. Nyström, G. Sanniti di Baja (1), S. Svensson
(1) Istituto di Cibernetica, CNR, Pozzuoli (Napoli), Italy
Conference: International Workshop on Visual Form (IWVF4), Capri, Italy
Publisher: Springer-Verlag, Lecture Notes in Computer Science 2059, pp. 229–238, 2001
Abstract: We present an algorithm that, starting from the surface skeleton of a 3D solid object, computes the curve skeleton. The algorithm is based on the detection of curves and junctions in the surface skeleton. It can be applied to any surface skeleton, including the case in which the surface skeleton is two-voxel thick.

8. **Multiple Tissue Antigen Analysis by Sequential Immunofluorescence Staining and Multi-Dimensional Image Analysis**
Authors: C. Wählby, F. Erlandsson (1), K. Nyberg (1), J. Lindblad, A. Zetterberg (1), E. Bengtsson
(1) Dept. of Oncology-Pathology, The Karolinska Institute, Stockholm
Conference: Scandinavian Conference on Image Analysis (SCIA 2001), Bergen, Norway
Publisher: NOBIM, Norwegian Society for Image Processing and Pattern Recognition, pp. 25–32, 2001
Abstract: This paper presents a novel method for sequential immunofluorescence staining, which, in combination with 3D image registration and segmentation, can be used to increase the number of antigens that can be observed simultaneously in single cells in tissue sections. Visualization of more than one antigen

by multicolor immunostaining is often desirable or even necessary, both for quantitative studies and to explore spatial relationships of functional significance. Sequential staining, meaning repeated application and removal of fluorescence markers, greatly increases the number of different antigens that can be visualized and quantified in single cells using digital imaging fluorescence microscopy. Quantification and efficient objective analysis of the image data requires digital image analysis. A method for 3D image registration combined with 2D and 3D segmentation and 4D extraction of data is described.

9. **Combined Visualisation of Functional and Anatomical Brain Images**
   Authors: R. Hult, E. Bengtsson
   Conference: Scandinavian Conference on Image Analysis (SCIA 2001), Bergen, Norway
   Publisher: NOBIM, Norwegian Society for Image Processing and Pattern Recognition, pp. 84–89, 2001
   Abstract: Fusion of multimodality images refers to not only the registration of the images but also to the visualisation and segmentation of VOI:s (Volume Of Interest). We have developed a toolbox to supplement a previously developed computerised brain atlas (CBA). Our tool for fusion of multimodality images of the brain has got the functionality for registration and segmentation as well for visualising the image data. Visualisation uses either as a 3D ray casted image with combined functional and anatomical information or as the functional data converted to a geometric model and displayed together with a geometric model of brain structures. Several application examples illustrate the use for these methods.

10. **Structure-Keeping Colour Segmentation of Tree Crowns in Aerial Images**
    Author: M. Erikson
    Conference: Scandinavian Conference on Image Analysis (SCIA 2001), Bergen, Norway
    Publisher: NOBIM, Norwegian Society for Image Processing and Pattern Recognition, pp. 185–191, 2001
    Abstract: A new method for colour segmentation of tree crowns in aerial images is presented. The first part of the method is based on the assumption that the pixel values inside each single tree differs only little while it differs more between the trees. This part, which is inspired by the fuzzy set theory, produces an area for a given start pixel. The area, representing the approximate tree, keeps the structure of the crown, in the way that the branches are visible. This is important if the result is to be useful for further investigation, such as classification. For each approximate tree, a lot of new areas are created. The second part of the method selects the most suitable area among all possible candidates for each tree. The method has been tested on high resolution aerial images with satisfactory results. The segmentation method proposed can be useful also in other applications of colour segmentation.

11. **A Comparison of Methods for Estimation of Intensity Non-Uniformities in 2D and 3D Microscope Images of Fluorescence Stained Cells**
    Authors: J. Lindblad, E. Bengtsson
    Conference: Scandinavian Conference on Image Analysis (SCIA 2001), Bergen, Norway
    Publisher: NOBIM, Norwegian Society for Image Processing and Pattern Recognition, pp. 264–271, 2001
    Abstract: A comparison of the accuracy and robustness of different data driven methods for intensity nonuniformity field estimation (background shading estimation) on simulated and real images of fluorescence stained cells is presented. A novel attempt to reduce the parameter space of a B-spline based algorithm for shading estimation using automatic thresholding with a kernel density estimator is tested and compared with exhaustive testing to find the optimal parameter value.

12. **2D Segmentation and Labelling of Clustered Ring-Shaped Objects**
    Authors: M. Aronsson, G. Borgefors
    Conference: Scandinavian Conference on Image Analysis (SCIA 2001), Bergen, Norway
    Publisher: NOBIM, Norwegian Society for Image Processing and Pattern Recognition, pp. 272–279, 2001
    Abstract: A robust segmentation and labelling method to identify individual ring shaped objects in clusters in 2D images has been developed. The rings are characterised as having a closed border and a void interior. The thickness of the rings should be approximately constant and their void shape smooth. First we find candidates by searching for all smooth regions that could be the void areas of rings. Then we label these and use a local distance transform feature to decide which are valid rings. In each local distance transform computed from the void, distance contours are used to get a profile of the average gray levels as a function of distance to the possible ring void border. We also use the profile to estimate the average thickness. Benefits are that we impose only loose constraints on the shape of the rings. As a real world application we use this method on microscopy images of paper, where we want to find all the fibres in cross

sections. The fibres have large shape and size variations, since paper is a biological material. A typical cluster of fibres with approximately constant wall thickness and only thin cracks in the fibre walls, are possible to recognize with this approach. We are thus able to find a high percentage of fibres in the images we used for validation. Another possible application is segmentation of cross sections of blood vessels.

13. **A Simple Method to Measure Homogeneity of Fat Distribution in Meat**
Author: L. Ballerini
Conference: Scandinavian Conference on Image Analysis (SCIA 2001), Bergen, Norway
Publisher: NOBIM, Norwegian Society for Image Processing and Pattern Recognition, pp. 343–349, 2001
Abstract: Fat distribution is an important criterium for meat quality evaluation and expected palatability. Visual inspection is often used to assess food quality, directly or indirectly. Image processing is a new way of doing quantitative and objective measurements of meat quality. In this paper we suggest an image processing method to describe and quantify the spatial homogeneity of fat distribution in meat images. The spatial distribution of features in an image is often interesting, but it is not simple to characterize. The method we propose is based on image pyramid representation and scale-based region homogeneity. This method give a description of feature distribution and a measure of homogeneity, depending on both size and spatial organization of features, without requiring any individual measure of them. The validity of the method have been illustrated by performing several simulations of different distributions on synthetic images. We applied our method to two kinds of meat images: color camera pictures and Nuclear Magnetic Resonance (NMR) images.

14. **Shape Approximation of Discrete Starshaped Objects**
Author: O. Weistrand
Conference: Scandinavian Conference on Image Analysis (SCIA 2001), Bergen, Norway
Publisher: NOBIM, Norwegian Society for Image Processing and Pattern Recognition, pp. 131–136, 2001
Abstract: A method for approximating starshaped digital objects is presented. After calculating an optimal position for the origin, the boundary is expressed in terms of spherical coordinates and approximated in the basis of spherical harmonics. The coefficients in the expansion are calculated using a least square approach, which requires small amounts of storage space even for very large objects.

15. **A Fractal Approach to Predict Fat Content in Meat Images**
Authors: L. Ballerini, L. Bocchi (1)
(1) Dept. Electronics and Telecommunications, University of Florence, Firenze, Italy
Conference: 2nd International Symposium on Image and Signal Processing and Analysis (ISPA 2001), Pula, Croatia
Publisher: IEEE Computer Society, pp. 351–354, 2001
Abstract: Intramuscular fat content in meat influences some important meat quality characteristics. Chemical analysis is currently used to determine intramuscular fat percentage in beef meat. Nevertheless, this is a tedious and expensive technique. For the food industry, it will be very useful a cheaper and non-destroying technique to determine fat content. In this paper we investigate the feasibility of a new method to predict fat content. We model meat structure as a fractal, and assume the projected image can be described by a fractional brownian motion (FBM). Experimental results shown that this assumption is satisfied over an acceptable scale range. Hurst coefficient of the FBM appear to present an high correlation with fat percentage.

16. **How Do People Choose Meat?**
Authors: L. Ballerini, A. Högberg (1)
(1) Dept. of Food Science, SLU
Conference: IASTED Int. Conf. on Visualization, Imaging and Image Processing, Marbella, Spain
Publisher: ACTA Press, pp. 501–505, 2001
Keywords: meat images, on-line survey, consumer choice
Abstract: In this paper we present a survey carried out to understand the choice of consumers when buying beef meat and compare preferences to features measured by image analysis. The project consists of two steps: i) Definition and preparation of the questionnaire. ii) Data collection and analysis. In this paper we describe the first step and we present and discuss some preliminary results for the second step.

17. **An Evaluative Study of Simulated Annealing Based MRI-SPECT Brain Scan Registration**
Authors: R. Lundqvist, L. Barnden (1), S. Som (2), E. Bengtsson, L. Thurfjell
(1) Dept. of Nuclear Medicine, The Queen Elizabeth Hospital, Woodwille, Australia

(2) Dept. of Nuclear Medicine, The Prince of Wales Hospital, Sydney, Australia
Conference: IASTED Int. Conf. on Visualization, Imaging and Image Processing, Marbella, Spain
Publisher: ACTA Press, pp. 423–427, 2001
Keywords: Multi-modal image registration, simulated annealing
Abstract: The goal of this work was to evaluate if simulated annealing optimisation methods can improve accuracy and robustness of multi-modal image registration. A simulated annealing method is presented and compared to Powell's optimisation method for two mutual information based similarity measures using MRI-SPECT data from 10 different subjects. The comparison shows that the simulated annealing method produces slightly more accurate results than Powell's method. An example of a difficult registration case with a large local optimum is also presented, where the simulated annealing method produces superior results compared to Powell's method. Conclusions are that simulated annealing based registration is mainly suited for problems where local optimisation methods do not converge properly at all, although it does slightly improve registration accuracy as well.

18. **Feature Vector Based Analysis: A Unified Concept for Multivariate Image Analysis**
Author: H. Hamid Muhammed
Conference: Irish Machine Vision and Image Processing Conference (IMVIP 2001), Maynooth, Ireland
Publisher: NUI Maynooth, pp. 219-226, 2001
Keywords: Independent Component Analysis, Principal Component Analysis, Multivariate Image Analysis, Feature Vector Based Analysis
Abstract: This paper presents a novel technique, which can be called Feature-Vector Based Analysis (FVBA). This technique is performed as subsequent analysis to a suitable transformation of multidimensional data. The outputs of the transformation step (which are a number of basis vectors and projections of the original data on these vectors) are considered as so called Component-FeatureVector pairs in the subsequent FVBA step. The FVBA task itself is application dependent. But, the common idea of FVBA is to look at the Feature Vectors to understand the corresponding Components. Two widely used transformations, Principal Component Analysis (PCA) and Independent Component Analysis (ICA), are used to illustrate the new technique, FVBA, with detailed examples on using ICA + FVBA. FVBA can be used for four main types of applications. Two of them can directly be distinguished where either well-defined Feature Vectors or well-defined Components are obtained. The other two types of applications are feature extraction and classification, where the Components and the Feature Vectors can be considered as outputs and weights in a neural network of a special type, trained or optimised by using a transformation.

