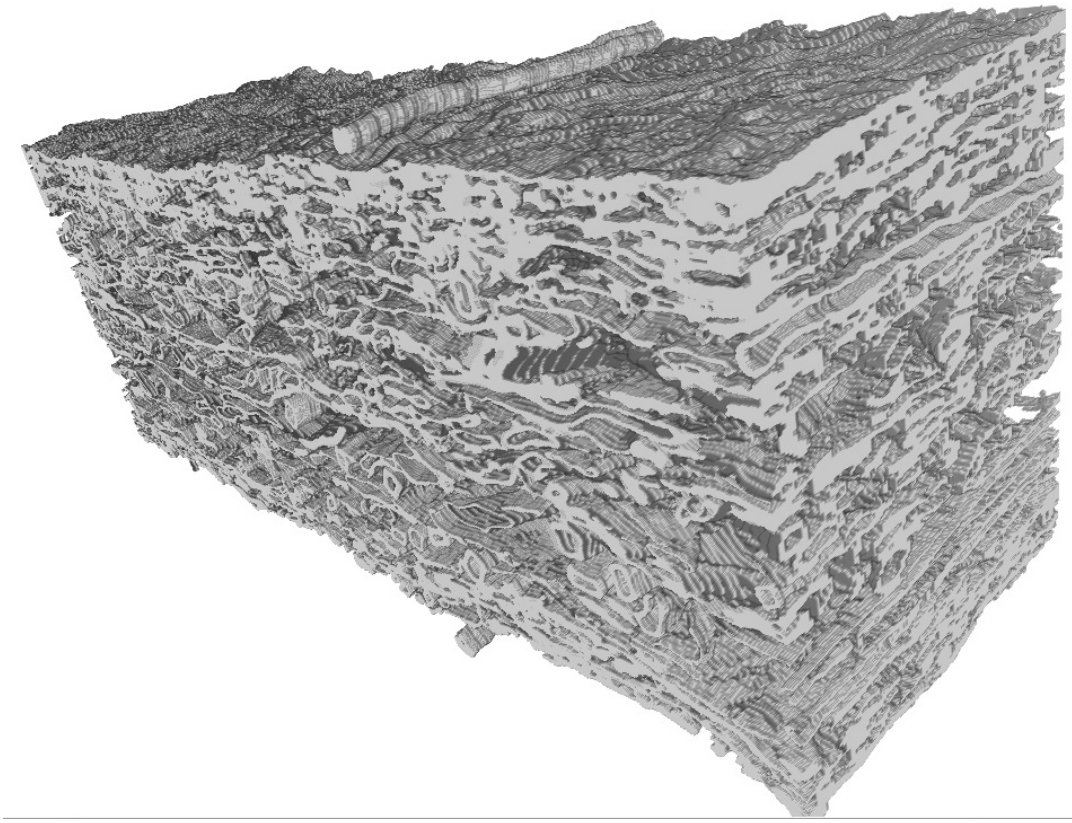
Centre for Image Analysis
Swedish University of Agricultural Sciences
Uppsala University

ANNUAL REPORT 2002



SLU

UPPSALA UNIVERSITET

Annual Report 2002

Centre for Image Analysis

Centrum för bildanalys

Cover:
Illustration from the PhD thesis presented by Mattias Aronsson at CBA during 2002.
Three-dimensional reconstruction of the inner structures of a small paper sample.
See Abstract in Section 4.3.

Edited by:
Gunilla Borgefors, Ingela Nyström, Ida-Maria Sintorn, Lena Wadelius
Centre for Image Analysis
Uppsala, Sweden
March 20, 2003

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 main activities at CBA is graduate education and research.

During 2002, there were a number of examinations, but also other notable achievements by CBA people. There was one dissertation, at the Faculty of Forestry, SLU (Mattias Aronsson), and one Licentiate exam at the TN-faculty, UU (Anders Hast). Fredrik Bergholm was promoted to Professor and Ingela Nyström became Docent in image analysis at CBA. Ingela Nyström was elected President of the Swedish Society for Automated Image Analysis, and Stina Svensson became its Secretary/Treasurer. In addition, Stina Svensson became one of two founding co-chairs of the International Association for Pattern Recognition Technical Committee for Discrete Geometry.

How many we are at CBA is a question with several answers. If we count everybody "in house" for at least part of their time we were 24 persons 20030101. In addition we supervise two PhD students at University College of Gävle. The employees are formally employed at either university. The whole of CBA is administrated through UU.

All personnel at CBA also participates, more or less intensely, in undergraduate education, mainly through the large Dept. of Information Technology at UU. There is also an undergraduate course at SLU.

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 on applications suitable for these. The areas are volume (three-dimensional) images, e.g., tomographic images of the human body; and spectral/hyperspectral images, that is images with 3–200 layers, where each layer represents a specific colour. Such images are, e.g., used to detect water pollution.

Generally speaking image analysis is a different subject than computer graphics and visualisation. CBA has, however, ever since its start, taken the responsibility for undergraduate education at UU in computer graphics and carried out some projects in graphics and visualisation. When, in 2002, UU finally created a Chair in Computer Graphics and Visualisation (jointly with University College of Gävle) it was decided that the chair was to be placed at CBA, when occupied (from 20030101). As a consequence, the UU PhD subject "Computerized image analysis" was widened to "Computerized image processing", since the latter subject also can include graphics and visualisation. The PhD subject at SLU is still "Image Analysis".

Most of the application projects are carried out in close co-operation with researchers from other research areas. We also co-operate internationally on basic research. During 2002 we had active and significant co-operation with 21 international groups in 15 countries and 44 national groups. We are also very active in international and national societies and committees, participate in international and national conferences, and give seminars in many different places and contexts, 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 2002, with abstracts of the refereed ones; and Section 7, finally, lists all the various activities we participate in. Note that each Section starts with a short summary printed in a larger font than the following detailed material.

Our annual reports have been available on the Internet since 1998. For this issue, see

http://www.cb.uu.se/verksamhet/annual_report/AR02html/

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, medicine, and industry." The research work is more or less organised in three groups. The borders between the groups are becoming more and more fuzzy, as many projects enclose people from several groups. The groups are: 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 group at SLU headed by Gunilla Borgefors, which concentrates on forestry applications and digital geometry, but also conducts research on medical applications. The order of groups and projects below is arbitrary.

The *SLU Image Analysis group* has the aim to be a central SLU source for image analysis knowledge. This means that we conduct basic image research, in addition to being involved in a number of applications, from forest inventory via paper fibre analysis *in situ* to virology. The main problem in the group in the past has been the lack of seniors, except the professor. However, from this year we employ an Assistant Professor ("Forskarassistent") for the first time.

For a number of years we have been working on wood fibre applications. One project investigates 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, to actually produce a high-resolution volume (3D) image of paper, which is quite difficult in itself, was accomplished about two years ago. Now, we have worked on shape analysis, at the individual fibre level, the fibre network level, and at the paper level, and developed algorithms for computing a number of useful measures. This project is part of the national VISIT programme, funded by SSF, and is done in co-operation with StoraEnso Research, Falun and Dept. of Science and Engineering, Linköping University, Campus Norrköping. Mattias Aronsson successfully defended his PhD thesis in this project 12 Dec. 2002.

Another fibre project, that was finished this year developed methods to automatically analyse fibre morphology in confocal microscopy transverse sections of wood. For the forest industry to be able to maximise the use of the wood fibre potential, more knowledge of the fibre morphology is needed. ¿From 1998, the work has been done in close collaboration with Forest Research New Zealand Ltd, and this co-operation will continue, as Mattias Moëll, who become a Doctor in this project Dec. 2001 is now employed at this company.

Two other small projects in Bengtsson's group deals with fibre and paper analysis.

Forest inventory from air-borne sensors have been an active and 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 very accurate segmentation methods for tree crowns, and species identification based on this segmentation. The goal is to be able to differentiate between spruce and pine. Even though they have the same spectral signatures, they do have, on the average, different shapes and

internal structure. This year, we have also worked together with Dept. of Forest Resource Management and Geomatics, SLU, Umeå to evaluate tree segmentation algorithms.

We also are involved in a pilot project to evaluate if horizontal laser scanning data is suitable for guiding a robot for thinning young forests.

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. Most of the work this year concentrated on evaluation of different meat processing methods.

The SLU group also works on several medical applications (a consequence of the CBA environment).

PhD student Xavier Tizon investigates the uses of grey-level connectivity and fuzzy set theory in 2D and 3D images. The main application is arteries-veins separation in magnetic resonance angiography images. Spin-offs also investigate segmentation of other images using the same principles, e.g., detection of liver cancer metastases. We co-operate with Dept. of Medicine and Care, Linköping University. This project, is part of the national VISIT programme, and involves both groups at CBA.

A new project, where Xavier Tizon is our main researcher has been started during the year. The task is to develop measures for and measure the total plaque burden index in whole-body magnetic resonance images. If this is successful, it can lead to massive scanning programmes for early detection of arteriosclerosis. This work is done in close co-operation with Dept. of Oncology, Radiology, and Clinical Immunology, UU Hospital.

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).

PhD student Ida-Maria Sintorn is involved in two virus applications. The first is the identification and classification of human cytomegalo virus. Available transmission electron microscopy images of infected cell nuclei are quite noisy. We have reached quite good results using normalised mean radial grey-tone profiles for the three main degrees of virus maturation. This work is done together with Centre for Molecular Medicine, Karolinska Hospital, Stockholm. Another virus application is to investigate the 3D shape of HIV viruses by reconstruction from a series of electron micrograph projections. Ingela Nyström is also active in both these projects.

In the theoretic work, the group concentrated on digital geometry in 3D and on extending methods for binary image processing to fuzzy images, to avoid the difficult and data-destroying binarisation step.

An old "obsession" of the group is the development of digital distance transforms. They are very useful tools for many types of image analysis. This year, the work included developing more exact distance transformations in 3D, using neighbourhoods up to $5 \times 5 times 5$ voxels. In medical and industrial volume images, the picture elements are often rectangular boxes rather than cubes. It is preferable to work directly in such grids, rather than interpolating the image to a cubic grid. We have optimised distance transforms in such grids. We have also investigated distance transforms in 4D, using $3 \times 3 \times 3 \times 3$ neighbourhoods. Finally, we have developed a way to apply distance transforms to fuzzy segmented objects. The various people involved in distance transform research are Gunilla Borgefors, Ida-Maria Sintorn, and Stina Svensson.

Assistant Professor Stina Svensson continues to work on digital shape in volume images. One direction of the research is the decomposition of 3D objects into significant parts, i.e., nearly convex parts and elongated parts, using distance transforms. It is often necessary to apply similar processes to the background of the objects and to compute and analyse their convex deficiencies. Another research direction is skeletonization (or thinning), which is the process where objects are reduced to structures of lower dimension. Objects in 3D can be reduced to surfaces or even to curves. This year, we have started serious work on skeletonization directly on grey-level images. One application is finding central lines through blood vessels in MR images. The computations of curve skeletons have also led to work on analysis of digital curves in 3D. Much of Svensson's work is done in co-operation with Istituto di Ciber-

netica, Napoli, Italy. At CBA, Ingela Nyström and Ida-Maria Sintorn are heavily involved in several aspects of this work. Finally, in co-operation with the Pattern Recognition Section at Delft University of Technology Svensson has started work on shape analysis in 4D.

PhD student Nataša Sladoje is working on the new project: Fuzzy shape analysis in 2D and 3D. This means development of shape analysis directly in grey-level images or in fuzzy segmented images. So far, the work has been concentrated on accurate and precise measurements of fuzzy objects that have low resolution. Ingela Nyström is assistant supervisor for Nataša Sladoje.

Another small grey-level shape project that started this year regards the computation of grey-level convex hulls.

Shape description derived from volume images is usually local, which prevents comparison between and analysis of shapes in different translations and rotations. We aim to develop global shape descriptions using a linear combination of spherical harmonics. The problem has been solved for starshaped objects and "nice" non-starshaped ones, but not yet generally. PhD student Ola Weistrand is working on this, in close co-operation with the Dept. of Mathematics at UU.

Lucia Ballerini has been working on genetic snakes, i.e., active contour models optimised using genetic algorithms.

The *UU Image Analysis group* has 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. A few years ago, 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, in particular the quantitative detection of so called "ruffling" cells. Carolina Wählby and Joakim Lindblad are the two PhD students working on these projects. Towards the end of the year a third student, Patrick Karlsson was recruited to this group.

Continuing our work on 3D tomographic images PhD student Roger Hult has worked in the Hubin (Human brain informatics) project at the Karolinska Institute and Hospital where he has implemented and tested his brain segmentation methods for MRI images. The main application is the relation between brain morphology and psychiatric conditions.

Another PhD student, Seyed Rahman Razifar, is working at the PET Centre, UU where he is studying how the multivariate information obtained from PET studies can be analysed and presented together with the multi-dimensional image data (3D+time). This year the work has mainly been focused on modelling the PET image formation processes.

PhD student Felix Wehrmann is working theoretically, and has continued his studies of fundamental methods for expressing the variation of shapes of natural objects in images. The most promising approach has turned out to be based on neural networks.