19. **Integrated Multispectral Edge and Line Detection for Feature Specific Segmentation**
Authors: A. Rydberg, G. Borgefors
Conference: Irish Machine Vision and Image Processing Conference (IMVIP 2001), Maynooth, Ireland
Publisher: NUI Maynooth, pp. 227-235, 2001
Keywords: Multispectral delineation, field boundaries, remote sensing
Abstract: The idea of this study is not to invent "yet another edge or line detector". Instead, it attempts to find an edge/line detector that performs well in the context of segmenting agricultural field boundaries. Agricultural landscapes are less homogeneous than first can be expected. The size of the field boundaries to be detected compared to the image resolution is, for example, small and the within-field variance large. Gradient information alone is not enough to detect such boundaries properly. Therefore, this boundary finding method is intended to be part of a larger segmentation scheme for agricultural field boundaries. To be able to segment agricultural fields in satellite images, features like homogeneity of regions, their shape and edges are important, but so are line segments. For example, a ditch or a road can separate fields with similar spectral characteristics. However, in order to get a good representation of agricultural fields, lines and edges have to be treated simultaneously, in order to avoid double boundaries. In this study, we compare the result from a multispectral edge detector to an edge/line version of the same detector. The amount of double boundaries have decreased, which is the purpose of this method. Some of the results are compared to interpreted field boundaries.

20. **Feature Based Merging of Application Specific Regions**
Authors: A. Rydberg, G. Borgefors
Conference: 11th International Conference for Image Analysis and Processing (ICIAP 2001), Palermo, Italy
Publisher: IEEE Computer Society, pp. 56–62, 2001
Abstract: Over-segmentation is a common problem for all kinds of segmentation tasks. Automated segmen-

tation of natural scenes is no exception. This paper proposes a solution to the over-segmentation problem, with the emphasis on satellite images of farmland. In many cases, an agricultural field can be considered as a flat region having a rather large area, a compact shape, and straight region boundaries because it is a man-made object. Our approach for dividing farmland into individual field units use region shape, as well as spectral information, when merging over-segmented regions. The results from the presented method are compared to two different methods of segmentation as well as interpreted field boundaries. The results show that task-specific knowledge adds important information to the decision step for the merging procedure of regions. About 70% of the edges are classified within one pixel away from the ground truth edges using our methods.

21. **Using Feature-Vector Based Analysis, based on Principal Component Analysis and Independent Component Analysis, for Analysing Hyperspectral Images**
Authors: H. Hamid Muhammed, P. Ammenberg, E. Bengtsson
Conference: 11th International Conference for Image Analysis and Processing (ICIAP 2001), Palermo, Italy
Publisher: IEEE Computer Society, pp. 309–315, 2001
Abstract: A pixel in a hyperspectral image can be considered as a mixture of the reflectance spectra of several substances. The mixture coefficients correspond to the (relative) amounts of these substances. The benefit of hyperspectral imagery is that many different substances can be characterised and recognised by their spectral signatures. Independent Component Analysis (ICA) can be used to blindly separate mixed statistically independent signals. Principal Component Analysis (PCA), also, gives interesting results. The next step is to interpret and use the ICA or PCA results efficiently. This can be achieved by using a new technique called Feature-Vector Based Analysis (FVBA), which produces a number of Component-FeatureVector pairs. The obtained Feature Vectors and the corresponding Components represent, in this case, the spectral signatures and the corresponding weight coefficients images (the relative concentration maps) of the different constituting substances.

22. **Weighted Distance Transforms in Rectangular Grids**
Authors: I.-M. Sintorn, G. Borgefors
Conference: 11th International Conference for Image Analysis and Processing (ICIAP 2001), Palermo, Italy
Publisher: IEEE Computer Society, pp. 322–327, 2001
Abstract: In this paper we have investigated weighted distance transforms in 2D images in rectangular grids. We use a local neighborhood of size 3×3 and assume a rectangular grid with arbitrary ratio between the sides. The weights (local distances) are optimized by minimizing the maximum error over linear trajectories, which is an all digital approach. General solutions for all ratios are presented. We also present numeric results for the cases when the ratio between the sides equals 1 (comparable with studies of weighted distance transforms in square girds), 4/3 and 3. Integer solutions for both real and integer scale factors are presented.

23. **Representing Volumetric Vascular Structures Using Curve Skeletons**
Authors: I. Nyström, G. Sanniti di Baja (1), S. Svensson
(1) Istituto di Cibernetica, CNR, Pozzuoli (Napoli), Italy
Conference: 11th International Conference for Image Analysis and Processing (ICIAP 2001), Palermo, Italy
Publisher: IEEE Computer Society, pp. 495–500, 2001
Abstract: This paper describes a technique to represent relevant information of tree-like structures in a compact way. The technique is general. In the application described here, the images are obtained with contrast-enhanced magnetic resonance angiography (MRA). After segmentation, the vessels are reduced to fully reversible surface skeletons. Thereafter, a novel approach to curve skeletonization based on the detection of junctions and curves in the surface skeleton is used. This procedure results in a good description of the tree structure of the vessels, where they are represented with a much smaller number of voxels. This representation is suitable for further quantitative analysis, e.g., measurements of vessel width and length.

24. **Grey-Level Morphology Based Segmentation of MRI of the Human Cortex**
Author: R. Hult
Conference: 11th International Conference for Image Analysis and Processing (ICIAP 2001), Palermo, Italy
Publisher: IEEE Computer Society, pp. 578–583, 2001
Abstract: In this paper an algorithm for fully automatic segmentation of the cortex from T1-weighted axial or sagittal MRI data is presented. When analysing 3D MRI images of the brain it is often important to segment the brain from non-brain tissue such as eyes and membranes of the brain. The segmentation algorithm uses a histogram-based method to find accurate threshold values. Four initial masks are created; first two

thresholded masks from the original volume, background and brain tissue, then a third mask thresholded from a 3D grey-level eroded version of the volume, brain tissue, and lastly a fourth mask thresholded from a 3D grey-level dilated version of the volume, containing surrounding fat. On the start slice of these masks, binary morphological operations and logical operations are used. Then the rest of the slices are segmented using information from the previous slice combined with the other masks. Information from earlier slices is propagated to keep the segmented volume from leaking into non-brain tissue.

25. **Grey-Level Morphology Based Segmentation of T1-MRI of the Human Cortex**
Authors: R. Hult, E. Bengtsson
Conference: MICCAI 2001, Utrecht, The Netherlands
Publisher: Springer-Verlag, Lecture Notes in Computer Science 2208, pp. 1371–1372, 2001
Abstract: In this paper an algorithm for fully automatic segmentation of the cortex from T1-weighted transversal, coronal or sagittal MRI data is presented. A histogram-based method is used to find accurate threshold values. Four initial masks are generated, containing background, brain tissue, 3D grey-level eroded brain tissue and 3D grey-level dilated surrounding fat. Information from previous slices are used to avoid leaking from non-brain tissue.

26. **A Tool for Decomposing 3D Discrete Objects**
Authors: S. Svensson, G. Sanniti di Baja (1)
(1) Istituto di Cibernetica, CNR, Pozzuoli (Napoli), Italy
Conference: IEEE Computer Society Conference on Computer Vision and Pattern Recognition (CVPR 2001), Lihue, Kauai (Hawaii Islands)
Publisher: IEEE Computer Society, pp. 850–855, 2001
Abstract: We suggest a tool to decompose 3D discrete objects into simpler parts. Decomposition is guided by object thickness and is based on region growing. Region growing starts from a set of seeds suitably identified in the innermost regions of the object. Our tool originates a decomposition into nearly convex and elongated parts. The decomposition is not affected remarkably by object rotation and has a limited computational cost. Since different recent imaging techniques give easier and cheaper access to 3D images, it is likely to believe that voxel-based decomposition tools, like the one here introduced, are of interest for future applications.

27. **Some Measurements of Fibres in Volume Images of Paper using Medial Representations Detected on Distance Transform**
Authors: S. Svensson, M. Aronsson
Conference: IEEE Computer Society Conference on Computer Vision and Pattern Recognition (CVPR 2001), Lihue, Kauai (Hawaii Islands)
Publisher: IEEE Computer Society, 4p. on CD-ROM Vol. 2, 2001
Abstract: Volume images are nowadays frequently used in many applications, e.g., it has proven to be of interest to understand the complexity of the fibre network structure in paper and its effect on the optical and mechanical properties of paper. We show how medial representations of the fibre wall (surface structure) and of the fibre lumen (curve structure) can be detected on the distance transform of the wall and of the lumen, respectively. These representations are used for easy computation of thickness statistics, degree of collapse, and fibre length.
Comment: Technical sketch.

6.3 Non-refereed conferences and workshops

1. **Analysis of CASI Data - A Case Study From the Archipelago of Stockholm, Sweden**
   Author: P. Ammenberg
   Conference: 6th International Conference, Remote Sensing for Marine and Coastal Environments 2000, Charleston, South Carolina, USA
   Publisher: Veridian ERIM International, 8p., 2001

2. **Plume Detection in Airborne CASI Data by Forward and Inverse Multispectral Modeling**
   Authors: N. Strömbeck (1), M. Liljeberg (2), P. Ammenberg
   (1) Dept. of Limnology, UU
   (2) IVL, Stockholm
   Conference: 6th International Conference, Remote Sensing for Marine and Coastal Environments 2000, Charleston, South Carolina, USA
   Publisher: Veridian ERIM International, 8p., 2001

3. **Perimeter and Area Estimates for Digitized Objects**
   Author: J. Lindblad
   Conference: Swedish Society for Automated Image Analysis Symposium – SSAB 2001
   Publisher: ITN, Campus Norrköping, Linköping University, pp. 113–117, 2001

4. **How Do People Choose Meat?**
   Author: L. Ballerini
   Conference: Swedish Society for Automated Image Analysis Symposium – SSAB 2001
   Publisher: ITN, Campus Norrköping, Linköping University, pp. 119–122, 2001

5. **Using Shape Information to Merge Over-Segmented Agricultural Fields**
   Author: A. Rydberg
   Conference: Swedish Society for Automated Image Analysis Symposium – SSAB 2001
   Publisher: ITN, Campus Norrköping, Linköping University, pp. 127–130, 2001

6. **What is FeatureVector Based Analysis?**
   Author: H. Hamid Muhammed
   Conference: Swedish Society for Automated Image Analysis Symposium – SSAB 2001
   Publisher: ITN, Campus Norrköping, Linköping University, pp. 131–134, 2001

7. **Grey-Level Morphology Based Segmentation of Cortex**
   Author: R. Hult
   Conference: Swedish Society for Automated Image Analysis Symposium – SSAB 2001
   Publisher: ITN, Campus Norrköping, Linköping University, pp. 151–154, 2001

8. **Detection of a Large Number of Antigens using Sequential Immunofluorescence Staining**
   Authors: F. Erlandsson (1), C. Wählby, E. Bengtsson, A. Zetterberg (1)
   (1) Dept. of Oncology-Pathology, The Karolinska Institute, Stockholm
   Conference: 7th European Society for Analytical Cellular Pathology Congress (ESACP 2001), Caen, France
   Publisher: IOS Press, Amsterdam, pp. 56–57, 2001

9. **Multi-Dimensional Image Analysis of Sequential Immunofluorescence Staining**
   Authors: C. Wählby, F. Erlandsson (1), A. Zetterberg (1), E. Bengtsson
   (1) Dept. of Oncology-Pathology, The Karolinska Institute, Stockholm
   Conference: 7th European Society for Analytical Cellular Pathology Congress (ESACP 2001), Caen, France
   Publisher: IOS Press, Amsterdam, p. 61, 2001

10. **Analysis of Cells using Image Data from Sequential Immunofluorescence Staining Experiments**
    Authors: C. Wählby, F. Erlandsson (1), J. Lindblad, A. Zetterberg (1), E. Bengtsson
    (1) Dept. of Oncology-Pathology, The Karolinska Institute, Stockholm
    Conference: 5th Korea-Germany Joint Workshop on Advanced Medical Image Processing, Seoul, Korea
    Publisher: Ehwa Womans University, 10p., 2001

11. **Statistical Quality Control for Segmentation of Fluorescence Labelled Cells**
    Authors: J. Lindblad, C. Wählby, M. Vondrus, E. Bengtsson, L. Björkesten (1)

(1) Amersham Biosciences, Uppsala
Conference: 5th Korea-Germany Joint Workshop on Advanced Medical Image Processing, Seoul, Korea
Publisher: Ehwa Womans University, 11p., 2001

12. **Theory and Applications of Image Analysis at the Centre for Image Analysis**
Authors: L. Ballerini, G. Borgefors
Conference: 5th Korea-Germany Joint Workshop on Advanced Medical Image Processing, Seoul, Korea
Publisher: Ehwa Womans University, 13p., 2001

13. **A New Approach Towards Microvessel Quantification**
Authors: M. Vondrus, K. Wester (1), C. Busch (2), E. Bengtsson, P.-U. Malmström (3)
(1) Dept. of Genetics and Pathology, UU
(2) Dept. of Pathology, University Hospital Tromsø, Norway
(3) Dept. of Urology, UU
Conference: 14th International Congress of Cytology, Amsterdam, The Netherlands
8p., 2001
Comment: Invited paper (found in Vondrus' licentiate thesis).