Another basic methods development project deals with the problem of representing and accurately and precisely measuring surface area and volume of 3D digitised objects. Especially measuring the surface is a difficult problem. This is being done mainly by Ingela Nyström and Joakim Lindblad in collaboration with Jayaram K. Udupa, University of Pennsylvania.

In a computer graphics project, Bengtsson is supervising PhD student Anders Hast from Gävle University College, who, together with Tony Barrera at 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.

Fredrik Bergholm has continued his research on plenoscopy, i.e., a new way of optically capturing and encoding 3D information in single 2D images.

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 for many years worked on our general platform for image analysis, the IMP system. Towards the end of the year we decided to reorganise the many changes and additions to the system that has been implemented over the last several years into a completely new system. This is expected to be completed in mid 2003.

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

One important area of research is our continued development of image analysis methods for 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.

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 goal here is using satellite, together with airborne hyperspectral data, for algae bloom detection, eutrophication, and pollution in Nordic waters. One aspect of the latter we have worked on is detection of industrial plumes in lakes and seas. Bio-optical modelling continues to be an important and necessary part of the work. At present PhD student Petra Philipson is working in the RESE project.

The co-operation with the Italian groups that participated in the SALMON project is continuing in ROSALMA, monitoring of chlorophyll and macrophytes from satellites, and NYMPHA, experimentation on a remote sensing integrated system for lake water monitoring.

Our work on the detection of coral bleaching from remote sensing sources has continued. It now includes sensors like IRS-LISS-III, SPOT, and IKONOS. Field work in Belize has been done during the year, to make evaluations possible. This project is also financed via RESE and Petra Philipson is the main researcher.

A new project in the group is focused on acquisition and colour correction of underwater multi- or hyperspectral data (e.g., colour photos). This can be important for many applications, such as marine biology and underwater archaeology. The research is carried out by PhD student Julia Åhlén at Gävle University College.

We also work theoretically on developing techniques for analysis of hyperspectral image data. This research in now mainly done by PhD student Hamed Hamid Mohammed. An important aspect is developing linear transformations method, based on such transforms as the familiar PCA (Principal Component Analysis) and the more recent ICA (Independent Component Analysis.) Hamid Mohammed also develops new techniques for information extraction using neuro-fuzzy systems, i.e., so-called Weighted Neural Networks (WNN).

Finally Hamed Hamid Mohammed has co-operated with Anders Larsolle at Dept. of Agricultural engineering, SLU, (Gunilla Borgefors is his assistant supervisor) on information extraction from hyperspectral crop reflectance data.

We have also supervised four Master Theses that were completed this year, most with industrial co-operation partners. They treated: Registration of electrophoresis gel images; Automatic high speed sorting of seed for quality control; Analysis of coal inclusions in cast iron; and Automatic detection and reading of road signs from a camera in a car window. Several other Master theses are in progress and will

be finished in 2003. Most of these are also industrial co-operations, e.g., Automatic detection of damages to pantographs on locomotives using image analysis; Detection and automatic reading of number plates on cars; and A system for quality control of shiny surfaces.

1.3 How to contact CBA

CBA maintains home-pages 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 contains links to a brief presentation, staff, vacant positions (if any), and "activities" that contains information on courses, seminars, this annual report (as .html and .pdf files), all publications since CBA started 1988 and other information, including an introduction to image analysis. Note that our Monday 15.15 seminar series is open to all interested persons.

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

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

CBA can be contacted in the following ways:

Address:	Lägerhyddsvägen 3†
	SE-752 37 Uppsala
	Sweden
Telephone:	+46 18 471 3460
Fax:	+46 18 553447
E-mail:	tt cb@cb.uu.se

† New number (but the same old house).

2 Organization

CBA is a joint entity belonging equally to Uppsala University (UU) and Swedish University for Agricultural Sciences (SLU), but administered through UU. How many we are at CBA is a question with several answers. If we count everybody "in house" for at least part of their time we were 24 persons 20030101. In addition we supervise two PhD students at University College of Gävle. If we count the time at CBA we get about 17 full time persons.

For many years, about half the graduate students have belonged to each university, but at the moment there are more graduate students at UU. Most seniors belong to UU. 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. The rest came from the two universities. Our total turnover for 2002 was 10.3 million SEK which is roughly 1 million less than last year. The main reason is that several big projects have finished during the year, without other projects taking their place (yet).

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 UU, even though we are responsible for and 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 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. A new Board was not appointed until 20030101. Thus we had to manage without this year.

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.

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, mostly digital geometry; 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 all 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 2002. 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. Changes from last year is that Governmental grants have increased, while research foundation grants and contracts have decreased. In total the income is about 0.5 million less than last year. This is compensated by an even larger decrease in personnel (due to many PhD exams late 2001) so that in

total we have a small positive financial result. This is necessary, as we do not have any accumulated funds worth mentioning at present.

The total turnover is thus 10.3 million for 2002, compared to 11.6 million for 2001. It is still true that about 50% of our research activities were financed by outside sources, which is the same as last year.

Table 1: CBA income and costs for 2002.

Income		**Costs**	
UU	2493	Personnel	6643
SLU	2420	Equipment	258
UU undergraduate education	1063	Operating exp. 4)	1122
Governmental grants 1)	1304	Rent	955
Non-governmental grants 2)	1597	University overhead	1306
Contracts 3)	1428		
Financial netto	86		
Total income	**10441**	**Total cost**	**10284**

1) Sw. National Space Board, Sw. National Land Survey

2) SSF, Research foundations etc.

3) Amersham Pharmacia Biotech, internal invoices etc.

4) Including travel and conferences

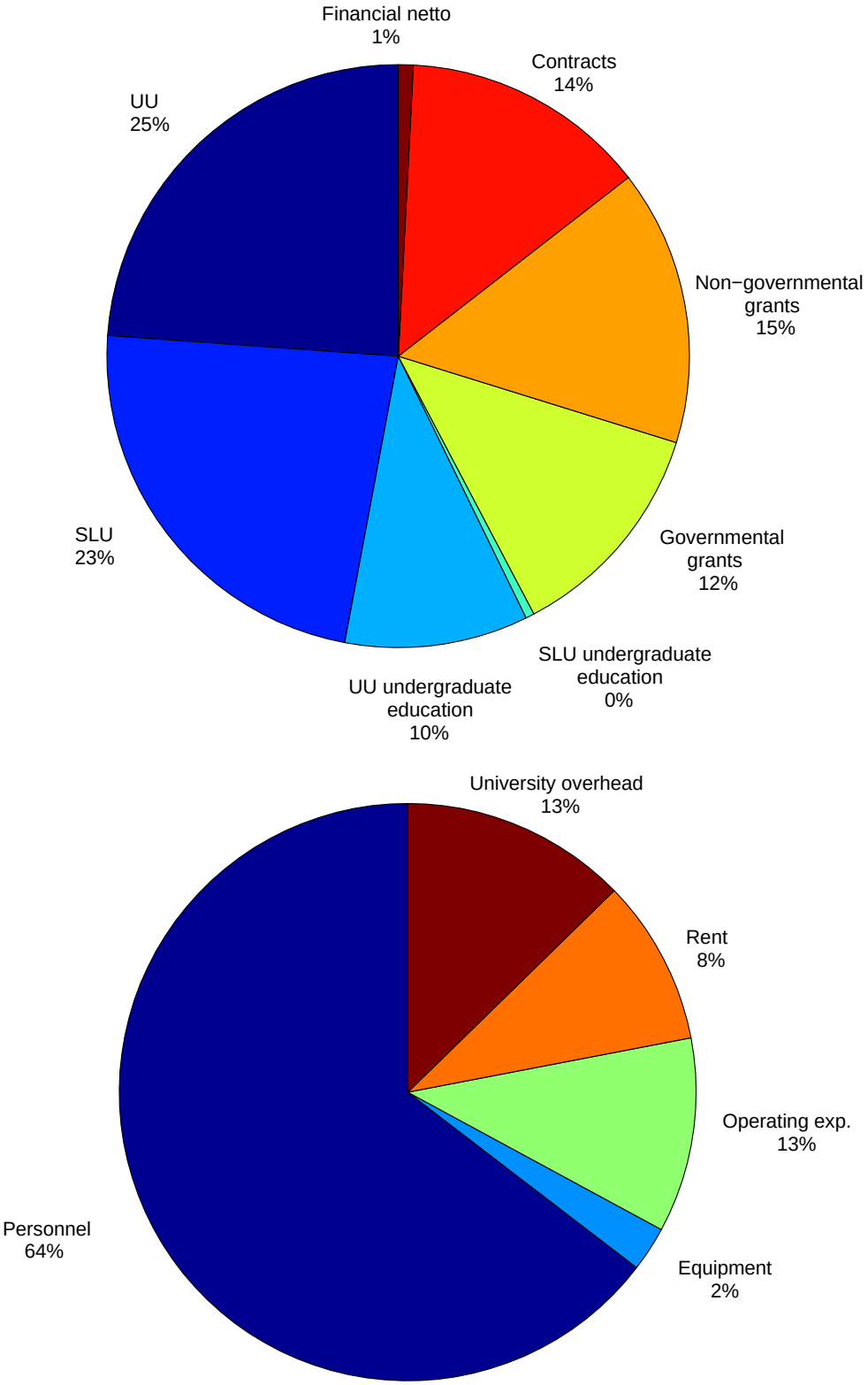


Figure 1: CBA income (top) and costs (below) for 2002.

2.3 Staff

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

Mattias Aronsson, Graduate Student/PhD, SLU
Lucia Ballerini, Researcher, PhD, –1030, SLU
Ewert Bengtsson, Professor, PhD, UU
Fredrik Bergholm, Professor, PhD, UU
Mats Erikson, Graduate Student, SLU
Hamed Hamid Muhammed, Graduate Student, UU
Patrick Karlsson, Graduate Student, 1201–, UU
Joakim Lindblad, Graduate Student, UU
Tommy Lindell, Docent, PhD, (part time) UU
Mattias Moëll, Graduate Student, –0331, SLU
Bo Nordin, Researcher/Lecturer, PhD, (part time) UU
Ingela Nyström, Docent, PhD, UU
Petra Philipson, nee Ammenberg, Graduate Student, UU
Seyed Rahman (Pascha) Razifar, Graduate Student, (part time) UU
Ida-Maria Sintorn, Graduate Student, SLU
Stina Svensson, Researcher, PhD, SLU
Xavier Tizon, Graduate Student, SLU
Felix Wehrmann, Graduate Student, UU
Ola Weistrand, Graduate Student, Dept. of Mathematics, UU
Carolina Wählby, Graduate Student, UU

Lena Wadelius, Administration

Karl-Johan Andersson, Master thesis
Karl Bohlin, Master thesis
Johan Helgesson, Master thesis
Robin Strand, Master thesis
Erik Vidholm, Master thesis

Per Bengtsson, project work
Patrick Karlsson, project work
Fredrik Lindell, 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
Roger Hult, Karolinska Institutet, Stockholm
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 Larsolle, nee 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

At SLU we are responsible for a course in basic image analysis. At UU, staff from CBA organizes and participates in many undergraduate courses, even though we are not the unit responsible for them. Of course we take care of the courses in image analysis and most of those in computer graphics, but we are also involved in many other courses.

We offer a number of Master thesis projects *(examensarbeten)* each year. Four were completed during 2002, which is less than usual. Many will be finished in early 2003.

3.1 SLU courses

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: 0202–03
   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**
   Exercise supervisor: Ida-Maria Sintorn
   Date: 0208
   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. Computer exercise on image analysis.

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. Many of these courses are on subjects closely related to our research, i.e., Computerized image analysis and Computer graphics. We have also taught courses in mathematics, and in programming languages such as C++ and Java.

1. **Data Mining, 5p**
   Hamed Hamid Muhammed
   Period: 0110-0201
   Comment: Computer exercises and assignments.

2. **Mathematics and Statistics with Computer Aided Learning, 10p**
   Hamed Hamid Muhammed
   Period: 0111–0201
   Comment: Computer exercises and assignments using Matlab.

3. **Software Tools MN1, 5p**
   Olle Eriksson
   Period: 0201–03

4. **Computers and Programming TDB1, 5p**
   Mattias Aronsson
   Period: 0201–04
   Comment: Evening course (17.15-21.00).

5. **Computer Programming, 4p**
   Mats Erikson
   Period: 0202–05
   Comment: Java programming.

6. **Computer Graphics I, 5p**
   Fredrik Bergholm
   Period: 0203–05
   Comment: Bergholm held 11 out of 17 lectures

7. **Computer Programming MN2, 5p**
   Olle Eriksson
   Period: 0203–05
   Comment: Java programming, 2nd course.

8. **Computerised Image Analysis MN1, 5p**
   Xavier Tizon
   Period: 0203–05

9. **Object Oriented Programming with C++, 5p**
   Bo Nordin
   Period: 0203–06
   Comment: Distance Course. Contents: Object oriented programming in C++, object oriented analysis and design, data structures.

10. **"Introduction to computerized image analysis" at the course "Surface characterization"**
    Stina Svensson
    Period: 020503
    Comment: Invited by Åsa Kassman-Rudolphi, Tribomaterials at Dept. of Materials Science, UU

11. **Object Oriented Programming with Java, 5p**
    Bo Nordin
    Period: 0206–08
    Comment: Summer Course. Contents: Object oriented programming with Java, object oriented analysis and design, data structures.

12. **Transform Methods, 5p**
    Ola Weistrand
    Period: 0209–10
    Comment: 14 problem sessions for the Engineering Physics program.

13. **Computers and Programming TDB1, 5p**
    Ida-Maria Sintorn
    Period: 0209–11
    Comment: C++ programming, 1st course.

14. **Computers and Programming TDB1, 5p**
    Bo Nordin
    Period: 0209–11
    Comment: Distance Course in C++ programming, 1st course, approximately 40% of the lectures

15. **Computer Programming MN1, 5p**
    Olle Eriksson
    Period: 0209–12
    Comment: Java programming, 1st course.

16. **Computer Programming MN1, 5p**
    Felix Wehrman
    Period: 0209–12
    Comment: Java programming, 1st course.

17. **Image Analysis**
    Carolina Wählby
    Period: 020924
    Comment: One lecture in a PhD course on “Current Scientific Methods”

18. **Computerized Image Analysis MN2, 5p**
    Ingela Nyström, Ewert Bengtsson, Fredrik Bergholm
    Period: 0210–12
    Comment: Continuation course on image processing. Three computer exercises on filtering, snakes (with help from Xavier Tizon), and fuzzy segmentation.

19. **Linear Algebra, 5p**
    Ola Weistrand
    Period: 0210–12
    Comment: 16 problem sessions for the IT program.

3.3 Master theses projects

1. **Algorithms for registration of gel images produced in 2D electrophoresis experiments**
   Student: Anna Persson
   Supervisor: Lennart Björkesten, Amersham Biosciences, Uppsala
   Examiner: Ingela Nyström
   Publisher: CBA Master Thesis Report No. 53, 36p., 2002,
   Uppsala University School of Engineering, UPTEC F 02 011
   Abstract: The standard method for separating proteins is two-dimensional gel electrophoresis (2DGE). The subsequent data analysis of the obtained digital gel images, is a bottleneck in the 2DGE procedure. One step in this analysis involves matching of protein patterns between gels, where proteins are visualised as spots. In existing matching methods, the images are normally matched after protein spots in the different gel images have been detected and assigned positional coordinates and identifying numbers. By reducing the gel images into a list of spot locations, a considerable amount of visual information, such as shape and intensity spread, is lost. Hence, matching algorithms that incorporate all available image information throughout the process are preferable. Such algorithms are commonly known as warping algorithms. Existing available warping algorithms have been investigated, and a suitable approach has been selected for a prototype implementation.
   The implemented algorithm uses a non-parametric transformation called piecewise bilinear mapping (PBM) together with a multi-resolution approach, which speeds up the optimisation process and removes misleading local optima close to the global optimum. A correlation function is used as a similarity measure and optimised using the BFGS algorithm. To evaluate the algorithm, images taken using the difference gel electrophoresis (DIGE) technique were used. This technique is based on fluorescence dyes. The testing of the warping algorithm on DIGE image pairs has produced successful results and the method has a potential to become a helping tool for existing matching methods. Some aspects of possible future improvements have also been identified.

2. **Implementation and evaluation of image analysis based seed classification and sorting system**
   Student: Torgil Svensson
   Supervisor: Jaan Luup, Nekros AB, Uppsala
   Examiner: Ewert Bengtsson
   Publisher: CBA Master Thesis Report No. 54, 43p., 2002,
   Uppsala University School of Engineering, UPTEC IT 02 021
   Abstract: An automatic seed sorting and classification system was implemented and evaluated. Image processing hardware was assembled and software was developed. Sorting divided 850 g seed samples into two fractions containing typical and non-typical seeds. Misclassification, when analysing a seed sample of a certain species, was defined as sorting seed kernels from other species into the fraction of typical seeds. Classification was based on statistical analysis of 22 morphological, colour and texture features extracted from seed kernel images. A decision algorithm, based on linear discriminant analysis and Mahalanobis distances, was used. Seed samples from eleven varieties of rye, barley, triticale, wheat and oats were classified into five classes. Classification into six and eleven classes was evaluated and a lower accuracy

than with five classes was found. Canonical discriminant analysis was performed. Extracted features were arranged in order of significance by stepwise discriminant analysis. Maximum misclassification of 2% was found for classification from and into rye, barley, wheat and oats. Misclassification of barley and oats into triticale was 2.5% and 4.1%, respectively. Results were achieved by sorting less than 10% of the sample as non-typical seeds. Requirements set for the project were met and the system will be developed into a commercial product.

3. **Image analysis of cast-iron**
   Student: Roya Khomand
   Supervisor: Jan Linder, Scania, Södertälje
   Examiner: Gunilla Borgefors
   Publisher: CBA Master Thesis Report No. 55, 62p., 2002,
   Scania, Reg. No. 02-580
   Abstract: This master thesis discusses the possibility of distinguishing salient features of cast-iron using a commertial image analysis system.
   There are three different types of cast-iron, “Ductile iron”, “Grey iron”, and “Compacted graphite iron”. It is the form of microstructure of graphite that determines the different types of cast-iron.
   Distinguishing cast-iron is presently done in accordance with the SS-EN ISO 945 standard that is visual comparison between reference photos and the test samples. Since the standard consists of visual manual comparison, there is the risk that the ascertainment, to a certain extent may be dependent on the operator. In order to distinguish the composition of cast-iron more objectively, as well as to allow more room for a number of measurable parameters for cast-iron, image analyse could be a powerful tool. In this study, it was possible to use image analyse as a tool to distinguish the different types and size of the graphite particles, but not their distribution. (In Swedish)

4. **Road sign recognition from a moving vehicle**
   Student: Björn Johansson
   Supervisor and Examiner: Ewert Bengtsson
   Publisher: CBA Master Thesis Report No. 56, 71p., 2002
   Abstract: This project aims to research the current technology for recognising road signs in real-time from a moving vehicle. The most promising technology for intelligent vehicle systems is vision sensors and image processing, so this is examined the most thoroughly. Different processing algorithms and research around the world concerned with sign recognition are investigated. A functioning system has also been implemented using standard web-camera mounted in a testing vehicle. The system is restricted to speed signs and achieves good performance thanks to fast but still robust algorithms. Colour information is used for the segmentation and a model matching algorithm is responsible for the recognition. The human-computer interface is a voice saying what sign has been found.

4 Graduate education

This year, there were two exams, one Licentiate at UU and one PhD at SLU. This is a little less than average, but then we had six exams in 2001. We also got a new Docent in Image Analysis at UU, the second one ever.

At the end of 2002, we were main supervisors for 14 and assistant supervisors for two graduate students; eleven at UU, three of which are oriented towards remote sensing; and five at SLU. Of these 16, eleven are working at CBA, while five are employed elsewhere, a proof of our extensive cooperation with other research units.

4.1 Courses

During 2002 the following two graduate courses were given:

1. **Analysis of Colour-, Multi- and Hyper-Spectral Images**
   Credits: 5 *Period:* 200203-06
   Examiners: Fredrik Bergholm and Ewert Bengtsson
   Lecturers: Fredrik Bergholm, Ewert Bengtsson, Hamed Hamid Muhammed
   Description: The goal of the course was to impart knowledge on how the spectral dimension in images gives rise to the impression we term "colour" and how colour can be used for interpretation and analysis of such (and other multi-spectral) images for various purposes. At the end of the course, the participants should understand how colour images are created from physics and biology, understand some aspects of the perceptual psychology behind colour perception, and thirdly, know the basic methods for dealing with colour information from multi- and hyper-spectral sensors. The course was aimed at researchers and students in fields where interpretation and analysis of colour images or other multi-spectral images is of interest.
   Comments: Four assignments were given. Text-book: Hunt, *Measuring Color*, 3rd edition.

2. **Application Oriented Image Analysis**
   Credits: 5 *Period:* 200210–12
   Examiner: Gunilla Borgefors
   Lecturers: Gunilla Borgefors, Mats Erikson, Ingela Nyström, Petra Ammenberg-Philipson
   Computer Exercises: Ida-Maria Sintorn was responsible
   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 Licentiate

Improved Fundamental Algorithms for Fast Computer Graphics

Anders Hast

Date: 20020528
Publisher: CBA Licentiate Thesis No. 7, 23 pages, 2002
Supervisor: E. Bengtsson
Opponent: Professor Vaclav Skala, West Bohemian University, Plzen, Czech Republic
Abstract: Fast algorithms for computer graphics is important both for interactive games and movies using computer animated special effects. We expect games as well as computer animated movies to have as much visual likeness to reality as possible. For games it is important that the graphics is fast and interactive. Whereas, for computer animated movies, a lot of off-line rendering time is needed. If this time could be reduced, money would be saved. Our research goal has been to come up with new ideas and to develop new and faster algorithms, methods and techniques as well as improved techniques giving a more realistic result. The papers presented in this thesis will discuss different software implementations. However, the algorithms themselves should be possible to realize in hardware. We have focused our research on shading algorithms and related techniques like bump mapping and filtering. Shading is relatively time consuming especially if Phong shading is used which involve a division and a square root. Several approaches is presented, which try to avoid these operations and still produce results similar to Phong shading.
Comment: The seminar took place at the Creative Media Lab, University College of Gävle.

4.3 Dissertation

On 3D Fibre Measurements of Digitized Paper - from Microscopy to Fibre Network

Mattias Aronsson

Date: 20021212
Publisher: Acta Universitatis Agriculturae Sueciae. Silvestria 254. ISBN 91-576-6338-6, 72 pages, Uppsala 2002
Supervisor: G. Borgefors
Opponent: Jayaram K. Udupa, MIPG, University of Pennsylvania, Philadelphia, USA
Committee:
Professor Hans Knutsson, Dept. of Biomedical Engineering, Linköping University
Professor Geoffrey Daniel, Dept. of Wood Science, SLU Uppsala
Dr Catherine Östlund, Swedish Pulp and Paper Research Institute (STFI), Stockholm
Abstract: Paper is a material that suits many different purposes, and is therefore used extensively. To be able to optimize the manufacturing parameters during the production in a paper mill, it is of great importance to know as much as possible about the material. Paper exists in many different qualities, and different paper grades can have very different properties. There already exists many techniques to measure paper properties, but nearly all are based on computerized image analysis of two spatial dimensions, or not based on image analysis at all. Recently, the processing power of computers has reached a level which makes it possible to analyze huge data sets, by 3D computerized image analysis. Most grades of paper consists of fibres connected in a 3D network, together with fillers and surface coatings. We have focused on the 3D network of fibres, to provide techniques to look into, and perform calculations on this network. Advantages of using image analysis is that if we can transform samples of paper into an accurate digital format, a computer can then be programmed to analyze some of the properties not easily accessible by other means. Both mechanical strength and opacity depend on the geometry of the fibre network, so the digital model could be useful for further analysis of these properties. Disadvantages are that the conversion from physical to digital form will introduce artefacts and this conversion is often time-consuming. Our work has been to develop a method to construct 3D digital models of paper and to develop some useful measurements. The digital models consist of efficient representations that enable our measurements and also provide a good base for further development. The measurements consist of a detailed fibre analysis, a few fibre network measures, and experiments to measure the fibre pore network. Both 2D and 3D based fibre segmentation algorithms have been implemented. The image capturing process is crucial, but we still believe that the core problem is to improve the fibre segmentation. Especially, a good reconstruction of the network requires a high percentage of the fibres to be found, something that need further work to be accomplished. This thesis will emphasize the image analysis part of the problem, even if there are as much to be said about paper as a material.

4.4 Docent degree

Challenges in measuring surface area and volume in digital images

Ingela Nyström

Date: 20021113
Abstract: In image analysis, quantitative measurements are used to describe objects. Two-dimensional objects can be described by, e.g., perimeter and area. The corresponding measures for three-dimensional objects are surface area and volume, respectively. This lecture will define different approaches to estimate such measures in the digital space. There are mainly two criteria that the computations should fulfil. The same estimate should be obtained repeatedly for the same object, i.e., the estimate should be invariant to, e.g., translation and rotation. In addition, the estimate should agree with ”truth”, i.e., the estimate should be accurate. It is important to be aware of the limitations that the discrete geometry may impose on precision and accuracy of measurements, but also of possibilities given. Results will be shown for mathematical phantoms, physical phantoms, and real objects segmented from medical images. Ideas for future improvements will also be presented.
Comment: Professor Bengt Lundberg was present as representative of “Docenturnämnden”.

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.

In this section, we list our current 44 research projects and provide a short description of each. We start with biomedical applications, then remote sensing for forestry and aquatic applications, followed by industrial applications, and finish with the basic research projects. Seven new projects were started during the year, and the same number were completed during the previous year.

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.

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 groups in 15 countries and 44 national groups with which we have had active cooperation in 2002.

5.1 Current research projects

1. **Fusion of 3D medical images**
   Xavier Tizon, Roger Lundqvist, Gunilla Borgefors, Ewert Bengtsson
   Funding: Swedish Foundation for Strategic Research, VISIT programme
   Period: 9707–0208
   Partners: Lennart Thurfjell, Personal Chemistry AB, Uppsala; 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 was focused on analysis of PET, SPECT, MR, and CT brain images. We 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 epileptic foci.
   Another important part throughout the fusion project has been a computerised brain atlas, which maps the human brain into anatomical and functional regions. Improved methods for atlas-based analysis and more accurate image registration methods have been developed. The brain atlas technique was 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 was used for discrimination from SPECT scans between patients suffering from Alzheimer's disease and normal controls subjects.
   Another development result has been improved methods for combined 3D visualisation of volume images.