14. **Determination of Water Quality of Lake Erken, Sweden, by using Feature-Vector Based Analysis**
Author: H. Hamid Muhammed
Conference: Irish Machine Vision and Image Processing Conference (IMVIP 2001), Maynooth, Ireland
Publisher: NUI Maynooth, p. 261, 2001
Comment: Presentation of reviewed Abstract.

15. **Improved Shading Performance by Avoiding Vector Normalization**
Authors: A. Hast, T. Barrera (1), E. Bengtsson
(1) Cycore AB, Uppsala
Conference: Conference for Promotion of Research in IT at New Universities and at University Colleges in Sweden
Publisher: The Knowledge Foundation, pp. 73–85, 2001

6.4 Other publications

See also Sections 4.2 and 4.3 where the two Licentiates and the four Doctoral theses presented during 2001, respectively, are listed. See also Section 3.3 for the nine Master theses.

1. **CBA Annual Report 2000**
Editors: M. Aronsson, G. Borgefors, I. Nyström, L. Wadelius
Publisher: Centre for Image Analysis, 85 pages, 2001

2. **Reviews of Scientific Papers on Discrete Geometry for Computer Imagery**
Editors: G. Borgefors, I. Nyström
Publisher: CBA Internal Report No. 22, 62 pages, 2001

7 Activities

We have as an aim to keep in contact with our colleagues in academia, with industries based on image analysis or need it in their production, and with society in general.

As a consequence of these aims we give and organize seminars; participate in conferences, generally with refereed oral or poster presentations; receive visitors and make visits, both for long and short stays; and participate in many different committees, both international and national. In the following Sections we have tried to list these activities for the year 2001. We have left out all meetings within ongoing research projects and all lectures we have given or attended as part of the regular educational activities of CBA (see Sections 3, 4, and 5). Still the lists become quite extensive.

Prof. Ewert Bengtsson has served as advisor to the Rector of UU on information technology ("rektorsråd") and also served as Chair of the virtual Faculty of information technology, together with many other related appointments. Fredrik Bergholm has been the executive programme Director for the national research programme VISIT.

To give some figures: We held 35 seminars outside CBA, in places from downtown Uppsala to Kimhae, Korea. This is more than twice the number of any previous year and thus a very positive development. There were also six lectures held at CBA by scientists from Sweden, Norway, Italy, Israel, Korea, and Australia, respectively. In addition we held 40 seminars in our internal "Monday series."

We have given one special invited presentation at a scientific conference; 18 oral and nine poster presentations at international reviewed conferences; and 14 other conference presentations. The number of oral reviewed presentations more than twice the "usual" number, the other numbers are normal.

We have had two long term visitors from abroad, both from Korea. Four persons from CBA have made extended visits as guest scientists abroad, in Napoli, Italy, Philadelphia, USA, and Sydney, Australia. Two of these were PhD students. We have also received a large number of visitors at many different occasions and have visited others ourselves.

Finally, we have listed 21 international and 34 national "committees" of the most varying types in which we have served.

Except for the comments above, all these figures make 2001 a "normal" year for these activities.

7.1 Awards

1. **Fredrik Walter**
   Award: One of the two Swedish candidates for "Best Nordic Thesis 1999-2000" in image analysis, awarded by the four Nordic IAPR members (International Association for Pattern Recognition).
   Comment: The thesis *"Extraction of Forest Stand Parameters from CARABAS VHF SAR Images* was presented at CBA, S-fak 991008.

7.2 Organised conferences and workshops

None were organized this year. (But we had six post-graduate exams with a number of guests.)

7.3 Seminars held outside CBA

1. **Ewert Bengtsson**
   Date: 010115
   Address: Main building, room X, UU
   Title: The international decade of a culture of peace- start meeting
   Comment: Jim Lawson, co-worker of Martin Luther King Jr was invited speaker. Bengtsson was chairing the event.

2. **Ewert Bengtsson**
   Date: 010119
   Address: Arlanda Conference City
   Title: How should Swedish image analysis cooperate after the end of the VISIT programme?
   Comment: Representatives of all academic image analysis groups in Sweden were present. Bengtsson was the initiator and chair of the event.

3. **Ewert Bengtsson**
   Date: 010122
   Address: Board room, UU
   Title: Presentation of the IT organisation committee proposal
   Comment: Bengtsson presented the proposal from the committe, which he had chaired, on how the IT field should be organized at UU in the future. Present were the Rector, Vice rectors, and the Heads of the IT departments plus other senior managers of UU. A discussion followed.

4. **Ewert Bengtsson**
   Date: 010130
   Address: Economicum, UU
   Title: IT in university education
   Comment: Seminar organized by the Faculty of social sciences.

5. **Ewert Bengtsson**
   Date: 010131
   Address: Administration building, UU
   Title: The use of the ping-pong web-platform for university courses
   Comment: Seminar to organize and coordinate courses and support.

6. **Ola Weistrand**
   Date: 010210
   Address: Dept. of Mathematics, UU
   Title: Shape Approximation of Discrete Starshaped Objects
   Comment: "Plurikomplexa seminariet". The audience were researchers in a completely different field. Therefore the seminar included a short introduction to image analysis.

7. **Ewert Bengtsson**
   Date: 010228
   Address: Downtown Uppsala
   Title: Closing the ITC project
   Comment: This project for the support of small companies in the Uppsala region in their IT competence has been running for about two years with Bengtsson as chair. In this seminar the project was officielly closed and the various participants thanked.

8. **Ewert Bengtsson**
   Date: 010301
   Address: Main building, UU
   Title: Reception for all the Ministers of education in Europe
   Comment: Part of the Swedish EU chairmanship. UU was hosting this event and Bengtsson was one of the university hosts.

9. **Gunilla Borgefors**
   Date: 010309

Address: Dept. of Signals and Systems, Chalmers University of Technology, Göteborg
Title: Weighted Distance Transforms in 2, 3, and 4 Dimensions

10. **Ewert Bengtsson**
    Date: 010323
    Address: Magistern lecture hall, UU
    Title: From idea to world standard, a strange journey over 15 years
    Comment: Bengtsson was on behalf of the virtual IT faculty co-hosting this seminar with the new honorary doctor Håkan Lanz.

11. **Ewert Bengtsson**
    Date: 010328
    Address: Hotel Rullan, Uppsala
    Title: A joint broadband regional network project in Uppsala?
    Comment: Bengtsson was on of the representatives of UU and one of the initiators of this seminar to discuss the possibility of coordinating all local interests around the development of a broadband network for the region.

12. **Ewert Bengtsson**
    Date: 010402-03
    Address: Odalgården Conference Centre, near Uppsala
    Title: Strategic Planning Seminar for the Dept. of IT, UU
    Comment: About 25 senior researchers met to discuss future strategies in education and research.

13. **Ingela Nyström**
    Date: 010402
    Address: Medical Image Processing Group, Dept. of Radiology, University of Pennsylvania, PA, USA
    Title: From Solid Three-Dimensional Objects via Surface Skeletons to Curve Skeletons
    Comment: Discussions on distance transforms.

14. **Ingela Nyström**
    Date: 010409
    Address: Computer Science Department, Princeton University, Princeton, NJ, USA
    Title: From Solid Three-Dimensional Objects via Surface Skeletons to Curve Skeletons

15. **Ingela Nyström**
    Date: 010410
    Address: Temple University, Philadelphia, PA, USA
    Title: From Solid Three-Dimensional Objects via Surface Skeletons to Curve Skeletons

16. **Xavier Tizon**
    Date: 010418
    Title: Medical Image Processing
    Address: Dept. of Human Computer Interaction, UU
    Comment: One 2h lecture in the course “Medical Informatics, 3p”.

17. **Carolina Wählby**
    Date: 010426
    Title: Image analysis applications in fluorescence microscopy
    Address: Amersham Pharmacia Biotech, Uppsala
    Comment: Seminar about segmentation and image analysis as part of a seminar series at the R&D, informatics and software at Amersham Pharmacia Biotech.

18. **Ewert Bengtsson**
    Date: 010503
    Address: Uppsala Learning Lab (ULL)
    Title: Presentation of the ULL and its activities for David Brady, vice-provost of Stanford University
    Comment: Bengtsson was host and chair of the seminar.

19. **Ewert Bengtsson**
Date: 010510
Address: Systema UDAC, Uppsala
Title: IT research at UU presented at a meeting of "Dataföreningen"
Comment: Five IT professors from UU presented their research areas. The program was arranged by Bengtsson. About 30 participants.

20. **Mattias Aronsson**
Date: 010521
Address: Fibre Science and Communication Network, (FSCN), Campus Sundsvall, Umeå University
Title: 3D reconstruction and identification of individual fibres in paper
Comment: Seminar in Swedish. Discussions about future cooperation.

21. **Joakim Lindblad**
Date: 010525
Address: Medical Image Technology Laboratory, Inje University, Kimhae, Korea
Title: Perimeter and area estimates for digitized objects

22. **Lucia Ballerini**
Date: 010525
Address: Medical Image Technology Laboratory, Inje University, Kimhae, Korea
Title: Introduction to Evolutionary Computation

23. **Ewert Bengtsson**
Date: 010531
Address: Grand Hotel Hörnan, Uppsala
Title: IT at UU
Comment: Presentation for a delegation of about 30 university Rectors and Deans from Holland.

24. **Ewert Bengtsson**
Date: 010606
Address: Main building, UU
Title: Prospects of cooperation between UU and Ericsson University
Comment: Ericsson University organizes internal education for Ericsson's 105.000 employees. With an annual turnover of 3 billions it is of the same size as UU. Are there possibilities of cooperation, e.g., in the development of web based learning? This was discussed in this meeting between the leaders of the two organizations.

25. **Mats Erikson**
Date: 010806
Address: Dept. of Forest Management and Production, Umeå
Title: Measurements and measuring in digital images
Comment: Seminar for 1h talking about how image analysis could be used in forest applications in general, and some discussion on how it could be used for pre-commercial thinning.

26. **Ewert Bengtsson**
Date: 010912
Address: Administration building, UU
Title: Discussions on collaboration between UU and the University of Rwanda in the IT field
Comment: A delegation of six leaders of Rwanda university, including the Rector plus representatives of SIDA, listened to presentations and discussed with leaders from UU.