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.
In November 2001, this work was presented and defended as a PhD thesis by Lundqvist. During 2002, he has worked on making the implementation of the methods in the atlas more robust and user friendly, on clinical verification of the methods and on finalising some publications documenting the results.

Arteries-veins separation in magnetic resonance angiography images
Another part of the project aimed 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. As a start set we used small sets of voxels marked by the user. Good user interaction possibilities, portability and reusability were important concerns in this project. That is why we chose to use public domain packages: the Visualization Toolkit (VTK) and the Insight Segmentation Toolkit. The work was published in "Journal of Magnetic Resonance Imaging" during this year.

2. **Plaque Burden Index estimation on whole-body Magnetic Resonance Angiography images**
   Xavier Tizon, Gunilla Borgefors
   Funding: Swedish Foundation for Strategic Research, VISIT programme
   Period: 0209–
   Partners: Lars Johansson, Håkan Ahlström, Dept. of Oncology, Radiology, and Clinical Immunology, UU Hospital
   Abstract: As part of a large clinical trial launched in order to study the causes of arteriosclerosis, a large number of volunteers will take part in a whole-body MR angiography study, using a protocol developed at the UU Hospital. The goal of the project is to develop Image Analysis tools to derive global measures of arteriosclerosis, from the characteristics of a limited portion of the arterial tree. The project will be split in four sub-tasks:

   1. Registration of the sub-volumes. The acquisition technique produces four MRA volumes that correspond to the head and upper torso, the abdomen, the upper legs and the lower legs. In order to be able to apply the subsequent image analysis procedure, they have to be assembled into one single image. The challenge here is the strong non-linearity of the imaging process, which shows considerable geometric distortion near the borders of the volume. This has to be corrected automatically, for example using a phantom approach, see Figure 2, left.
   2. Segmentation and identification of the arterial structure. Once the full volume has been reconstructed, the next step is the segmentation of the arteries from the rest of the visible structures. See Figure 2, right, for an unsegmented MRA image. Some methods developed in other projects, e.g., Project 1 will be used. The segmented arteries must then be identified, and only the interesting parts of the artery tree should be kept.
   3. Geometric measures to give an estimate of plaque burden. The geometry of the tubular structure of the arterial tree has to be studied. Irregularities in the diameter along the central line of the vessel may be a candidate measure of the plaque burden, but other indicators may also be interesting.
   4. Clinical testing. It is important, finally, to evaluate the clinical significance of the potential measures derived in Step 3. A clinical study will help to choose which one is the best for the physician to use. This part involves the writing of user-friendly and robust software, that would have to be used in different environments

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

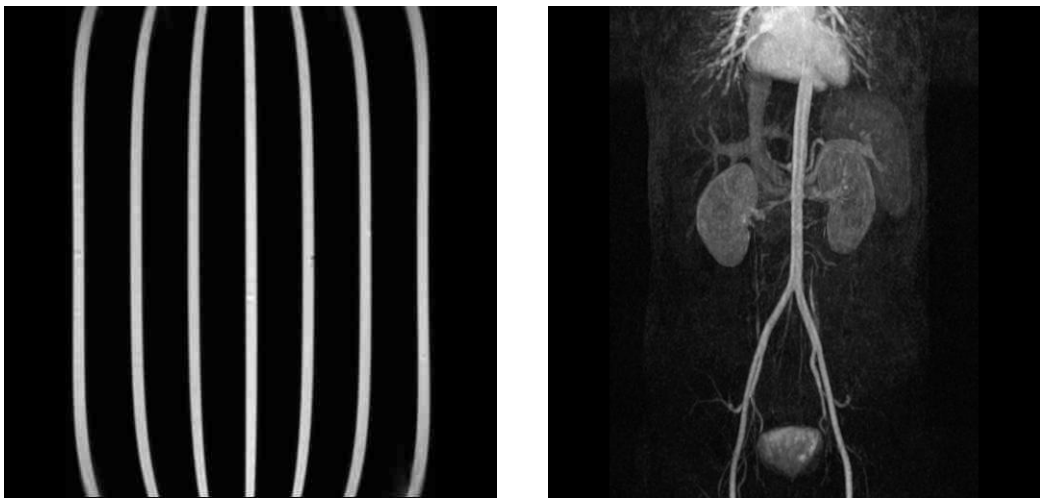


Figure 2: Left: Maximum Intensity Projection of a MRI of a phantom consisting of 7 water-filled tubes. The geometric distortion brought by the MR sequence is clearly visible. Right: MIP of one sub-volume of the complete data set used. The abdominal aorta can be seen, which splits into the femoral arteries below the renal arteries. The kidneys are also visible, along with the venous system of the liver (upper left), the heart (upper center) and the bladder (bottom center).

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. The project is carried out in close collaboration with the medical partners.

4. **3D medical image analysis of MRI images of the brain for psychiatric research**
   Ewert Bengtsson, Roger Hult
   Period: 0105–
   Partners: 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. A tool for segmenting the hippocampus is under development. See Figures 3 and 4. The project is carried out in close collaboration with the medical partners.

5. **Simultaneous visualisation of 3D anatomical and multidimensional physiological information - with application to positron emission tomography**
   Pascha Razifar, Ewert Bengtsson
   Period: 0110–
   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.

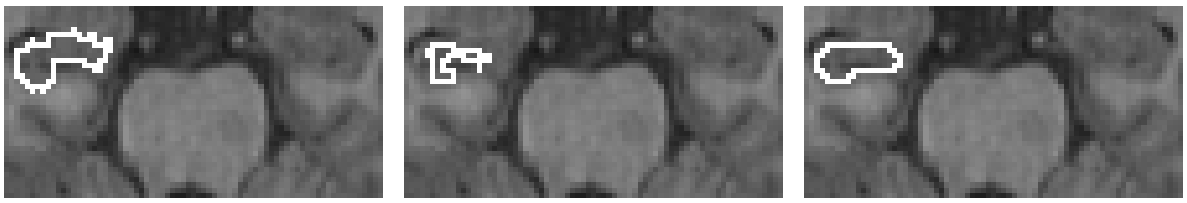


Figure 3: Left: A manually segmented slice of the right hippocamopus. Middle: A segmented slice of the hippocampus using the original automatic segmentation method. Right: A segmented slice of the hippocampus using the improved automatic segmentation method.

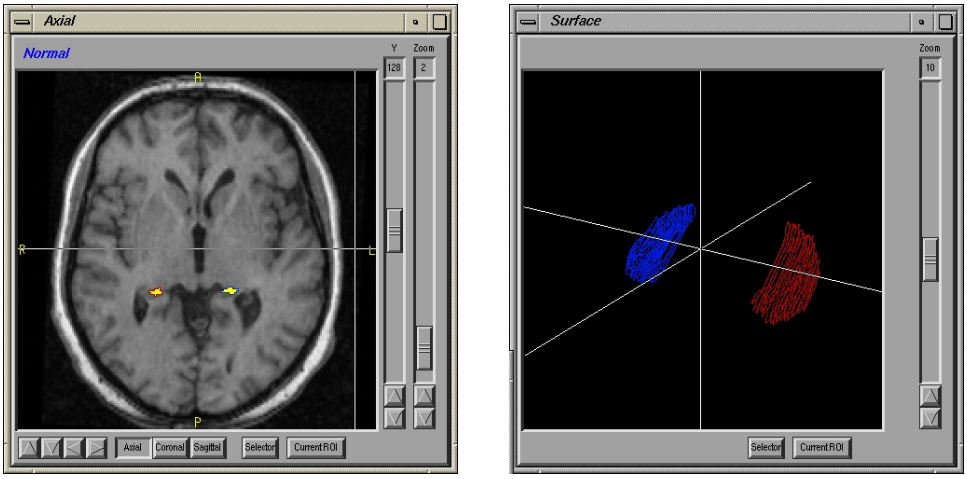


Figure 4: Left: A slice showing the two hippocampi segmented. Right: A 3D view of the two hippocampi.

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.
One-way of understanding the nature of PET images and thus how they can be effectively interpreted is to create synthetic PET images with full control over the correlated noise processes, etc. During 2002, a program that can generate synthetic PET images has been developed. One result of this work is the application of the auto-correlation function (ACF) for verification of the precision of the reconstruction algorithm in the actually used PET cameras.

6. **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 5, left. 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, see Figure 5, right. 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.

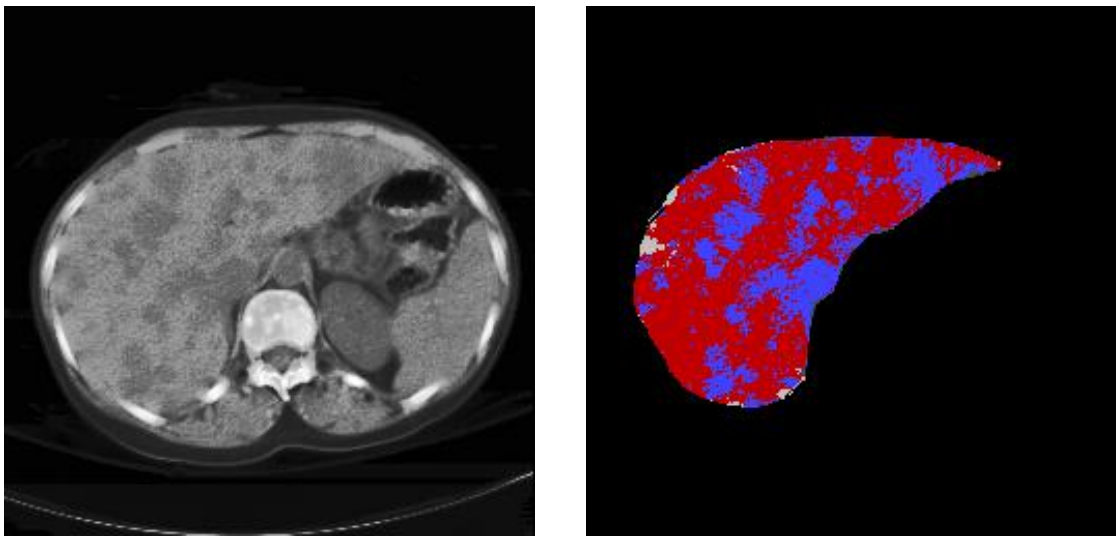


Figure 5: Left: Liver metastasis as seen on a CT scan slice of a patient. Right: A primary segmentation result using the mean-shift algorithm.

7. **Quantification of microvessels in the prostate**
   Patrick Karlsson, Ewert Bengtsson
   Funding: UU TN-faculty
   Period: 0212–
   Partners: Christer Busch, Dept. of Genetics and Pathology, The Rudbeck Laboratory, UU; Kenneth Wester, Depts. of Surgical Sciences, Experimental Urology and Genetics and Pathology and Biomedical Radiation Sciences, 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. Automated 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 pros tate 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.

8. **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-hybridisation 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 signal factors involved in the cell cycle control indicate that minor changes in the signalling systems are the first signs of cancer transformation and tumour formation. Understanding the 3D organisation 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 normalisation. The aim of the project is to examine the relationships between changes in the signalling systems within individual cells, either in culture or in sections of tumours. A second part of this project is carried out in Gustavsson's research group at the Dept. of Signals and Systems, Chalmers University of Technology, Göteborg.

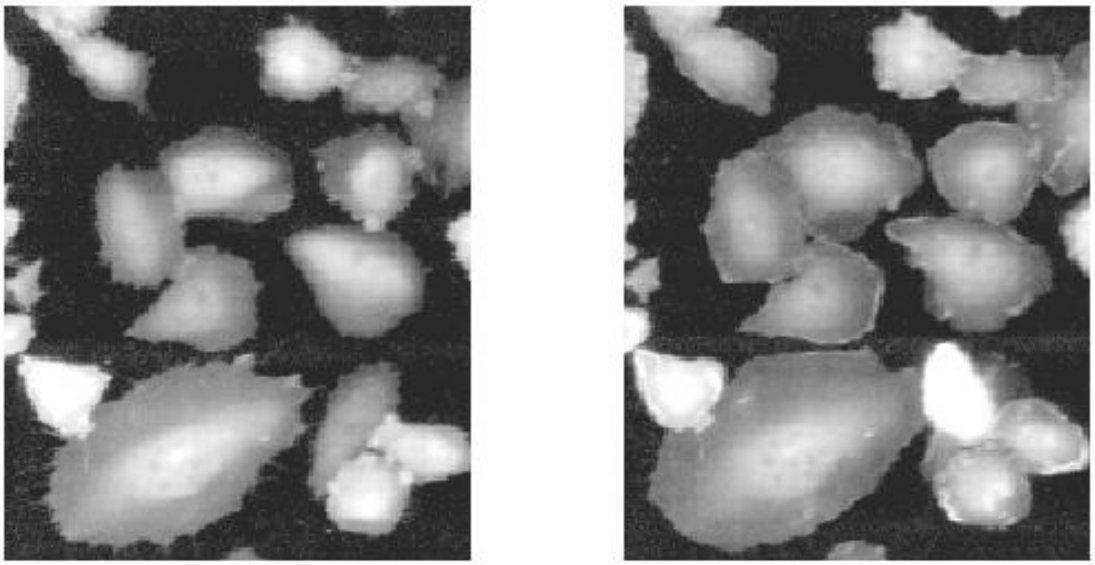


Figure 6: CHO-hIR cells expressing GFP-Rac1 fusion protein, imaged on IN Cell Analyzer, Amersham Biosciences, Cardiff, UK. Cytoplasms, before (left) and 4.3 min after (right) incubation with IGF-1. The translocation of GFP-Rac1 appears as bright formations along the edges of the cells. This translocation can be quantified by image analysis.

9. **Algorithms for segmentation of fluorescence labelled cells**
   Carolina Wählby, Joakim Lindblad, Mikael Vondrus, Ewert Bengtsson
   Funding: Amersham Biosciences, Uppsala, Cardiff, UK; UU TN-faculty; SSF through the VISIT programme
   Period: 9902–
   Partners: Lennart Björkesten, Amersham Biosciences, Uppsala; Stuart Swinburne, Simon Port, Alla Zaltsman, Gareth Bray, 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. High throughput methods for analysis of cells can be used as a tool in the drug discovery process. The overall objective of this project is to develop image analysis methods for segmentation, feature extraction and classification of cells and subcellular structures in fluorescence microscopy images.

   Segmentation of cytoplasms
   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. 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 presented at an international conference in 2001 and documented in a journal paper that was published in 2002.

   Classification of Rac1 activation
   Based on the experience from the segmentation of cytoplasms, a more problem specific project was initiated in cooperation with Amersham Biosciences in Cardiff, UK, in 2002. The aim of this project was to develop algorithms enabling fully automatic, real-time segmentation and analysis of fluorescence images of cells so as to quantitatively estimate the IGF-1 induced translocation of GFP-Rac1 to the cellular membrane for individual cells. See Figure 6. Due to the ultimate goal of analysing one image containing roughly 200 cells in less than two seconds, effort was taken not to use algorithms of high time complexity. The results were documented in a journal paper to be submitted for publication.

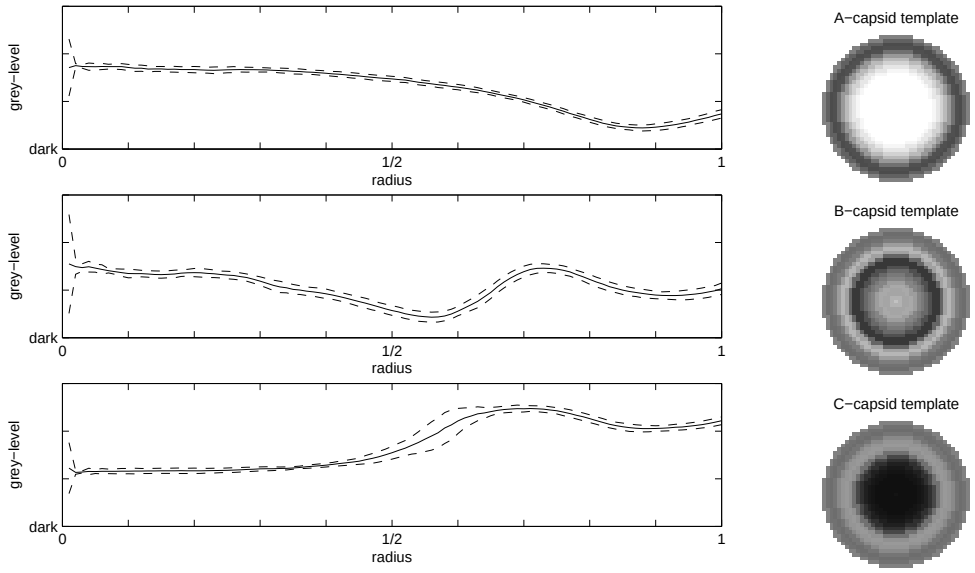


Figure 7: Left: Class grey-level profiles and standard deviation for the three classes of capsid maturation. The radius is ranging from 0, being the centre, to 1 being the edge of the capsid shelf. The solid lines correspond to the grey-levels at each radius and the dashed lines to the grey-level +/- 2 standard deviations. Right: Templates of radius 20 constructed from the class grey-level profiles.

10. **Segmentation and classification of Human Cytomegalo Virus**
    Ida-Maria Sintorn, Gunilla Borgefors
    Funding: SLU S-faculty
    Period: 0111–
    Partners: Mohammed Homan, Cecilia Söderberg-Naucler, Centre for Molecular Medicine, Karolinska Hospital, Stockholm
    Abstract: Human Cytomegalo Virus (HCMV) is a rather unexplored virus belonging to the herpes virus family. The goal of this project is to segment, classify, and describe virus capsids at three different maturation stages from transmission electron microscopy (TEM) images of an infected cell nuclei. The virus capsids are to be classified as immature, in between, or mature. The segmentation is done by template matching for one class at a time. The templates, see Figure 7, right, were produced from the images of a number of typical particles of each class. Each class is then described by producing a normalised mean radial grey-tone profile, see Figure 7, left, from the capsids 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.

11. **3D image reconstruction and analysis of HIV-1**
    Ingela Nyström, Ida-Maria Sintorn
    Funding: UU TN-faculty, SLU S-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 $+60°$ to $-60°$ with a goniometer in transmission electron microscopy (TEM). A tilt series consists of 25–40 electron micrograph projections. Each of these is digitised. 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 computat ions. The effects of GPG treatment of HIV-1 is presented in the November 2002 issue of Antimicrobial Agents and Chemotherapy.

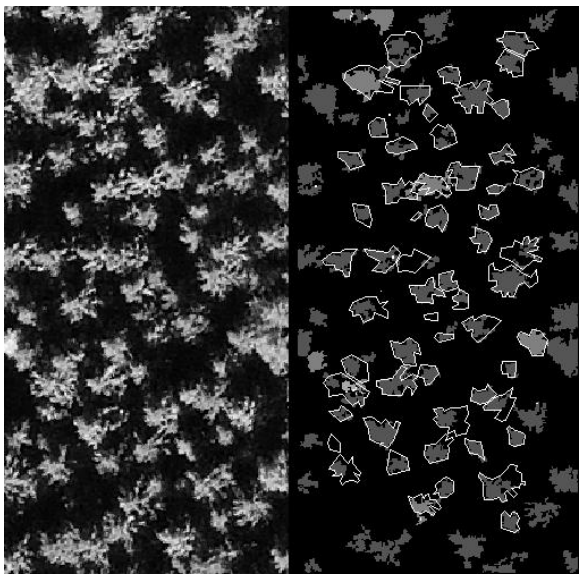


Figure 8: Left: Original tree image. Right: The result from the fuzzy segmentation method together with manually delineated crowns using field data (white polygons).

12. **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; Kenneth Olofsson, Dept. of Forest Resource Management and Geomatics, SLU, Umeå
    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, and to use the results in forestry and environmental assessment instead of (or as a complement to) field visits by humans. A set of 50 research aerial images (digitised colour-IR film), with resolution approximately 10 cm and 3 cm (flight height 600 m, focal length 300 mm) to make the individual tree crowns clearly visible is used. Interesting forest stand parameters to measure in the images are: number and positions of trees, horizontal tree crown areas, tree heights, and tree species composition. Features related to the individual tree species are, e.g., colour, internal structure (texture), and boundary structure.
    During 2001 a tree crown segmentation was developed. This year, this method is being evaluated in a joint project with SLU, Umeå. They have developed another type of method for detecting trees in images. Together we use new (2002) aerial and field data to evaluate both methods against each other and against ground truth. See Figure 8 for a small example of the segmentation results. We have also developed a new segmentation method based on Brownian motion. The method preserves the inner structure of the tree crown in a much better way than the old ones and also finds the contour of the crown in a better way. A method for classification of tree species using, among other clues, the inner structure from the segmentation method based on Brownian motion is in development.

13. **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 Products and Markets, SLU
    Abstract: This is a pilot project on finding stems in horizontal laser images in the forest. The goal is to investigate if data can be extracted from such images to automatically select 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.

14. **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, especially borders, in agricultural fields were 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. The key problem is almost always segmentation. To achieve good segmentation, it is advantageous to integrate several techniques. As the first step in our project, a multispectral edge and line detector was developed. A region growing procedure, which detects additional boundaries, followed this step. This results in an over-segmented image, therefore segmentation was followed two merging procedures, where one procedure merged small regions with similar spectral characteristics, and one procedure merged 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. This year, a book chapter the book "Geospatial Pattern Recognition", describing the whole process, was published.

15. **New techniques for information extraction from hyperspectral crop reflectance data**
Hamed Hamid Muhammed
Funding: UU TN-faculty, Swedish National Space Board
Period: 0201–
Partners: Anders Larsolle, Dept. of Agricultural Engineering, SLU
Abstract: Hyperspectral crop reflectance data can be used for studying the pathological condition of the crop. The influence of pathological status of a crop on its spectral characteristics is detectable in the visible and/or the near-infrared regions of the electromagnetic spectrum. FVBA can be used here to analyse and study the pathological condition of a crop, by taking a reference or training data set consisting of hyperspectral data vectors and the corresponding field measurements of the leaf-damage level in the studied crop. Then, the damage levels can be estimated for new collected hyperspectral data vectors. It has been noticed that differences in the spectral characteristics between normal or healthy crops and others suffering from physiological stress or disease, can be revealed and/or magnified by simply normalising the data properly. Such effects can be achieved when normalising each hyperspectral reflectance data vector into a zero-mean and unit variance vector (i.e., a whitened data vector is obtained), and then performing a band-wise normalisation on the previous results (i.e., putting all elements at a certain wavelength interval or band in one vector and whitening it). Using these normalised vectors in FVBA gives better results. Also, it has been noticed that using normalised hyperspectral data, including the training data, gives good results when a simple nearest neighbour classifier is used to classify our data against the training data. The correlation coefficient and the sum of squared differences are used as distance measures in the nearest neighbour classifier. High correlation is obtained, between the results (of using FVBA and the nearest neighbour classifier) and the corresponding field measurements, confirming the usefulness and efficiency of these methods for this type of analysis.

16. **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 aircraft. Data have been collected from Lakes Erken and Mälaren, and from coral bottoms in Bisceyne National Park.
Recently, tests of the usefulness of those images have been performed for the classification of the Swedish coastline.

17. **Detecting Coral Reef Bleaching from Optical Satellites: a pilot and demonstration project (CORBOS)**
Petra Philipson, Tommy Lindell
Funding: Foundation for Strategic Environmental Research (MISTRA), RESE programme
Period: 0001–0212
Partners: Swedish Meteorological and Hydrological Institute (SMHI), Norrköping
Abstract: Recent dramatic bleaching events on coral reefs have enhanced the need for global environmental monitoring. The development of remote sensing methods for monitoring of coral reefs requires investigation

of the sensor limitations, the optical properties of the bottom features and understanding of the influence of the atmosphere and water column on the collected remote sensing data. This project have been investigating the possibilities of using remote sensing technique for coral reef monitoring and change detection, with focus on detection of coral bleaching using existing satellite sensors. We have compared an IRS LISS-III image taken during the 1998 bleaching event in Belize to images taken before the bleaching event. The sensitivity of different sensors has been investigated and a simulation has been 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 has been compared to field observations. The spectral characteristics of the pixels corresponding to the field observations and the manually interpreted bleaching have been analysed and compared to pixels from unaffected areas, with positive results for the detection of bleaching from medium resolution satellites. Procedures for an automated analysis have been tried to make monitoring more efficient.
A field study has been performed in Belize in 2002 and together with the use of SPOT and IKONOS images further improvements have been achieved in detecting changes on coral bottoms.

18. **HYSENS — Hyperspectral remote sensing using a new version of ROSIS**
Tommy Lindell, Petra Philipson
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 & Philipson have participated in the work on Lake Garda, Italy earlier and in the evaluations.
The focus of the last part of this project will be devoted to applications of the MERIS sensor to water quality monitoring, using the experiences gained from the CASI and ROSIS sensors.

19. **Industrial plume detection in multispectral remote sensing data**
Petra Philipson, Tommy Lindell
Funding: Foundation for Strategic Environmental Research (MISTRA), RESE programme
Period: 0001–0212
Partners: Marcus Liljeberg, IVL - Swedish Environmental Research Institute, Stockholm;
Niklas Strömbeck, Dept. of Evolutionary Biology, Limnology, UU
Abstract: There are a number of paper and pulp industries located along the East coast of Sweden. The amount of substances discharged into the coastal sea water is regulated for each industry, but the size of the area affected by each outlet is relatively unknown and varies during the year.
The general objective for this project was to investigate if and to what degree remote sensing data could be used to locate and map the extent of the industrial plumes. Such an investigation involves the analysis of the optical properties of plumes in comparison to the properties of natural water constituents. The atmospheric influence on the remote sensing data must also be considered for any aquatic application that should result in general descriptions of the properties and quantitative estimations of the substances present in the water.
Airborne hyperspectral images and laboratory measurements of water samples have been used to investigate if there are any spectral properties related to paper mill discharges that can be useful for identification of the existence and concentration level of the discharges using present and future remote sensing data.
Besides correlation studies between remote sensing data and field data, the spectral properties of the discharge water have been investigated and used in the analysis of available remote sensing data.