27. **Ewert Bengtsson**
Date: 010913
Address: IT-FORUM, Uppsala County Council
Title: The plans for a National IT User Centre in Uppsala
Comment: Bengtsson was invited to present the plans and current progress in the NITA project for IT-FORUM which consists of all the heads of IT of public organizations in Uppsala County.

28. **Ewert Bengtsson**
    Date: 010917
    Address: Dept. of IT, UU
    Title: Prospects for coordination between UppMAX and local GRID efforts
    Comment: UppMAX is the effort by UU at setting up a regional high performance computing centre. GRID is the effort by Physics researchers (initiated at CERN) at establishing an international computing infrastruture.

29. **Carolina Wählby**
    Date: 010925
    Address: SLU, Uppsala
    Title: Image Analysis
    Comment: One lecture in the course "Current Scientific Methods".

30. **Ewert Bengtsson**
    Date: 011009
    Address: "Näringslivskontoret", Borough of Uppsala
    Title: Planning a project to carry out a cluster analysis in order to map and promote the IT companies in the Uppsala region
    Comment: Representatives of the public organisations, universities etc. participated and a working committie was formed.

31. **Ewert Bengtsson**
    Date: 011010
    Address: ULL
    Title: Presentation of UU IT related activites for Tomas Oppermann, minister of education in Lower Saxony.

32. **Mattias Aronsson**
    Date: 011022
    Address: CBA
    Title: 3D tracking of fibres in paper
    Comment: Presentation for the VISIT board, about the current status of the "3D tracking of fibres in paper" project.

33. **Ewert Bengtsson**
    Date: 011026
    Address: Administration building, UU
    Title: IT supported learning and its relation to educational research
    Comment: Discussions between the virtual IT faculty and the new Faculty for education science

34. **Ewert Bengtsson**
    Date: 011113
    Address: UU administration building
    Title: The national Swedish Net-university
    Comment: Meeting between UU and a new governmental planning committee

35. **Ewert Bengtsson**
    Date: 011128
    Address: ULL
    Title: Presentation of IT at UU to the LearnIT Board
    Comment: LearnIT is a national collaboration project on IT supported learning.

7.4 Seminars at CBA with invited guest lecturers

1. **Ari Shenhar**
   Date: 010404
   Address: Dept. of Electrical Engineering, Technion, Israel Institute of Technology Haifa, Israel
   Title: Ultrasound Imaging: Correction of Geometric Deformations

2. **Arvid Lundervold**
   Date: 010406
   Address: Physiological institute, Universtity of Bergen, Norway
   Title: Texture in MR images (in Norwegian)

3. **Hans-Eric Nilsson**
   Date: 010423
   Address: Plant Pathology and Biological Control Unit, SLU, Uppsala
   Title: The use of the Cropscan-radiometer for non-destructive studies of plant evolution (in Swedish)
   Comment: Professor Emeritus.

4. **Heung-kook Choi**
   Date: 010726
   Address: School of Information and Computer Engineering, Inje University, Korea
   Title: Tele-communication System for Medical Image Analysis Based on Web Tele-communication System for Medical Image Analysis Based on Web
   Comment: Work by Byeong-il Lee and Heung-kook Choi.

5. **Giancarlo Iannizzotto**
   Date: 010829
   Address: Dept. of Mathematics, University of Messina, Italy
   Title: Still-Image Segmentation with MOVels

6. **Robert Evans**
   Date: 011213
   Address: CSIRO, Melbourne, Australia
   Title: Rapid Assessment of Wood Fibre Properties using Three Kinds of Light

7.5 Seminars at CBA

Some of these seminars were held in Swedish.

1. **Fredrik Bergholm**
   Date: 010108
   Title: Introduction to plenoscopy

2. **Stina Svensson**
   Date: 010115
   Title: Using distance information for decomposing a 3D object

3. **Lena Wadelius**
   Date: 010122
   Title: Administrative things at CBA

4. **Joakim Lindblad**
   Date: 010129
   Title: A comparison of methods for estimation of intensity nonuniformities in 2D and 3D microscope images of fluorescence stained cells

5. **Anna Rydberg**
   Date: 010205
   Title: Segmentation of agricultural fields in remotely sensed images

6. **Hamed Hamid Muhammed**
   Date: 010212
   Title: How to make the “blind” ICA “see” again

7. **Ida-Maria Sintorn**
   Date: 010219
   Title: WDTs in rectangular grids

8. **Petra Ammenberg**
   Date: 010226
   Title: Detection of coral bleaching from high resolution satellite images

9. **Ewert Bengtsson**
   Date: 010305
   Title: What does an advisor to the vice-chancellor on IT do?

10. **Carolina Wählby**
    Date: 010312
    Title: Evaluation of fluorescence microscopy image data

11. **Mattias Aronsson**
    Date: 010319
    Title: Robust and unsupervised registration?

12. **Felix Wehrmann**
    Date: 010326
    Title: Feature extraction and abstraction

13. **Anders Hast**
    Date: 010402
    Title: Faster algorithms for interactive computer graphics

14. **Lucia Ballerini**
    Date: 010409
    Title: Segmentation of meat images

15. **Cedric Cano**
    Date: 010411
    Title: Image processing algorithms for the hexagonal grid
    Comment: Presentation of Master Thesis

16. **Mats Erikson**
    Date: 010507
    Title: Random number generators and generation of normally distributed random numbers

17. **Henrik Hindbeck**
    Date: 010508
    Title: Real-time map generation and display for moving vehicles
    Comment: Presentation of Master Thesis

18. **Ola Weistrand**
    Date: 010514
    Title: A short proof of the Isoperimetric inequality

19. **Xavier Tizon**
    Date: 010521
    Title: Classification of blood flow images of rat brains with fuzzy C-Means

20. **Jonas Sundin**
    Date: 010605
    Title: Magic Fridge
    Comment: Presentation of Master Thesis.

21. **Roger Lundqvist**
    Date: 010618
    Title: A combined intensity and gradient magnitude based similarity criterion for inter-individual SPECT brain scan registration

22. **Felix Wehrmann**
    Date: 010820
    Title: Regular expressions in the world of grammars

23. **Björn Menze**
    Date: 010821
    Title: Parameterisation of the size distribution of biofuel by methods of image analysis
    Comment: Presentation of project work.

24. **Joakim Lindblad**
    Date: 010827
    Title: Version management with Concurrent Versions System (CVS)

25. **Julia Åhlén**
    Date: 010903
    Title: Analysis of multi- and hyperspectral images for water related applications

26. **Alexander Lakic**
    Date: 010906
    Title: Biometrics: Face Verification/Recognition
    Comment: Presentation of Master thesis.

27. **Ingela Nyström**
    Date: 010910
    Title: Squirrel versus CBA Annual Report

28. **Carolina Wählby**
    Date: 010917
    Title: A faster watershed for fluorescence microscopy image segmentation

29. **Fredrik Bergholm**
    Date: 010924
    Title: Image formation in image space: lens with obstacles

30. **Roger Lundqvist**
    Date: 011001
    Title: Fusion of medical images: methods and applications

31. **Hamed Hamid Muhammed**
    Date: 011008
    Title: Mapping water quality by using feature-vector based analysis

32. **Mattias Aronsson**
    Date: 011015
    Title: ShearWarp rendering - an efficient way to render huge voxel volumes

33. **Johan Olofsson**
    Date: 011016
    Title: Implementation and evaluation of a person-tracking system
    Comment: Presentation of Master Thesis.

34. **Roger Hult**
    Date: 011022
    Title: BRAINS 2, a software package for image analysis of the brain

35. **Mats Erikson**
    Date: 011029
    Title: Pre-estimation of the tree size before segmentation

36. **Anna Rydberg**
    Date: 011105
    Title: Multispectral image analysis for extraction of remotely sensed features in agricultural fields
    Comment: Pre-seminar to the dissertation 011109.

37. **Anders Hast**
    Date: 011119
    Title: Reconstruction filters for bump mapping

38. **Ola Weistrand**
    Date: 011126
    Title: Generalizing Fourier descriptors to three-dimensional discrete objects

39. **Mattias Moëll**
    Date: 011203
    Title: Image analysis of wood fibers
    Comment: Pre-seminar to the dissertation 011214.

40. **Stina Svensson**
    Date: 011211
    Title: Representing and analyzing 3D shapes using distance information

7.6 Conference participation

7.6.1 Special invited speakers

1. **Ewert Bengtsson**
   Conference: 14th Internatinal Congress of Cytology
   Address: Amsterdam Conference Centre, The Netherlands
   Date: 010527–010529
   Title: Morphometric analysis of microvessels
   Comment: Bengtsson was one of many invited speakers at this giant event (2000 participants)

7.6.2 Oral presentations - refereed conferences

1. **Lucia Ballerini**
   Conference: SPIE Electronic Imaging 2001
   Address: San José, California, USA
   Date: 010120–010126
   Title: Colour image analysis technique for measuring of fat in meat: An application for the meat industry

2. **Ewert Bengtsson**
   Conference: The 9th International Conference in Central Europe on Computer Graphics, Visualization and Computer Vision (WSCG-2001)
   Address: Plzen, Czech Republic
   Date: 010205–010208
   Title: Computer graphics and image processing curricula at Uppsala and other Swedish universities.

3. **Anders Hast**
   Conference: The 9th International Conference in Central Europe on Computer Graphics, Visualization and Computer Vision (WSCG-2001)
   Address: Plzen, Czech Republic
   Date: 010205–010208
   Title: Improved Shading Performance by Avoiding Vector Normalization

4. **Lucia Ballerini**
   Conference: EuroGP2001 and EvoWorkshops2001
   Address: Como, Italy
   Date: 010418–010420

Title1: Genetic snakes for color images segmentation: An application for the meat industry
Title2: Colour image analysis technique for measuring of fat in meat: An application for the meat industry

5. **Gunilla Borgefors**
   Conference: 4th Int. Workshop on Visual Form (IWVF4)
   Address: Capri, Italy
   Date: 010528–010530
   Title: Optimal local distances for distance transforms in 3D using an extended neighbourhood
   Comment: Session Chair.

6. **Stina Svensson**
   Conference: 4th Int. Workshop on Visual Form (IWVF4)
   Address: Capri, Italy
   Date: 010528–010530
   Title: Curve skeletonization by junction detection

7. **Lucia Ballerini**
   Conference: 12th Scandinavian Conference on Image Analysis (SCIA'01)
   Address: Bergen, Norway
   Date: 010611–010614
   Title: A simple method to measure homogeneity of fat distribution in meat

8. **Mats Erikson**
   Conference: 12th Scandinavian Conference on Image Analysis (SCIA'01)
   Address: Bergen, Norway
   Date: 010611–010614
   Title: Structure-keeping colour segmentation of tree crowns in aerial images

9. **Ola Weistrand**
   Conference: 12th Scandinavian Conference on Image Analysis (SCIA'01)
   Address: Bergen, Norway
   Date: 010611–010614
   Title: Shape approximation of discrete starshaped objects

10. **Carolina Wählby**
    Conference: 12th Scandinavian Conference on Image Analysis (SCIA'01)
    Address: Bergen, Norway
    Date: 010611–010614
    Title: Multiple antigen analysis by sequential immunofluorescence staining and multi-dimensional image analysis

11. **Lucia Ballerini**
    Conference: 2nd International Symposium on Image and Signal processing and Analysis (ISPA 2001)
    Address: Pula, Croatia
    Date: 010619–010621
    Title: A fractal approach to predict fat content in meat images

12. **Lucia Ballerini**
    Conference: VIIP 2001 Visualization, Imaging and Image Processing
    Address: Marbella, Spain
    Date: 010903–010905
    Title: How do people choose meat?