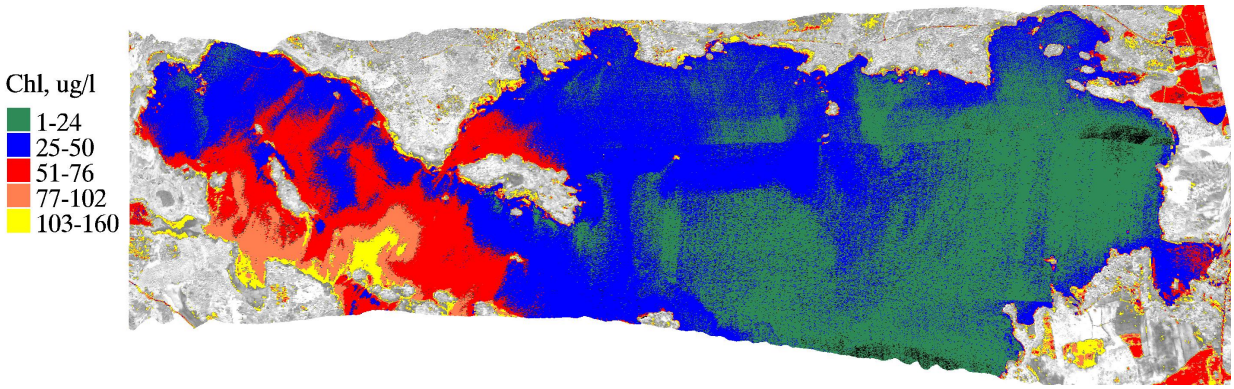


Figure 9: Chlorophyll concentrations in Lake Erken on the 6th of August, 1997. The estimation is made by applying algorithms derived from the bio-optical modelling to airborne remote sensing data.

20. **Remote sensing for change detection and monitoring of Case II and lake waters**
Petra Philipson, Tommy Lindell
Funding: Foundation for Strategic Environmental Research (MISTRA), RESE programme
Period: 9701–0212
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, Lake Mälaren and Lake Erken 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 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 coloured 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 the atmospherically corrected CASI data from Lake Mälaren and Lake Erken, see Figure 9. The resulting concentration maps were validated using ground truth measurements. The results from the validation of the CASI algorithms are satisfying, and the modelled concentrations and absorption coefficients corresponds well to the ground truth measurements, which is very encouraging for the future work. The work has been presented in reviewed international publications.

21. **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- 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 utilised 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. In a cooperation with the University of Southern Florida, St. Petersburg a field session was performed in the spring of 2002 in the Mexican Gulf.

22. **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: A substance can be characterised and recognised by its spectral signature. 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.

23. **Wood fibre morphology**
Mattias Moëll, Gunilla Borgefors
Funding: Wood and Wood Fiber graduate school; SLU S-faculty
Period: 9509–0203
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 concentrated on analysis of fibre cross-sections in confocal microscopy images of transverse sections of wood. The aim was 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 was developed, where each individual fibre was measured, and the measures are averaged along the wood section. The same method can be used for different wood species by changing a few parameters. In December 2001, Moëll successfully defended his PhD thesis.

24. **Analysis of AFM images of wood fibres using image analysis algorithms**
Carolina Wählby
Funding: UU TN-faculty
Period: 0101–
Partners: Jesper Fahlén, STFI, Swedish Pulp and Paper Research Institute, Stockholm
Abstract: Understanding the arrangement of wood polymers within the fibre wall is important for understanding the mechanical properties of the fibres themselves. Due to their high load bearing ability, the arrangement of cellulose fibrils within the cell wall are of special interest. In this work AFM-Atomic Force Microscopy-in combination with image analysis algorithms originally developed for cell segmentation has been used to obtain more information about the arrangement of cellulose aggregates (fibrils) in the secondary cell wall layer of spruce wood. The effects of chemical processing on the arrangement of these cellulose aggregates were also studied. Enlargement of cellulose aggregates was found in the initial phase of the kraft cook. This increase in cellulose aggregate dimensions depended mostly on temperature for treatment temperatures above $140°$C, regardless of the amount of alkali present. Although hemicelluloses are lost to various degrees under alkaline conditions, the increase in cellulose aggregate size was mainly related to thermally induced rearrangement of the cellulose molecules. The mean side length of cellulose aggregates was found to be around 18 nm in unprocessed wood and 23 nm in processed wood. The cellulose aggregates were assumed to be square shaped in cross section in both cases.

25. **3D tracking of fibres 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; Per Nygård, Cristine Antoine, Rune Holmstad, Norwegian Pulp and Paper Research Institute (PFI), Trondheim, Norway
Abstract: Using image analysis on paper samples can increase the understanding of the individual fibres build up the paper and what effects 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 imaging 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 volume image created from a series of 2D scanning electron microscopy (SEM) images captured at StoraEnso Research, Falun. We have now created a rather large digital volume of a paper sample from the original data set, see cover page, for a visualisation of a small part of the paper volume.
As fibre curvature effects the mechanical properties of paper, we are developing methods to estimate the curvature. The theoretical work, i.e., curvature estimations for voxels in a discrete curve, is described in Project 41. Initial results, where the curvature estimator was used in the analysis of the fibres, were presented at the SSAB symposium in Lund. Continuing our efforts to develop three dimensional measurements, we added a method for twist and aspect ratio estimation, which was presented at ICPR in Québec, Canada. A previous fibre detection algorithm assumed a quadratic grid. This was generalised and the new method developed was presented at ICIP in Rochester, NY, USA. A number of different types of fibre and fibre network measurements have also been developed. Many of the measurements are based on using distance transformations (see Project 37) of the fibres, fibre walls, fibre lumens, and the paper pores. An article where we describe many distance based measures was accepted for publication in a special issue of IEEE Transactions on Systems, Man and Cybernetics, and will be published during 2003. For Aronsson, preparations for the PhD thesis dominated this year's work. This included finalising and description of the progress and the insights gathered during the project in a structured manner. On 12 December 2002, Aronsson successfully defended his thesis entitled "On 3D Fibre Measurements of Digitized Paper - from Microscopy to Fibre Network". See Section 4.3.

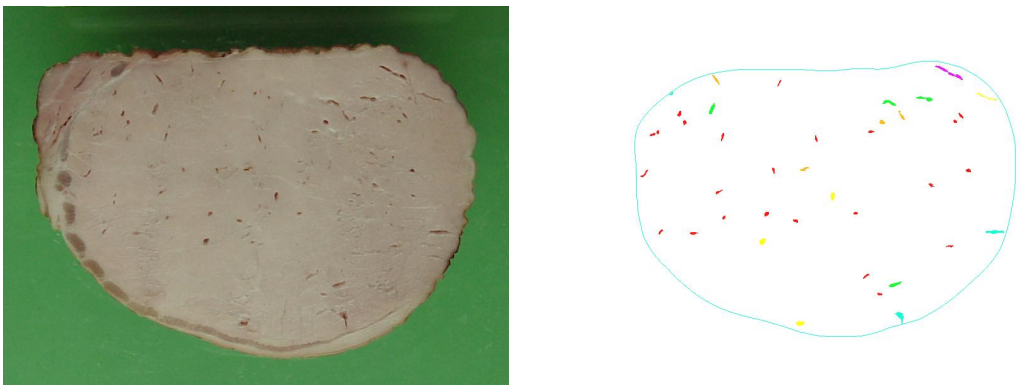


Figure 10: Digital camera image of pig meat and extracted holes (holes are coloured based on their size).

26. **Analysing the structure of paper sheet through confocal microscope images**
    Ingela Nyström
    Funding: UU TN-faculty
    Period: 0205–
    Partners: Catherine Östlund, Swedish Pulp and Paper Research Institute (STFI), Stockholm
    Abstract: It is of interest to study the structure of paper surface under different pressure to measure how the pores change. One possible way is to produce confocal microscope images of paper sheet and analyse these. The original three-dimensional (3D) images consist of, in principle, cubic voxels which can be transformed to two-dimensional (2D) grey-level images, where the grey-levels correspond to the depth at which the first paper fibre is visible, i.e., how deep the pores penetrate into the paper. Initially, we have analysed three such 2D grey-level images, where the pressure has been low, medium, and high, respectively. The pressure may be unevenly distributed, a problem overcome by computing a grey-level convex hull (see Project 35).

27. **Image analysis methods for food quality measurements**
    Lucia Ballerini, Gunilla Borgefors
    Funding: Foundation for Strategic Environmental Research (MISTRA), FOOD 21 programme
    Period: 9908–0209
    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. Image processing methods have been successfully applied to meat images in order to determine the percentage and the distribution of fat and various defects. We have been working with camera photographs and Magnetic Resonance images. Segmentation algorithms have been optimised for these kinds of images, in order to classify different substances as muscle, fat and connective tissue. Moreover, we developed methods 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 organisation of features, without requiring any individual measures of them. Similar segmentation techniques and distribution measurements have also been developed for defects in processed meat, such as pores, holes, and cracks. See Figure 10. Different meat processing methods have been evaluated using these results. This year the project has produced one article in "IEEE Transactions on Nuclear Science" and three conference papers.

28. **New techniques for information extraction by using new neuro-fuzzy systems**
    Hamed Hamid Muhammed
    Funding: UU TN-faculty, Swedish National Space Board
    Period: 0201–
    Abstract: New neuro-fuzzy systems, which imitate the functionality of the biological visual system, were developed in this work based on the new so-called Weighted Neural Networks (WNN). The basic idea of WNNs, is to modify well-known Artificial Neural Networks (ANN) by additional mechanisms to be able to capture/calculate and store as much useful information as possible about the input data set at hand. So far,

two main types of WNNs can be recognised: incremental and fixed (or grid-partitioned) depending on the original ANN algorithm used as a start point. It seems possible to make a WNN version for every existing ANN. The WNN algorithm (incremental or grid-partitioned) produces a net of nodes connected by edges. Additional weights, which are proportional to the local densities in the input space, are associated with the resulting nodes and edges to store useful information about the topological relations in the given input data set. A fuzziness factor, proportional to the connectedness of the net, is introduced in the system. The basic idea is based on the famous Hebb's postulate which states that the connection between two winning neurones gets stronger. The result is a weighted connected net, consisting of weighted nodes connected by weighted edges, which reflects and preserves the topology of the input data set, and in addition to that, it acts as a fuzzy representation of the input data set. Two main types of WNNs have been recognised, so far:

- Weighted Fixed Neural Networks (WFNN): The basic idea here is to distribute a number of zero-weighted nodes, as an equidistant initial grid in input space where the input data set is found. Then, weights are assigned to these nodes, where a relatively high node-weight corresponds to a relatively high density in a neighbourhood around the node in input space. In addition to that, the algorithm connects neighbouring nodes with weighted connections or edges, where an edge-weight is also proportional to the density of input data in the region between the connected nodes (or in a neighbourhood around the edge). A fuzziness factor is introduced here as mentioned above. The work has resulted in a refereed journal paper presenting the WFNN algorithm.
- Weighted Incremental Neural Networks (WINN): The WINN is an incremental self-organising model with no pre-defined structure, and therefore no restrictions on the dimensionality of the input data set, which can have different dimensions in different regions of input space. The model is built by successive addition, adaptation, and sometimes deletion of elements (i.e., nodes and edges), according to suitable strategies, until a stopping criterion is met. Here also, a weighted connected net, which preserves the topology of the input data set, is produced. The algorithm begins with only two nodes connected by an edge, then new nodes and edges are generated and the old ones are updated (and sometimes deleted) while the learning process proceeds until a certain stopping criterion is met. Here also, a fuzziness factor is introduced here as mentioned above when talking generally about WNNs.

29. **Genetic snakes**
Lucia Ballerini
Period: 0107–0209
Abstract: Genetic Snakes are active contour models, also known as snakes, with an energy minimisation procedure based on Genetic Algorithms. Genetic Snakes have been proposed to overcome some limits of the classical snakes and successfully applied to medical, radar and meat images. During 2002, they have been extended by using a new form of the image energy which considers texture features. They have been applied to segment liver in CT images, which was presented at EMBEC in Vienna in December 2002). The model has also been extended by adding an elastic force that couples multiple contours together and create what we call "multiple genetic snakes". This model has been used to segment bones in hand radiograms, which will be presented at SPIE Medical Imaging in San Diego in February 2003. A further extension, currently under study, is the evolution of the weights and 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.).

30. **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 recognise and localise 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

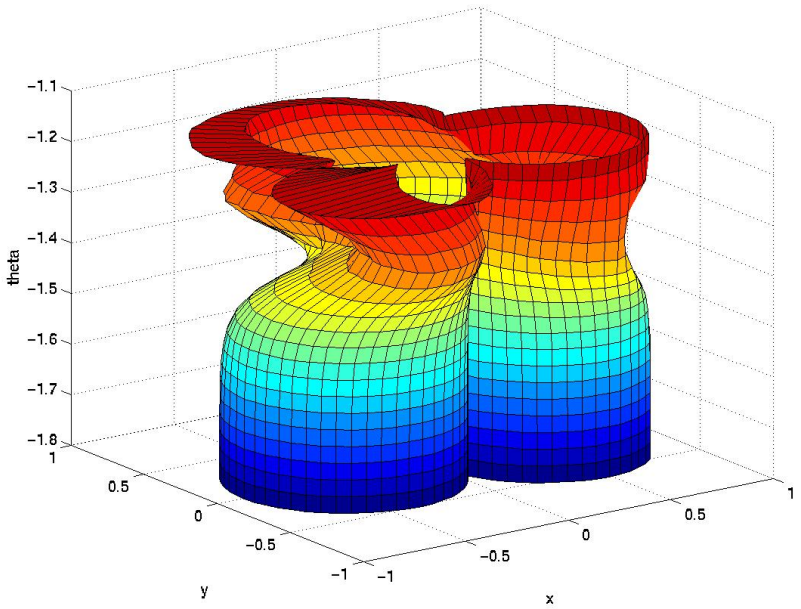


Figure 11: A neural network learns the variation of a clover-like shape. The shapes are produced by the network after learning the essentials from examples. Stacked together, they leave the impression of a vase.

derive the characteristic correlations between similar shapes. Moreover, the applicability of Markov random fields as a stochastic modelling concept was analysed.
It turned out that a general model should not be dependent on landmarks as required for the previous transformations. Since variations in landmark-less shape data appear as non-linear manifolds, a neural network was designed to acquire the particularities of the data. After training on examples, the network provides a non-linear representation of shape by means of its modes of variation. So far the representation has been tested on simple shapes and variations showing promising results, see Figure 11.
Further characteristics of non-linear models should be examined in the future, as for example the possibilities of shape decomposition.

31. **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 generalised 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 parametrisation of the object is obtained from a parametrisation of the sphere. The method is computationally attractive. Using the object parametrisation 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

32. **Accurate and precise size estimators for digitised 2D and 3D objects using local computations**
Joakim Lindblad, Ingela Nyström
Funding: UU TN-faculty
Period: 0012–
Partners: Jayaram K. Udupa, MIPG, Dept. of Radiology, University of Pennsylvania, Philadelphia, USA
Abstract: Information is irrevocably lost in the process of digitising a continuous object of the real world to fit the digital world of the computer. Therefore, feature measurements of digitised 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 computerised 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 digitised 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 digitised objects. The breakdown behaviour at very low resolution, as well as the asymptotic behaviour at high resolution have been studied.
A surface area estimator with improved precision and accuracy obtained by optimising the area contribution locally, was 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, was presented at SPIE Medical Imaging 2002. This projects relates to Project 33 on shape of fuzzy sets.

33. **Fuzzy shape analysis in 2D and 3D**
Nataša Sladoje (Matic), Ingela Nyström, Gunilla Borgefors
Funding: SLU S-faculty, UU TN-faculty
Period: 0109–
Partners: Punam K. Saha, MIPG, Dept. of Radiology, University of Pennsylvania, Philadelphia, USA
Abstract: Fuzzy segmentation methods, that have been developed in order to reduce the negative effects of the unavoidable loss of data in the digitisation process, initialise the interest for new shape analysis methods, handling grey-level images. Very little has been published to date on shape analysis of fuzzy segmentations. We have performed initial studies on perimeter and area of 2D fuzzy subsets, where the focus have been on objects with fuzzy border. We assume that in the segmentation process most pixels easily can be classified either as object or background, but for pixels located in the vicinity of the boundary of the digitised object it is hard to make such a discrimination. One way to treat these pixels is to determine the extent of their membership to the object. The membership value of a pixel can be defined as the fraction of its area that belongs to the original object, see Figure 12. We have implemented a method where we propose perimeter and area estimators adjusted to the discrete case. The estimates are computed for a large collection of fuzzy segmented digitised objects. We have concluded that our method highly improves both accuracy and precision of the results obtained from crisp (hard) segmentation, especially in the case of low resolution images, i.e., small objects.
As the next step, we will investigate different ways to extend the main binary shape analysis tools (e.g., distance transform, medial axis, notion of convexity, and moments) to fuzzy segmented 2D and 3D images.

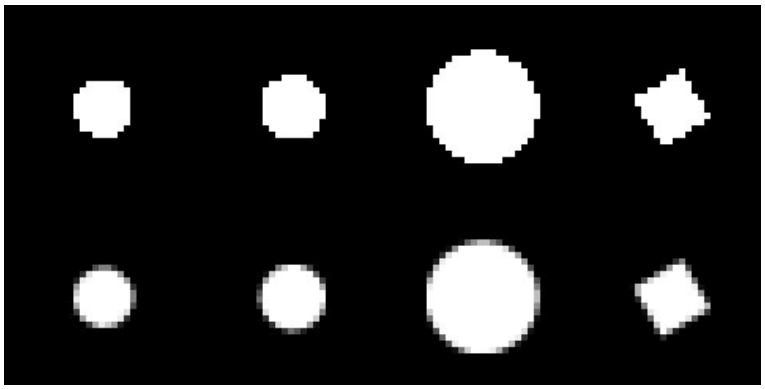
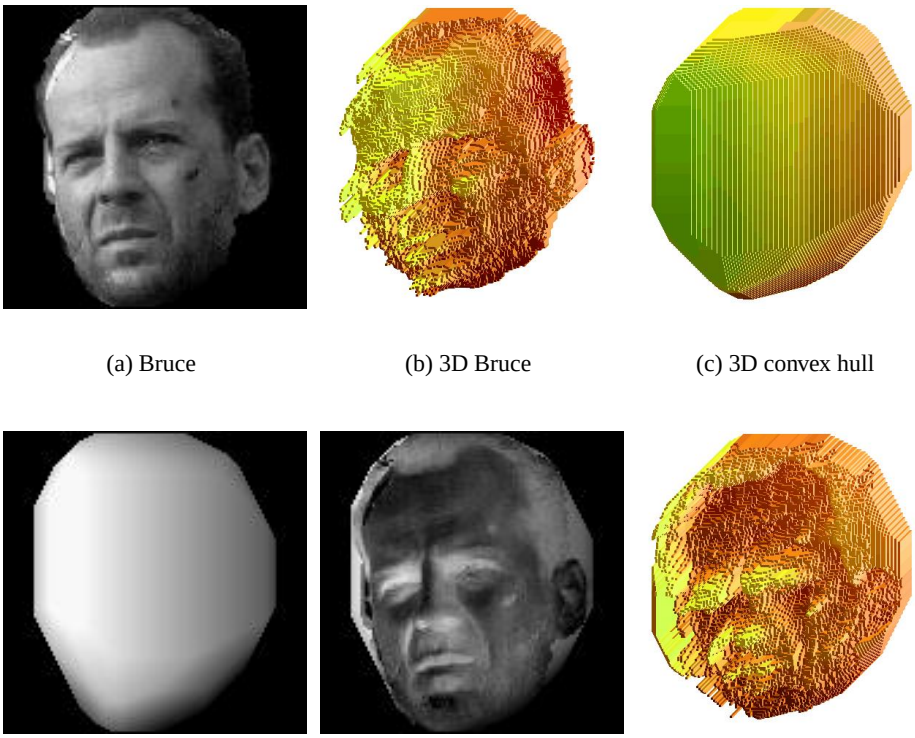


Figure 12: Examples of digitised objects with crisp (top) and fuzzy border (bottom).

34. **Shape analysis in four dimensional images**
Stina Svensson
Funding: SLU S-faculty, STINT
Period: 0210–
Partners: Pieter Jonker, Pattern Recognition Section, Faculty of Applied Physics, Delft University of Technology, Delft, The Netherlands
Abstract: In medical applications, devices giving three dimensional (3D) images are in use since the sixties for imaging anatomical or functional aspects of the human body. It is also possible to use images with more than three dimensions. Four dimensional (4D) images can be used to represent a 3D object traversing in space-time, e.g., a beating heart or a moving robot. During 2002 we have started to work with this kind of images and, more specifically, to analyse the shape of the objects in such images. As 4D images contain huge amounts of data, we first need to find a suitable representation with reduced amount of data, still containing enough information to actually perform shape analysis. This can be achieved using skeletonization algorithms (see Project 39 – skeletonization of volume images). These create a compact representation of a complex object that can be used, for instance, in the visualization and quantitative analysis of spatial processes in living cells and tissues.
The first, and on-going, step is to develop methods for identifying hyxels (hyper volume picture elements) that can be removed without altering the topology of the original object. This is necessary to have a topology preserving skeletonization algorithm.
The work within this project was facilitated by a two months visit for Stina Svensson in the Pattern Recognition Group in Delft, The Netherlands (possibly by a grant from STINT – The Swedish Foundation for International Cooperation in Research and Higher Education).

35. **Grey-level convex hull computation**
Ingela Nyström, Gunilla Borgefors
Funding: UU TN-faculty, SLU S-faculty
Period: 0209–
Partners: Gabriella Sanniti di Baja, Istituto di Cibernetica, CNR, Pozzuoli, Italy
Abstract: We compute discrete convex hulls in 2D grey-level images, where we interpret grey-level values as heights in 3D landscapes. For these 3D objects, we compute approximations of their convex hull using a 3D binary method. Differently from other grey-level convex hull algorithms, producing results convex only in the geometric sense, our convex hull is convex also in the grey-level sense, which implies that uneven illumination can be eliminated. See Figure 13.

36. **Decomposition of 3D objects**
Stina Svensson, Ida-Maria Sintorn
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 an article published in Image and Vision Computing.
Recently, we have started to use the method for various applications and by that investigated what modifications and simplifications that can be done for the method in order to optimise it for the specific application. When analysing the shape of an object it is not only of interest to study the object itself but also its complement. This can give us information on, for example, the structure of tunnels possibly existing in the object. We start the analysis by identifying the convex deficiency of the object, i.e., the difference between the convex hull of the object and the object. The convex deficiency can then be decomposed into regions corresponding to cavities or tunnels in the object. The structure of the tunnels can be further analysed with respect to branching, thickness, and length. The research regarding the analysis of the convex deficiency was initiated during 2002 and facilitated by a two months visit for Stina Svensson in Napoli during the summer of 2002 (possible by an Italian Institute of Culture “C. M. Lerici” Foundations grant).



(a) Bruce (b) 3D Bruce (c) 3D convex hull

(d) Grey-level convex hull (e) Grey-level concavities (f) 3D concavities

Figure 13: Grey-level convex hull computation and analysis. (a, b) A photograph of a face and its 3D representation. (c) The convex hull of (b). (d) The grey-level representation of (c). (e) The grey-level concavity regions, i.e., (d)−(a). (f) The 3D representation of (e): the uneven illumination has been eliminated and the spots of dirt shows quite well.

Recently, we have started to use the method for various applications and by that investigated what modifications and simplifications that can be done for the method in order to optimise it for the specific application. An example of a synthetic object with shape suitable to be decomposed by our method is shown in Figure 14.

Figure 14: Decomposed synthetic object, with parts shown using different grey-levels, resembling an object from an application where decomposition is a suitable shape representation scheme.

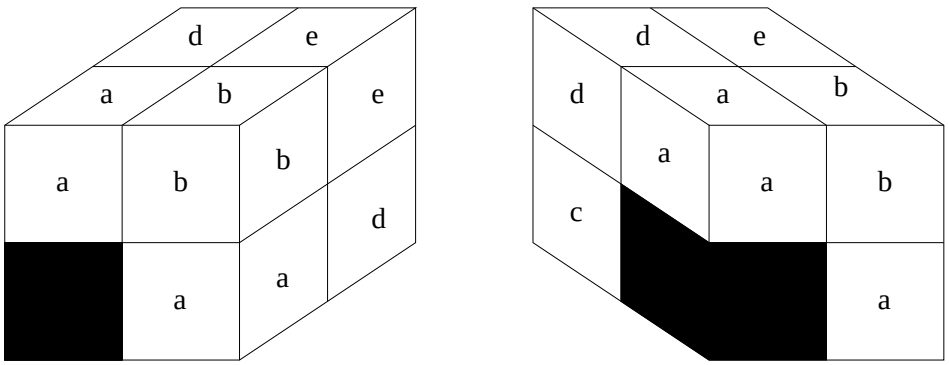


Figure 15: Local distances for $3 \times 3 \times 3$ WDTs in rectangular grids. (Two views of the same neighbourhood.)

37. **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. 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. This resulted in an article published in Computer Vision and Image Understanding in 2002.
More and more applications are moving towards 4D imagery (e.g., a sequence of volume images or a grey-level 3D image seen as a 4D "landscape"). Optimal DTs for weighted DTs in $3 \times 3 \times 3 \times 3$ have been computed. The results will be published in "Discrete Applied Mathematics" in 2003.
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 to non-cubic grids. Therefore, we have investigated DTs in such elongated grids with voxels of size $1 \times 1 \times \Lambda$, i.e., two sides are equal (to one) and the third is larger $\Lambda > 1$. The neighbourhood used is shown in Figure 15. The optimisation in 3D gives rise to four types of regular DTs of which one, the simplest, 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 are needed and rotation invariance is not important. This work was presented at the 10th International Conference in Discrete Geometry for Computerised Imagery 2002, and will shortly appear in a "Pattern Recognition Letters" special issue from the conference.