13. **Roger Lundqvist**
    Conference: Visualization, Imaging and Image Processing (VIIP 2001)
    Address: Marbella, Spain
    Date: 010903–010905
    Title: An evaluative study of simulated annealing based mri-spect brain scan registration

14. **Anna Rydberg**
Conference: Irish Machine Vision and Image Processing Conference (IMVIP 2001)
Address: Dept. of Computer Science, National University of Ireland, Maynooth, Ireland
Date: 010905–010907
Title: Integrated multispectral edge and line detection for feature specific segmentation

15. **Hamed Hamid Muhammed**
Conference: Irish Machine Vision & Image Processing Conference (IMVIP 2001)
Address: Dept. of Computer Science, National University of Ireland, Maynooth, Ireland
Date: 010905–010907
Title: Feature vector based analysis: A unified concept for multivariate image analysis

16. **Roger Hult**
Conference: 11th International Conference on Image Analysis and Processing (ICIAP 2001)
Address: Palermo, Italy
Date: 010926–010928
Title: Grey-level morphology based segmentation of MRI of the human cortex

17. **Anna Rydberg**
Conference: 11th International Conference on Image Analysis and Processing (ICIAP 2001)
Address: Palermo, Italy
Date: 010926–010928
Title: Feature based merging of application specific regions

18. **Mattias Aronsson**
Conference: IEEE Computer Society Conference on Computer Vision and Pattern Recognition (CVPR 2001)
Address: Lihue, Kauai (Hawaii Island), USA
Date: 011210–011214
Title: Some measurements of fibres in volume images of paper using medialrepresentations detected on the distance transform
Comment: Technical sketch paper (reviewed)

7.6.3 Poster presentations - refereed conferences

1. **Mattias Aronsson, Gunilla Borgefors**
Conference: 12th Scandinavian Conference on Image Analysis (SCIA 2001)
Address: Bergen, Norway
Date: 010611–010614
Title: 2D segmentation and labelling of clustered ring-shaped objects

2. **Roger Hult**
Conference: 12th Scandinavian Conference on Image Analysis (SCIA 2001)
Address: Bergen, Norway
Date: 010611–010614
Title: Combined visualisation of functional and anatomical brain images

3. **Joakim Lindblad, Ewert Bengtsson**
Conference: 12th Scandinavian Conference on Image Analysis (SCIA 2001)
Address: Bergen, Norway
Date: 010611–010614
Title: A comparison of methods for estimation of intensity nonuniformities in 2D and 3D microscope images of fluorescence strained cells

4. **Hamed Hamid Muhammed**
Conference: Irish Machine Vision & Image Processing Conference (IMVIP 2001)
Address: Dept. of Computer Science, National University of Ireland, Maynooth, Ireland
Date: 010905–010907
Title: Determination of water quality of Lake Erken, Sweden, by using feature-vector based analysis

5. **Hamed Hamid Muhammed**
   Conference: 11th International Conference for Image Analysis and Processing (ICIAP 2001)
   Address: Palermo, Italy
   Date: 010926–010928
   Title: Using feature-vector based analysis, based on principal component analysis and independent component analysis, for analysing hyperspectral images

6. **Ingela Nyström, Stina Svensson**
   Conference: 11th International Conference for Image Analysis and Processing (ICIAP 2001
   Address: Palermo, Italy
   Date: 010926–010928
   Title: Representing volumetric vascular structures using curve skeletons

7. **Ida-Maria Sintorn**
   Conference: 11th International Conference for Image Analysis and Processing (ICIAP 2001)
   Address: Palermo, Italy
   Date: 010926–010928
   Title: Weighted distance transforms in rectangular grids

8. **Roger Hult**
   Conference: MICCAI 2001
   Address: Utrecht, The Netherlands
   Date: 011015–011017
   Title: Grey-level Morphology Based Segmentation of T1-MRI of the Human Cortex

9. **Stina Svensson**
   Conference: IEEE Computer Society Conference on Computer Vision and Pattern Recognition (CVPR 2001)
   Date: 011209–011214
   Address: Lihue, Kauai (Hawaii Island), USA
   Title: A tool for decomposing 3D discrete objects

7.6.4 Oral presentations

1. **Lucia Ballerini**
   Conference: Swedish Society for Automated Image Analysis Symposium 2001 (SSAB 2001)
   Address: ITN, Linköping University, Campus Norrköping
   Date: 010314–010315
   Title: How do people choose meat?

2. **Hamed Hamid Muhammed**
   Conference: Swedish Society for Automated Image Analysis Symposium 2001 (SSAB 2001)
   Address: ITN, Linköping University, Campus Norrköping
   Date: 010314–010315
   Title: What is featurevector based analysis?

3. **Roger Hult**
   Conference: Swedish Society for Automated Image Analysis Symposium 2001 (SSAB 2001)
   Address: ITN, Linköping University, Campus Norrköping
   Date: 010314–010315
   Title: Grey-level morphology based segmentation of cortex

4. **Joakim Lindblad**
   Conference: Swedish Society for Automated Image Analysis Symposium 2001 (SSAB 2001)
   Address: ITN, Linköping University, Campus Norrköping
   Date: 010314–010315
   Title: Perimeter and area estimates for digitized objects

5. **Anna Rydberg**
   Conference: Swedish Society for Automated Image Analysis Symposium 2001 (SSAB 2001)
   Address: ITN, Linköping University, Campus Norrköping

Date: 010314–010315
Title: Using shape information to merge over-segmented agricultural fields

6. **Ewert Bengtsson**
Conference: Seminar on computer graphics and visualization
Address: University College of Gävle
Date: 010321
Title: The need for improved interactive visualization methods in 3D medical imaging
Comment: About a dozen international researchers were invited to this seminar.

7. **Carolina Wählby**
Conference: 7th European Society for Analytical Cellular Pathology, ESACP Congress
Address: Caen, France
Date: 010401–010405
Title: Multi-dimensional image analysis of sequential immunofluorescence staining

8. **Lucia Ballerini**
Conference: The Fifth Korea-Germany Joint Workshop on Advanced Medical Image Processing
Address: Seoul, Korea
Date: 010515–010518
Title: Theory and applications of image analysis at the centre for image analysis

9. **Carolina Wählby**
Conference: The Fifth Korea-Germany Joint Workshop on Advanced Medical Image Processing
Address: Seoul, Korea
Date: 010515–010518
Title: Analysis of cells using image data from sequential immunofluorescence staining experiments

10. **Joakim Lindblad**
Conference: The Fifth Korea-Germany Joint Workshop on Advanced Medical Image Processing
Address: Seoul, Korea
Date: 010515–010518
Title: Statistical quality control for segmentation of fluorescence labelled cells

11. **Carolina Wählby**
Conference: 2001 Stockholm Workshop on Computational Vision
Address: Rosenön, Dalarö
Date: 010730–010801
Title: Image segmentation for drug and tumor evaluation

12. **Ewert Bengtsson**
Conference: SweLL national workshop
Address: Karolinska Institute, Solna
Date: 010914
Title: The Uppsala Learning Lab
Comment: A one day workshop to present and discuss the progress in the Swedish Learning Lab collaboration.

13. **Petra Ammenberg**
Conference: RESE - annual meeting
Address: Västerbacken Hotell och Konferens AB, Holmsund, Umeå
Date: 001114-001116
Title: Bio-optical modelling combined with remote sensing to assess water quality

14. **Petra Ammenberg**
Conference: Bio-optical modelling and remote sensing of the Baltic Sea
Address: Dept. of Physical Geography and Quaternary Geology, Stockholm University
Date: 011129–011130
Title: Industrial plume detection in multispectral remote sensing data
Comment: This conference was held in connection with the Baltic Sea Science Congress 2001.

7.6.5 Poster presentations

No unreviewed poster presentations this year.

7.6.6 Attendee

1. **Mattias Aronsson, Ewert Bengtsson, Mats Erikson, Anders Hast, Roger Hult, Roger Lundqvist, Ola Weistrand, Carolina Wählby**
   Conference: SIGRAD 2000
   Address: ITN, Linköping University, Campus Norrköping
   Date: 010124
   Comment: SIGRAD is the Swedish Computer Graphics Association. This years topic was “Virtual Reality and Web Based Visualization”. Demonstration of ITN:s new VR Theater.

2. **Ingela Nyström**
   Conference: SPIE Medical Imaging 2001
   Address: San Diego, CA, USA
   Date: 010218–010222
   Comment: Experiencing the conference as a guest of MIPG.

3. **Petra Ammenberg, Mattias Aronsson, Ewert Bengtsson, Fredrik Bergholm, Gunilla Borgefors, Mats Erikson, Roger Hult, Ida-Maria Sintorn, Stina Svensson, Felix Wehrmann, Ola Weistrand, Carolina Wählby**
   Conference: Swedish Society for Automated Image Analysis Symposium 2001 (SSAB 2001)
   Address: ITN, Linköping University, Campus Norrköping
   Date: 010314–010315

4. **Petra Ammenberg, Mattias Aronsson, Mats Erikson, Roger Hult, Ida-Maria Sintorn, Stina Svensson, Felix Wehrmann, Ola Weistrand, Carolina Wählby**
   Conference: “PhD students day”, in connection with the SSAB 2001 conference
   Address: ITN, Linköping University, Campus Norrköping
   Date: 010316

5. **Ewert Bengtsson**
   Conference: National conference about future priorities for the SSF
   Address: Heaven Conference Centre, Stockholm
   Date: 010320
   Comment: About 500 reserachers from all over Sweden attended this conference where the Foundation for strategic reserch presented their plans for future reserach funding strategies.

6. **Ewert Bengtsson**
   Conference: Conference on Cooperation between Academia and Industry with Focus on the IT Sector
   Address: Concert Hall, Stortorget, Karlskrona
   Date: 010417–010418
   Comment: Bengtsson was the representative of UU at this high level conference which was part of the Swedish EU Chairmansip, headed by the Minister of Education and Science, Tomas Östros.

7. **Ewert Bengtsson**
   Conference: Vinnova annual national conference on Medical Technology
   Address: Scandic Hotel Star, Lund
   Date: 010418–010419
   Comment: This is the main event in Medical technology in Sweden each year.

8. **Ewert Bengtsson**
   Conference: Conference for the Promotion of Research in IT at New Universities and at University Colleges in Sweden
   Address: Ronneby Brunn conference centre, Ronneby
   Date: 010423–010425
   Comment: Bengtsson attended the conference as supervisor of two Phd students (Hast and Åhlén) in the program sponsored by the Knowledge foundation which was hosting the conference.

9. **Petra Ammenberg**
   Conference: Geographical Information Technology (GIT 2001)
   Address: Älvsjömässan, Stockholm
   Date: 010509–010511

10. **Ewert Bengtsson**
    Conference: Workshop on ICT and the Swedish Universities co-operation with Developing Countries
    Address: Dept. of Computer and Systems Sciences (DSV), KTH, Kista
    Date: 010510
    Comment: About 30 participants discussed how Swedish universities can help develop IT knowledge and infrastructure at universitites in developing countries.

11. **Ingela Nyström**
    Conference: International Workshop on Visual Form (IWVF4)
    Address: Capri, Italy
    Date: 010528–010530

12. **Ewert Bengtsson, Gunilla Borgefors**
    Conference: 12th Scandinavian Conference on Image Analysis (SCIA 2001)
    Address: Bergen, Norway
    Date: 010611–010614
    Comment: Borgefors was Session Chair.

13. **Ewert Bengtsson**
    Conference: 6th International Conference on the Medical Aspects of Telemedicine
    Address: Main building, UU
    Date: 010618–010621
    Comment: Bengtsson was chairing the opening session with presentations by Lars Engqvist, minister of social affairs, Bo Sundqvist, rektor of UU and Steinar Pedersen President of the Institute for Telemedicine (ISfT), the organizing organisation.

14. **Gunilla Borgefors, Hamed Hamid Muhammed, Ida-Maria Sintorn, Ola Weistrand**
    Conference: First French-Nordic Summer School in Mathematics
    Address: UU limnology research station, Erken (Norrtälje)
    Date: 010626–010703
    Comment: Themes: Digital geometry, Projective geometry, Complex geometry. Borgefors was on the organising committee.

15. **Petra Ammenberg**
    Conference: International Workshop on Geo-Spatial Knowledge Processing for Natural Resource Management
    Address: University of Insubria, Varese, Italy
    Date: 010628–010629

16. **Fredrik Bergholm**
    Conference: 2001 Stockholm Workshop on Computational Vision
    Address: Rosenön, Dalarö
    Date: 010730–010802
    Comment: Bergholms's attendance was linked to VISIT research program.

17. **Roger Hult**
    Conference: Brain Imaging Workshop 2001
    Address: Iowa City, USA
    Date: 010807–010810

18. **Ewert Bengtsson**
    Conference: "The broadband day" (Bredbandsdagen)
    Address: The Concert Hall, Gävle
    Date: 010823
    Comment: This National conference discussed the social implications of broad band development. It was held in conjunction with an international conference arranged by the World Internet Institute.

19. **Mattias Aronsson**
Conference: Maple7 seminar
Address: Ångström laboratory, UU
Date: 010912
Comment: Information about the new version 7 of the symbolic calculus software Maple.

20. **Ewert Bengtsson**
Conference: Medical Image Computing and Computer Assisted Intervention (MICCAI) 2001
Address: Utrecht, The Netherlands
Date: 011013–011017

21. **Ewert Bengtsson**
Conference: Interactive Medical Image Visualization annd Analysis (IMIVA)
Address: Utrecht, The Netherlands
Date: 011018
Comment: IMIVA was a workshop in conjunction with MICCAI 2001.

22. **Roger Hult**
Conference: Information Retrieval and Exploration in Large Medical Image Collections
Address: Utrecht, The Netherlands
Date: 011018
Comment: A MICCAI 2001 Satellite symposium.

23. **Mattias Aronsson, Mats Erikson, Ola Weistrand**
Conference: Matlab 6 seminar
Address: KTH, Stockholm
Date: 011019
Comment: Cleve Moler, the inventor of Matlab, talked about how the software package has evolved. There were also demonstrations of Matlab's toolboxes.

7.7 Visits to other research groups (for at least 2 weeks)

1. **Roger Lundqvist**
Hosts: John Frawley, Walter Haindl
Address: Dept. of Nuclear Medicine, The Prince of Wales Hospital, Sydney, Australia
Date: 000905–010327
Topic: Joint research work, e.g., quantitative analysis of carotid endarterectomy patients.

2. **Ingela Nyström**
Host: Jayaram K. Udupa
Address: Medical Image Processing Group, Dept. of Radiology, University of Pennsylvania, PA, USA
Date: 010217–010517
Topic: Three months visit at MIPG to start collaboration on quantitative 3D shape analysis.

3. **Stina Svensson**
Host: Gabriella Sanniti di Baja
Address: Istituto di Cibernetica, CNR, Via Toiano 6, IT-800 72 Arco Felice (Napoli), Italy
Date: 010419–010627
Comment: Continuing research co-operation in digital shape and its representations. Sanniti di Baja was Svensson's assistant supervisor.

4. **Gunilla Borgefors, Ingela Nyström**
Host: Gabriella Sanniti di Baja
Address: Istituto di Cibernetica, CNR, Via Toiano 6, Arco Felice (Napoli), Italy
Date: 010531–010601
Topic: Discussions of ongoing research

7.8 Short visits to other research groups and meetings outside CBA

1. **Tommy Lindell**
   Host: Philip Kramer
   Address: Rosenstiel School of Marine and Atmospheric Science, University of Miami, FL, USA
   Date: 010108–010115
   Topic: Work on common paper on bleaching of Belizian corals

2. **Ingela Nyström**
   Host: Kalle Åström
   Address: Phone group meeting
   Date: 010111
   Topic: SSAB Board Meeting

3. **Everyhopa at CBA**
   Host: Lennart Thurfjell
   Address: Reachin AB, Årstaängsvägen 24, Stockholm
   Date: 010117
   Topic: Our former colleague Lennart invited us to the company where he is employed. He gave a presentation of the structure of Reachin and presented the current projects. After that we had a chance to try one of the haptic systems that can "mimic real world operations with a combination of touch and sight."
   Comment: Lucia visit 2000 (sic!)

4. **Ewert Bengtsson, Fredrik Bergholm, Gunilla Borgefors**
   Host: VISIT
   Address: Arlanda Meeting
   Date: 010119
   Topic: Discussion of future funding in the field of visual information technology.
   Comment: Participants from all partners (KTH, UU, SLU, LiU, CTH, HH, LTH) in the VISIT consortium, and Photogrammetry, KTH. Discussion on how to proceed with applications for funding in the filed in the future, since the VISIT programme ends 2003.

5. **Fredrik Bergholm**
   Host: Hans Knutsson
   Address: Dept. of Biomedical Engineering, Linköping University
   Date: 010202
   Comment: VISIT Research Programme. Presentations and discussions.

6. **Ewert Bengtsson**
   Host: Bengt Långström, Mats Bergström
   Address: PET Centre, UU hospital
   Date: 010212
   Topic: Discussion about a new collaboration project involving a new joint PhD student

7. **Ewert Bengtsson**
   Host: Rector Birgitta Stymne
   Address: University College of Gävle
   Date: 010227
   Topic: Discussion about cooperation between UU and Gävle university college regarding a joint chair in computer graphics.

8. **Fredrik Bergholm**
   Host: Jan-Olof Eklundh, Stefan Carlsson
   Address: NADA, KTH, Stockholm
   Date: 010306
   Topic: VISIT board meeting (No. 29).
   Comment: Board meeting and presentations by host.

9. **Ingela Nyström**
   Host: Gabor T. Herman

Address: Temple University, Philadelphia, PA, USA
Date: 010313
Topic: Visited Gabor's group. Attended T. Yung Kong's seminar on Khalimsky topologies.

10. **Ewert Bengtsson**
Host: Viveka Hallden, Eva Mueller, IngMari Munktell
Address: UU library
Date: 010329
Topic: Discussion about the need for and the technical possibilites of realising a virtual museum to present the cultural heritage of UU on the web.

11. **Tommy Lindell**
Host: Rutger Rosenberg, Odd Lindahl
Address: Kristineberg Marine Research Station, Lysekil
Date: 010329–010330
Topic: Discussions with the hosts, the RESE research group, and Kai Sørensen, NIVA, Oslo on monitoring of water quality from satellites.

12. **Tommy Lindell**
Host: Kai Sørensen
Address: NIVA, Oslo, Norway
Date: 010331
Topic: Continued discussions on water quality monitoring from satellites.

13. **Ingela Nyström**
Host: Patrick Min, Thomas Funkhouser
Address: Dept. of Computer Science, Princeton University, NJ, USA
Date: 010409
Topic: Nyström held a seminar on skeletonization and distance transformation and was introduced to the activities of the graphics group. Min presented his research on shape analysis in terms of skeletons and decompositions.

14. **Tommy Lindell**
Host: Eugenio Zilioli
Address: CNR, Milano, Italien
Date: 010419–010424
Topic: Discussions on water quality monitoring from satellites and continued common work on hyperspectrol sensors. Work on the Hy-Sens project with data from ROSIS on Lake Garda.

15. **Ewert Bengtsson**
Host: Ann-Katrin Malmnäs
Address: ESF-rådet, Uppsala
Date: 010503
Topic: Discussions about possible support from EU mål-3 (EU Goal3) funds for the Uppsala Internet Protocol Academy Project

16. **Lucia Ballerini, Joakim Lindblad, Carolina Wählby**
Host: Heung-Kook Choi
Address: Medical Image Technology Laboratory (MITL), Inje University, Kim-Hae, Korea
Date: 010520–010527
Topic: Discussions and exchange of ideas concerning medical image analysis. The visit was made in connection with the Fifth Korean-German Joint Workshop on Advanced Medical Image Analysis in Seoul. Joakim Lindblad and Lucia Ballerini held seminars at Inje University. Wählby left 010522.

17. **Fredrik Bergholm**
Host: Tomas Gustavsson
Address: Chalmers, Göteborg
Date: 010529
Topic: VISIT board meeting (No. 30).
Comment: Board meeting and presentation of educational tools.

18. **Petra Ammenberg**
Host: Brittmarie Ammenberg
Address: Stigslund compulsory school, Gävle
Date: 010530
Topic: Information about water quality and remote sensing.

19. **Petra Ammenberg**
Host: Eugenio Zilioli, Claudia Giardino
Address: CNR, Milan, Italy
Date: 010702–010705
Topic: Water quality and remote sensing.

20. **Fredrik Bergholm**
Host: Jens Arnspang
Address: Dept. of Computer Science, Copenhagen University (DIKU), Denmark
Date: 010809–010810
Comment: Negotiations and discussions concerning joint patent (Bergholm, Arnspang, Henriksen), with company from Aalborg. Presentation of plenoscopy.

21. **Ewert Bengtsson**
Host: Kenneth Wester
Address: Rudbeck lab, UU
Date: 010817
Topic: Discussion about continued and renewed cooperation on tissue and microvessel analysis
Comment: Christer Busch also participated

22. **Roger Hult**
Host: Vince Magnotta
Address: Iowa MHCRC Image Processing Lab, Iowa City, USA
Date: 010820–010824
Topic: Discussions on development in the program BRAINS 2.

23. **Ewert Bengtsson**
Host: Bernt Ericson, Magnus Karlsson, Per-Olof Karlsson
Address: Ericsson Foresight and Ericsson University. Actual meeting at Royal Viking Hotel, Stockholm
Date: 010822
Topic: Discussion about the planned National IT User Centre hosted by UU

24. **Ewert Bengtsson, Joakim Lindblad, Carolina Wählby**
Host: Stuart Swinburne
Address: Amersham Pharmacia Biotech, Cardiff, Wales
Date: 010927–010928
Topic: Presentation of segmentation methods for fluorescence microscopy images and discussions on further developments and cooperations.

25. **Ingela Nyström, Stina Svensson**
Host: Gabriella Sanniti di Baja, Carlo Arcelli
Address: Istituto di Cibernetica, CNR, Pozzuoli (Napoli), Italy
Date: 011001–011003
Topic: A new project was started on 3D grey-level skeletons. Carlo Arcelli, Ingela Nyström, Gabriella Sanniti di Baja, and Svensson had fruitful discussions.

26. **Gunilla Borgefors**
Host: SLU
Address: Ultuna
Date: 011004
Topic: "SLU Forum" where Dept. heads are given the latest news from the SLU Rector.

27. **Ingela Nyström, Carolina Wählby**
Host: Anna Persson, Erik Sloge, Lennart Björkesten

Address: Amersham Pharmacia Biotech, Uppsala
Date: 011009
Topic: Milestone of Master thesis project. Persson presented a literature study and selected algorithms.

28. **Fredrik Bergholm**
Host: CBA
Address: CBA
Date: 011022
Topic: VISIT board meeting (No. 31)
Comment: VISIT Research Programme and presentation by Mattias Aronsson.

29. **Ewert Bengtsson**
Host: Håkan Hall, Ingrid Agartz, Stefan Arnborg
Address: Dept. of Psychiatry, Karolinska Hospital, Stockholm
Date: 011024
Topic: Discussion of progress and plans for Roger Hult's research work

30. **Gunilla Borgefors**
Host: Brita Fagerström
Address: JLT-fak, Ultuna
Date: 011114
Topic: Discussions on future contacts between CBA and JLT-fak

31. **Fredrik Bergholm**
Host: Gunnar Sparr
Address: Mathematical Imaging Group, Lund University
Date: 011115
Topic: Visit related to VISIT Programme. Presentations.

32. **Ewert Bengtsson**
Hosts: Museums in London
Address: London, England
Date: 011117–011119
Topic: Visits to five major museums, galleries and libraries in London to study how they use IT to present their collections to the public.
Comment: A delegation from UU Museum, Library and IT faculty made this study trip

33. **Fredrik Bergholm**
Host: Kerstin Malmqvist
Address: Halmstad University
Date: 011126
Topic: VISIT board meeting (No. 32)

34. **Ewert Bengtsson**
Host: Eva Müller
Address: UU Library "Carolina"
Date: 011205
Topic: Metadata and portfolios, how can the university digital publishing group and the Uppsala Learning Lab developments on portfolios cooperate.

35. **Ewert Bengtsson**
Host: Yngve Sundblad
Address: Centre for User-Oriented IT Design (CID), KTH, Stockholm
Date: 011206
Topic: Discussions on cooperation through NITA, the National IT User Centre
Comment: Ylva Hambreaus from "IT-företagen" and Mia Lindegren also participated

36. **Ingela Nyström, Carolina Wählby**
Host: Anna Persson, Erik Sloge, Lennart Björkesten
Address: Amersham Biosciences, Uppsala

Date: 011217
Topic: Second Milestone of the Master thesis project: "Algorithms for registration of gel images produced in 2D electrophoresis experiments". Persson presented results and we discussed an outline of the forthcoming report.

37. **Ewert Bengtsson**
Host: Jerry Pettersson, Tony Barrera
Address: Cycore AB, Uppsala
Date: 011218
Topic: Discussions on possibilities for increased cooperation in development of low level computer graphics algorithms

7.9 Visiting scientists (staying at least 2 weeks)

1. **Heung-Kook Choi**
Host: Ewert Bengtsson
Address: Medical Image Technology Laboratory, Inje University, Kimhae, Korea
Date: 010702–010728
Topic: Visiting researcher. PhD at CBA 1996.

2. **Hyun-Ju Choi**
Host: Ewert Bengtsson
Address: Medical Image Technology Laboratory, Inje University, Kimhae, Korea
Date: 011213–020210
Topic: Visiting researcher. (Not relative of 7.9.1)

3. **Örjan Smedby**
Host: CBA
Address: Dept. of Radiology, Linköping University Hospital
Date: most Wednesdays
Topic: Smedby is involved in many CBA activities.

7.10 Other visitors

1. **Jesper Fahlén**
Host: Carolina Wählby
Address: Swedish Pulp and Paper Research Institute (STFI), Stockholm
Date: Several visits during the Spring 2001.
Topic: Analysis of wood fibers using image analysis algorithms originally developed for cell segmentation.
Comment: The work resulted in a presentation at the 11th ISWPC, International Symposium on Wood and Pulping Chemistry, Nice, France, June 11-14, 2001 with the title "Cross section structure of the secondary wall of wood fibers as affected by processing" by Jesper Fahlen and Lennart Salmen.

2. **Don Pierson**
Host: Tommy Lindell
Address: Evolutionary Biology Centre, Dept. of Limnology, UU
Date: Several visits during Spring 2001
Topic: Discussions on joint paper on water quality from remote sensors.

3. **Rutger Roseen**
Host: Ewert Bengtsson
Address: Electrolux AB, Stockholm
Date: 010126
Topic: Discussions on extended co-operation in relation to ongoing Master Thesis project (see #)

4. **Håkan Hall, Ingrid Agartz, Stefan Arnborg**
Host: Ewert Bengtsson
Address: Dept. of Psychiatry, Karolinska Hospital, Stockholm

Date: 010201
Topic: Presentation of the Human Brain Informatics, HUBIN project, and discussion of possible collaboration with participation of Roger Hult

5. **Stefan Höglund**
   Host: Ingela Nyström, Ida-Maria Sintorn
   Address: Dept. of Biochemistry, BMC
   Date: 010213
   Topic: Planning a future study of quantifying approximately 10 similar virus particles.

6. **Stefan Seipel**
   Host: Ewert Bengtsson
   Address: Man Machine Interaction group, Dept. of Information Sciences, UU
   Date: 010214
   Topic: Discussion of possible collaboration projects between Image analysis, Computer graphics and Man machine interaction

7. **Don Pierson**
   Host: Petra Ammenberg
   Address: Evolutionary Biology Centre, Dept. of Limnology, UU
   Date: 010221
   Topic: Discussions on modelling of water properties.

8. **Alexandre Xavier Falcão**
   Host: Ingela Nyström (at MIPG)
   Address: Institute of Computing, State University of Campinas - UNICAMP, Campinas, Brazil
   Date: 010306
   Topic: Discussion on how the Image Forest Transform can be used in shape analysis, i.e., in computing distance transforms, skeletons, and convex hulls.
   Comment: Falcão is "Dr. Live Wire".

9. **Kjell Wallin**
   Host: Ewert Bengtsson
   Address: Sensys Traffic AB, Jönköping
   Date: 010307
   Topic: Discussion about cooperation in developing image analysis for traffic monitoring including two master thesis student projects.

10. **Stuart Swinburn, Lars Majlöf, Lennart Björkesten, Ali Mahmadi**
    Host: Ewert Bengtsson, Carolina Wählby, Joakim Lindblad
    Address: Amersham Biosciences, Uppsala
    Date: 010312
    Topic: Discussion about extended cooperation in developing image analysis for fluorescence microscopy applications based on our previous cooperation with APB

11. **Gunnar Bergström, Petter Ranefall**
    Host: Ewert Bengtsson
    Address: Bergström Instruments AB, Stockholm
    Date: 010507
    Topic: Discussion about possible cooperation concerning the developing a commercial image analyiss software based on the IMP/IPAD system to be marketed by the company.

12. **Kjell Wallin**
    Host: Ewert Bengtsson
    Address: Sensys Traffic AB, Jönköping
    Date: 010509
    Topic: Discussion about two combined Master thesis projects at Sensys with the aim of developing a system for automatically detecting and reading license plates in images taken by an automatic traffic monitoring camera
    Comment: The two Master thesis students Tarek Kasim and Patrick Karlsson also participated.

13. **Stefan Simon (1), Mats Klaar (1), Tim Harris (2), Dietrich Ruelhmann (3), and Len Pagliaro (4)**
Host: Carolina Wählby, Joakim Lindblad and Ewert Bengtsson
Address: APBiotech; (1) Uppsala site, (2) US site, and (3) UK site, (4) Bioimage, Denmark
Date: 010530
Topic: Discussions on cooperations on development of image analysis methods with applications in fluorescence microscopy of cells.

14. **Louis Pastor Pérez**
Host: Gunilla Borgefors
Address: University Rey Juan Carlos, Madrid, Spain
Date: 010619
Topic: Discussions on possible future co-operation and exchange of students

15. **Mikiji Shigematsu**
Host: CBA, SLU
Address: Dept. of Bioprocessing, Division of Utilization of Biological Resources, Faculty of Agriculture, Gifu University, Japan
Date: 010720–010723
Topic: Wood Technology
Comment: Presentation of some research at CBA, presentation by M. Shigematsu, and discussions.

16. **Leonardo Bocchi**
Host: Lucia Ballerini
Address: Dept. Electronics and Telecommunications, University of Florence, Italy
Date: 010820–010825
Topic: Discussion on possible cooperation

17. **Karin Vestlund, Johan Stendahl**
Host: Gunilla Borgefors, Mats Erikson
Address: Dept. of Forest Management and Products, SLU, Ultuna
Date: 010823
Topic: Discussions on analysis of horizontal laser imagery from forests, for thinning purposes.

18. **Ubirajara C. Malavasi**
Host: Gunilla Borgefors
Address: Parana State Western University, Candido Rondon, Brazil
Date: 010824, 010830
Topic: Discussions of possible co-operation on detemination of seed vitality through image analysis.

19. **Anna Persson, Erik Sloge, Lennart Björkesten**
Host: Ingela Nyström, Carolina Wählby
Address: Amersham Pharmacia Biotech, Uppsala
Date: 010906
Topic: Kickoff for Anna Persson's Master thesis project: "Algorithms for registration of gel images produced in 2D electrophoresis experiments".

20. **Jan Vincent**
Host: Ewert Bengtsson
Address: Archiboldo, c/o Antarctic Pharma, Stockholm
Date: 010921
Topic: Discussions about renewed activities based on our wound analysis software.

21. **Election Board, Faculty of Forestry, SLU**
Host: Gunilla Borgefors
Address: SLU
Date: 010927
Topic: Discussions of possible candidates for "Fakultetsnämnden".

22. **Arash Fayyazi, Björn Kruse, Rainer Lenz**
Host: Gunilla Borgefors, Mattias Aronsson

Address: Dept. of Science and Technology, Linköping University, Campus Norrköping
Date: 010929
Topic: Discussions of the VISIT Paper research programme.

23. **Olof Eggestig**
Host: Ewert Bengtsson
Address: IT support department, UU
Date: 011003
Topic: IT security
Comment: Eggestig is the new head of IT security at UU. Discussions of various strategies for improving the IT security at UU.

24. **Stefan Seipel, Lennart Thurfjell, Gunnar Jansson**
Host: Ewert Bengtsson
Address: ReachIn Technologies AB, Stockholm
Date: 011003
Topic: Possible future cooperation project on medical applications of haptic displays

25. **Marcus Liljeberg**
Host: Petra Ammenberg
Address: IVL, Swedish Environmental Research Institute, Stockholm
Date: 011010
Topic: Industrial plume detection using remote sensing techniques.

26. **Mohammed Homan**
Host: Ida-Maria Sintorn, Carolina Wählby, Ingela Nyström
Address: Dept. of Medicine, Centre for Molecular Medicine, Karolinska Hospital, Stockholm
Date: 011101
Topic: Discussion on cooperation on development of image analysis methods for classifying virus particles in electron micrographs.

27. **Jonas Pertoft**
Host: Carolina Wählby, Felix Wehrmann, Gunilla Borgefors
Address: Information office, UU
Date: 011107
Topic: How to realize both of the design profiles, at UU and SLU, on the web pages of CBA.

28. **Martin Peterzon**
Host: Ingela Nyström, Ida-Maria Sintorn
Address: Dept. of Biochemistry, HIV group, BMC, Uppsala
Date: 011107
Topic: Martin presented the latest reconstructions of HIV particles. Discussions on how segmentation will be performed.

29. **Göran Erskers, Håkan Bergqvist, Kjell Wallin**
Host: Ewert Bengtsson
Address: Banverket, Gävle
Date: 011108
Topic: Discussion about a development project to develop ways of inspecting the power collectors on locomotives for damage based on images taken along the tracks. CBA will try to recruit a Master thesis student for this.

30. **Christine Antoine, Per Nygård**
Host: Gunilla Borgefors, Mattias Aronsson
Address: Norwegian Pulp and Paper Research Institute, Trondheim, Norway
Date: 011113
Topic: Discussions about cooperation and sharing ideas for future work. Christine Antoine and Per Nygård demonstrated their X-ray microtome approach to create voxel volumes of paper samples.

31. **Johan Lidros, Anders Sandström**
Host: Ewert Bengtsson
Address: Transcendent Group, Stockholm
Date: 011120
Topic: Overview of IT organisation at UU as an introduction to the IT revision that is to be carried out by the vistors

32. **Gabriella Sanniti di Baja**
Host: Gunilla Borgefors, Stina Svensson, Ingela Nyström
Address: Istituto di Cibernetica, CNR, Pozzuoli (Napoli), Italy
Date: 011121–011128
Topic: Sanniti di Baja was assistant supervisor to Svensson and visited for the dissertation. Some common reseach was also done.

33. **Annick Montanvert**
Host: Gunilla Borgefors, Stina Svensson
Address: Institut National Polytechnique de Grenoble, Saint Martin d'Hères, France
Date: 011122–011125
Topic: Opponent for PhD dissertation of Stina Svensson. Scientific discussions also held.

34. **Bengt Hoppe**
Host: Ewert Bengtsson
Address: Falun
Date: 011128
Topic: The visitor has made an invention based on image analysis and he is interested in cooperation in evaluating this and possibly in developing a prototype .

35. **Pär Råghall**
Host: Ewert Bengtsson
Address: Systeam UDAC AB, Uppsala
Date: 011204
Topic: Discussions on Råghalls future engagement in the virtual IT-faculty and NITA

36. **Participants of the course Computerized Image Analysis MN2**
Host: Ingela Nyström
Address: –
Date: 011207
Topic: Profs Borgefors and Bengtsson presented Master thesis projects. Petra Ammenberg, Ingela Nyström, Anna Rydberg, and Ola Weistrand presented current research.

37. **Robert Evans**
Host: Mattias Moëll, Gunilla Borgefors
Address: CSIRO, Melbourne, Australia
Date: 011212–011214
Topic: Opponent for Mattias Moëll's PhD thesis defence. Also gave a seminar.

38. **Lars-Ulrik Bergström**
Host: Tommy Lindell
Address: Uppsala
Date: 011220
Topic: Discussion on proposed common work with Ramon Buzeta, Santiago, Chile

39. **Srinivas Mahadev**
Host: Ewert Bengtsson
Address: The National Institute of Information Technology (NIIT), India
Date: 011220
Topic: Presentation of IT learning support activities by UU and by NIIT which is one of the largest software and elearning companies in India, recently established in Sweden.

7.11 Committees

In addition to the international and national committees we participate in (listed below), the PhDs and senior PhD students at CBA annually review a considerable number of articles for many diverse international scientific journals and conferences. These are not listed in detail, as that would violate the confidentiality of refereeing.

Ewert Bengtsson
International:

- Board member of "European Society for Analytical Cellular Pathology" (ESACP), 1997–
- Editorial board member of "Machine Graphics & Vision", 1994–
  Comment: Published by Polish Academy of Sciences
- Editorial board member of "Computer Methods and Programs in Biomedicine", 1995–
  Comment: Published by Elsevier
- Editorial board member of "Analytical Cellular Pathology", 1999–
  Comment: Published by IOS press
- PhD dissertation opponent for Birgitte Nielsen, Dept. of Informatics (Ifi), University of Oslo, Norway, 20010906
  Comment: Title: Radial Differentiation of Low Dimensionality Adaptive Texture Feature Vectors in Cell Nuclei as a Tool in Tumour Pathology

National:

- Royal Society of Sciences in Uppsala (Kungliga Vetenskaps-Societeten), Member No.2, 199809–
  Comment: Elected member of this, the oldest scientific society in Sweden. (Four meetings.)
- Advisor to the rector on Information Technology at UU, 199802–
  Comment: One of five advisors appointed to lead the strategic planning of UU and give advice to the Rector. Thus member of "Rectors advisory council". (Twelve meetings.)
- Chair of the Virtual Faculty of Information Technology, UU, 199807–
  Comment: The faculty is responsible for coordinating all aspects of the information technology field at UU. The faculty board has about 15 members. (Eight meetings.)
- Chair of the board of Uppsala Learning Lab, ULL, 199908-
  Comment: Uppsala Learning Lab is, through the Swedish Learning Lab - network, cooperating with KTH and KI and through the Wallenberg Global Learning Network also with Stanford and Learning Lab Lower Saxony. The object of the cooperation is to develop new ways of using IT support in higher education. (35 meetings.)
- Chair of the WWW management board of UU, 200001–
- Chair of the Uppsala-Makerere IT cooperaton project, 200006–
  Comment: A project financed by SIDA aiming at developing IT infrastructure and competence at Makerere University, Kampala, Uganda. (Five meetings.)
- Member of the Board of UpGIS, the net for Geographical Information Systems at UU, 199904–
  Comment: Representing the virtual IT faculty, responsible for managing the economy of the network. (Eight meetings.)
- Member of the virtual museums group of UU. 200109–
  Comment: This informal new group works to develop how the cultural heritage treasures owned by UU can be presented on the web. (Three meetings, one study trip.)
- Member of the student cooperation group, 200001–
  Comment: A group where the leadership of the university and the student unions meets to discuss matters of common interest. (Five meetings.)

- Planning committe for a new Medical Engineering Course, UU, 20011205
  Comment: A new course will be given VT2002 with some lectures on medical imaging.
- Member of the HPC High Performance Computing working group *UppMAX*, 199803–
  Comment: The group developed a proposal for a Regional High Performance Computing Center in Uppsala during a series of meetings. The group is continuing the efforts of establishing such a center. (Five meetings.)
- Member of the Board of Entrepreneuring school in Heby, 199904–
  Comment: Representing IT which is one of the profiles of this planned new school. (Two meetings.)
- Member of the Uppsala Chamber of Commerce IT board, representing UU. 200006–
  Comment: Working with various activities to promote cooperation researchers - companies. (Eight meetings.)
- Chair of working group for a National IT User Centre, NITA, 200008–
  Comment: Established a Swedish national IT user centre funded by Vinnova and UU and in cooperation with industry. (13 meetings.)
- Member of work group for developing a joint public municipal area network in Uppsala, 200008–
  Comment: This project is actively coordination the interest between local and county authorities, landlords, universities etc. in order to achieve a new IT infrastructure in the Uppsala region. (Five meetings.)
- Chair of Uppsala Internet Protocol Academy, UIPA, 200011-
  Comment: A cooperation network between universities, local authorities, other education providers and companies to develop education and other kinds of cooperation on Internet technology on all levels in the Uppsala region. (14 meetings.)
- Member of group to analyse Uppsala region IT clusters. 200108–
  Comment: A cooperation between local and regional authorities, chamber of commerce and universities. (Three meetings.)
- Chair of the National Reference group of the VISIT research program, 199702–
  Comment: Responsible for coordination between the various research groups and the board of the VISIT research program financed by the Foundation for Strategic Research.
- Chair and initiator of a national application for VITAMIN, a new research framework project
  Comment: A network of 14 senior research leaders in 10 different groups were coordinated to submit a large application to the foundation for Strategic Research. It was approved in the first round and then a second more extensive applicaiton was written and submitted. (Only two physical meetings but 212 emails.)
- PhD thesis examination committee for Tomas Sundin, Systems and control, UU, 20010420
  Comment: Title: Spectral analysis and magnetic resonance spectroscopy
- PhD thesis examination committee for Björn Knutsson, Dept. of Computer Systems, UU, 20010502
  Comment: Title: Architectures for application transparent proxies: A study of network enhancing software

Fredrik Bergholm
National:

- Executive Programme Director of the VISIT research program, 001211–

- Dissertation committee for the degree of PhD, Danny Roobaert, Dept. of Computer Science, University of Toronto, Canada
  Comment: Title: Pedagogical support vector learning: A pure learning approach to object recognition.

Gunilla Borgefors
International:

- Fellow of the “International Association for Pattern Recognition” (IAPR), 1998–
  Comment: Secretary 1990–1994, 1st Vice President 1994–1996
- Constitution and Bylaws Committee, International Association for Pattern Recognition (IAPR), 2000–

- Nordic correspondent for the IAPR Newsletter, 1998–
  Comment: Published by International Association for Pattern Recognition.
- Senior member of the “Institute of Electrical and Electronics Engineers”, Inc. (IEEE), 1998–
- Editorial board member, “Rivista di informatica”, 1994–2001
  Comment: Published by the Italian Association for Informatics and Automatic Computation, Milano, Italy
- Editorial board member, “Image Processing and Communications”, 1994–
  Comment: Published by the Institute of Telecommunications, Bydgoszcz, Poland
- Editorial Board member, “Pattern Recognition Letters”, 1998–
  Comment: Published by Elsevier
- Steering Committee member for Discrete Geometry for Computer Imagery (DGCI) conferences, 200012–
- Organizing Committee Member for First French-Nordic Summer School in Mathematics (EEFN), Erken (Norrtälje), 200101-200106
  Comment: EEFN was initiated by the Counsellor for Science and Technology at the French Embassy in Sweden, Professor Jean-Marie Guastavino, and conducted under the auspices of the Royal Swedish Academy of Sciences, Institut Mittag-Leffler, and UU.
- Programme Committee Member for 4th International Workshop on Visual Form, Capri, Italy, 200105
- Programme Committee Member for 6th Int. Conference on Pattern Recognition and Information Processing, Minsk, Belarus, 200105
- Programme Committee Member 3rd Int. Conf. on Audio- and Video-based Biometric Person Authentication, Halmstad, Sweden, 200106
- Programme Committee Member 12th Scandiavian Conference on Image Analysis, Bergen, Norway, 200106
- Programme Committee Member for 2nd IEEE Region 8-EURASIP Symposium on Image and Signal Processing and Analysis (ISPA’01), Pula, Croatia, 200106
- Dissertation Committee for the Degree of Doctor of Mark Ollila, Curtin University of Technology, Perth, Australia, 2001
  Comment: Title: Networking of geometric concepts for algebraic metrology. Written assessment.

National:

- Royal Society of Sciences in Uppsala (Kungl. Vetenskaps-Societeten), Member No. 19, 200009–
  Comment: Elected member of this, the oldest scientific society in Sweden (founded 1710)
- Member, Swedish Parliamentarians and Scientists, 1987–
  Comment: Members are elected. Only one scientist per field admitted.
- Permanent member, Appointments board, Faculty of forestry, SLU, 199907–
- Member of the Board of UpGIS, the net for Geographical Information Systems at UU, 199904–
  Comment: Representing Faculty of Science and Technology at UU
- Member of National Reference group of the VISIT research program, 199702–
- Dissertation Committee for the degree of Ph.D. for Sasan Gooran, Dept. of Science and Technology, Linköping University, Campus Norrköping, 20010302
  Comment: Title: High quality frequency modulated halftoning
- Discussion leader (“diskutant”) for the degree of Licentiate for Magnus Lundberg, Dept. of Signals and Systems, Chalmers University of Technology, Göteborg, 20010309
  Comment: Title: Electro-optical land mine detection
- Dissertation Committee for the degree of Ph.D. of Niklas Strömbeck, Dept. of Limnology, Evolutionary Biology Center, UU, 20010515
  Comment: Title: Water quality and optical properties of Swedish lakes and coastal waters in relation to remote sensing

Tommy Lindell
International:

- Affiliate Associate Professor and Officer for Valle Scandinavian Exchange Program, University of Washington, Seattle, WA, USA, 1985–

Ingela Nyström
National:

- Board member, Swedish Society for Automated Image Analysis (SSAB), 200003–
- Member of the Electorial Board (“elektorsförsamlingen”) of the Faculty of Science and Technology, UU
- Member of the recruiting board for Computer science, UU