38. **Fuzzy border distance transforms 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 some bi-level methods we have developed to deal with objects in grey-level images, called *grey-level objects*.

One simple type of grey-level objects is where the segmentation is rather easy, except for the elements placed in the border of the object. This is the case for the 3D images of fibres in paper (see Project 25) 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 assigned 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. During 2002, two papers was published on this topic. The fuzzy border distance transform was introduced for 2D images at International Conference on Pattern Recognition (ICPR) 2002 and published in the proceedings for the conference. A skeletonization algorithm developed for the "regular" distance transform was modified to be guided by fuzzy border distance transforms. The algorithm was given as an example in the paper. For 3D image s, the fuzzy border distance transform was introduced and, again, exemplified by a skeletonization algorithm at Swedish Symposium on Image Analysis 2002.

39. **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; Pieter Jonker, Pattern Recognition Section, Faculty of Applied Physics, Delft University of Technology, Delft, The Netherlands
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 follow the approach to first reduce an object to a surface skeleton and then to further reduce the surface skeleton to a curve skeleton. One method to reduce an object to a surface skeleton is based on iterative thinning of the distance transform of the object in a topology and shape preserving way. The skeletons produced fulfil the skeletal properties: they are topologically correct, centred within the object, thin, and fully reversible. The last property is rare for 3D skeletons. During 2002, an attempt of creating a general framework for different distance transforms was published in a proceedings book from an international workshop held in December 2000.
During the Autumn, we started to study the relation between using a mathematical morphology framework and using a distance transform based framework to reducing an object to a surface skeleton. This work is done in cooperation with Pieter Jonker and was initiated while Stina Svensson visited Pattern Recognition Group in Delft, The Netherlands, for two months.
To 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 during 2002 published as an article in Pattern Recognition Letters.

40. **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-

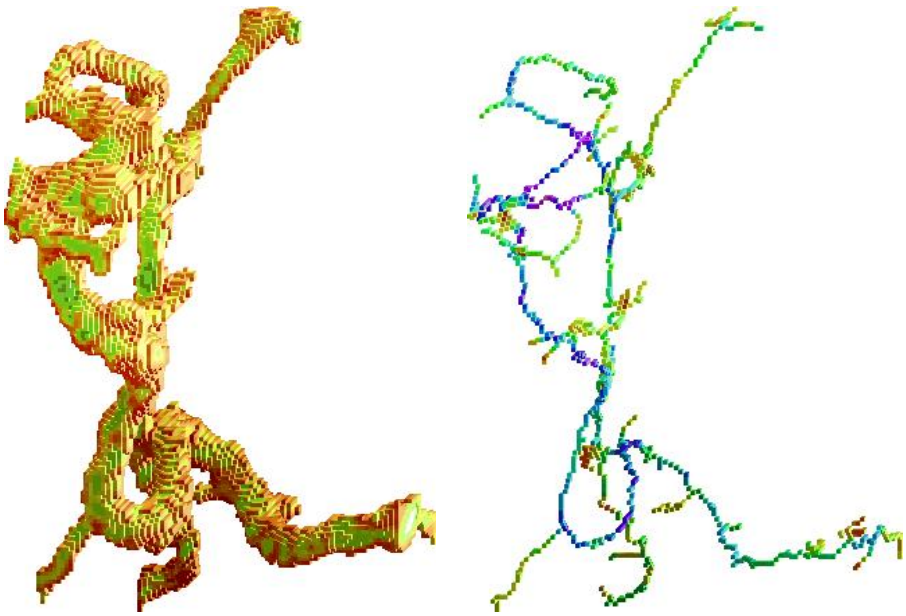


Figure 16: Blood vessel and its grey-medial surface representation. [By courtesy of Dr. Punam K. Saha, MIPG, Dept. of Radiology, University of Pennsylvania, Philadelphia.]

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. We presented the above described approach for skeletonization of 3D grey-level objects at International Conference on Pattern Recognition (ICPR) 2002 and it was published in the proceedings for the conference. An example of a blood vessel and the resulting grey-medial surface representation can be found in Figure 16. The original image is a fuzzy segmented magnetic resonance angiography image. The grey-medial surface representation is indeed a surface representation, but in the case of the blood vessel, depending on the elongated shape of the vessel, the representation is close to a curve everywhere.

41. **Analysis of curves in 3D images**
Stina Svensson
Funding: SLU S-faculty
Period: 0201–
Partners: Gabriella Sanniti di Baja and Carlo Arcelli, Istituto di Cibernetica, CNR, Pozzuoli, Italy; David Coeurjolly, Laboratoire LIRIS, Université Lumière Lyon 2, Lyon, France
Abstract: Elongated objects in 3D images can be represented by curves. See Project 25, where a curve representation is used for the fibres. For this reason it is of interest to develop tools to analyse curves in 3D images.
The distance from the end-points of the curve can be propagated over the curve. This can be used to distinguish important branches from non-important ones and thereby find the most significant branches. This topic has been extensively investigated for 2D line patterns, but so far not much has been done for 3D images.
More than the distances between various parts of the curve, the curvature along the curve is of interest. For each voxel in a curve, we can compute the curvature in that specific voxel. David Coeurjolly has developed a purely discrete curvature estimator that can be computed in linear time. We have studied the performance of this and used it in the analysis of the fibres in 3D images of paper (Project 25). A small, preliminary study on synthetic data was presented at Swedish Symposium on Image Analysis 2002.

42. **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, Uppsala
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 re-examining those algorithms and are findingnew mathematical ways of simplifying the expressions and increasing the implementation speeds without sacrificing image quality. See Figure 17. The project is carried out in close collaboration with Tony Barrera at Cycore AB. In May 2002, Hast presented his licentiate thesis based on this work. See Section 4.2. Additionally, one journal and three conference papers were submitted as well as five chapters for a book on graphics algorithms.

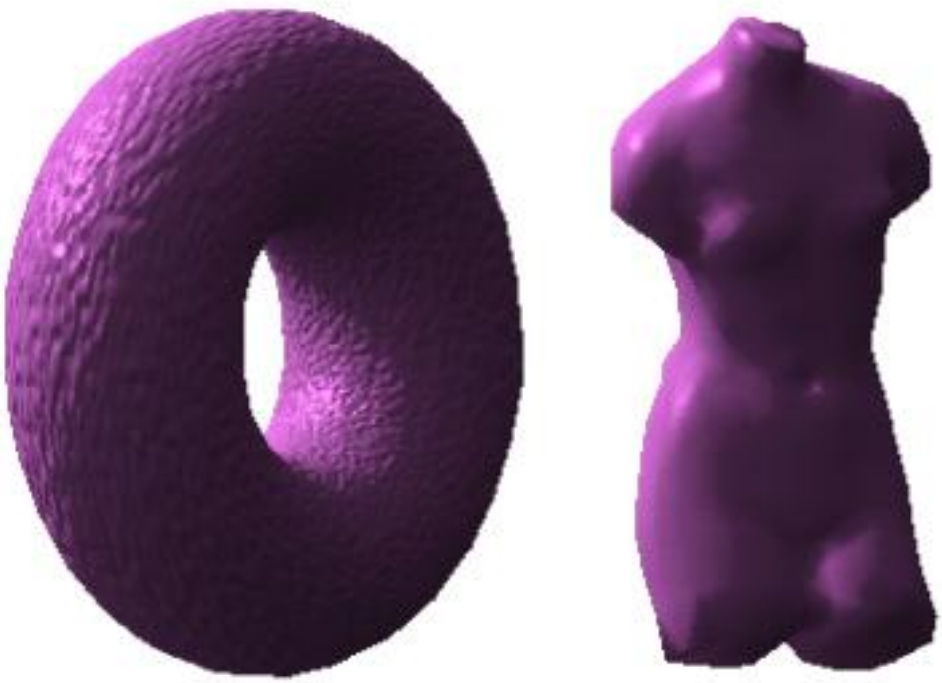


Figure 17: The shadowed area is not set to ambient light, as usually is the case, which would make it flat and dull. Instead, a new modified Phong-Blinn model is used where the underlying geometry is clearly visible.

43. **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. In 2001–02, a theoretical frame-work for describing the image formation in plenoscopes was established. In a short proceedings article (SSAB02), some useful formulas are briefly described. The obstacles in plenoscopes, have been modified in Autumn 2002, to obtain more precision. A typical obstacle plate contains thousands of elements. Obstacles have been tested in microscopes.

44. **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 co-ordinated 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 Nordin. The main goal was to re-program the core system in C++ to make it easier to maintain and extend. In 2002, we decided to write a completely new program platform, *pixy*, based on the new C++ core and with all image analysis functions written in C++ in order to take advantage of the C++-specific language constructs (classes, inheritance, polymorphism, templates, etc.) to enhance the programmer’s API and make the code more reusable. In pixy, it is easy to add plug-in modules with new functionality and new classes: several such modules have been implemented: MUSE (multivariate segmentation) and filter editors for editing filters in the spatial domain as well as in the Fourierdomain. A first release of pixy is planned for the summer of 2003.

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 2002.

International

Prince of Wales Hospital, Sydney, Australia

West Bohemian University, Plzen, Czech Republic

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

Wallac Oy, Åbo, Finland

Laboratoire LIRIS, Université Lumière Lyon 2, Lyon, France

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

Faculty of Applied Physics, Delft University of Technology, Delft, The Netherlands

Forest Research Insitute (FRI), Rotorua, New Zealand

Norwegian Pulp and Paper Research Institute (PFI), Trondheim, Norway

Faculty of Engineering, University of Novi Sad, Serbia

Dept. of Surveying, Makerere University, Kampala, Uganda

Amersham Biosciences, Cardiff, UK

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

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

National

Amersham Biosciences, Uppsala

Banverket, Gävle

Cycore AB, Uppsala

Diascan AB, Uppsala

Nekros AB, Uppsala

Personal Chemistry AB, Uppsala

ReachIn AB, Stockholm

Scania, Södertälje

Sensys Traffic AB, Jönköping
Sidec Technologies AB, Stockholm
StoraEnso Research, Falun
Swedish Environmental Research Institute (IVL), Stockholm
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 Genetics and Pathology, The Rudbeck Laboratory, 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
Uppsala Learning Lab, Uppsala
Dept. of Agricultural Engineering, SLU, Uppsala
Dept. of Food Science, SLU, Uppsala
Dept. of Forest Products and Markets, SLU
Dept. of Forest Resource Management and Geomatics, SLU, Umeå
Dept. of Wood Science, SLU, Uppsala
Centre for Molecular Medicine, Karolinska Hospital, Stockholm
Dept. of Clinical Neurophysiology, Karolinska Institute/Hospital, Stockholm
Div. of Clinical Virology, The Karolinska Institut, Huddinge University Hospital, 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 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 2002. As can be seen from the lists in the following sections we have published 12 international journal articles, 10 papers in refereed international conference proceedings, and 23 non-refereed conference papers, of which 9 were presented at SSAB 2002 (the annual Swedish Symposium on Image Analysis). Compared to last year, we have two more Journal articles, fewer refereed international conference papers, and more non-refereed conference papers. One reason is that several of "our" international conferences are biennial. In addition, we produced one book chapter and were Guest Editors of an special issue of *Pattern Recognition Letters* on Discrete Geometry of Computer Imagery. We also have our own report series and some other publications that are difficult to classify.

6.1 Book chapter

Extraction of agricultural field boundaries from remotly sensed images
Authors: Rydberg, A., Borgefors, G.
Book title: Geospatial Pattern Recognition
Editors: Binaghi, E., Brivio. P.A., Serpico, S.B.
Publisher: Research Signpost, Trivandrum, Kerala, India, pp. 57–86, 2002
Abstract: We describe a system for automated detection of agricultural fields, which integrates new and existing methods for segmentation and where knowledge about agricultural fields is incorporated. The difficulties associated with different image resolutions and spectral characteristics are also investigated. We thus propose a novel multispectral edge- and line detection method, which combines the results from oriented filters. The detected boundaries are combined with information generated by a region oriented segmentation method, which produces an over-segmentation. Known shape properties of fields are used for merging. Evaluation, including comparison with interpreted ground truth, show that almost 80% of the boundaries are detected correctly, but that the results may vary significantly with image properties.

6.2 Special journal issue

Pattern Recognition Letters 23(6):621-754, April 2002.
Special Issue on Discrete Geometry for Computer Imagery
Guest Editors: Borgefors, G.; Nyström, I.; Sanniti di Baja, G. (1)
(1) Istituto di Cibernetica, National Research Council of Italy (CNR), Arco Felice (Napoli), Italy

6.3 Journal articles

1. **Bio-optical Modelling Combined with Remote Sensing to Assess Water Quality**
   Authors: Ammenberg-Philipson, P.; Flink, P.; Pierson, D. (1); Lindell, T.; Strömbeck, N. (1)
   (1) Dept. of Evolutionary Biology, Limnology, UU
   Journal: International Journal of Remote Sensing, 23(8):1621–1638, 2002
   Abstract: A simple bio-optical model, with parameter values derived from measurements of the inherent optical properties (IOPs) and optically active substances that are known to influence the IOPs, has been developed. A large historical dataset of measurements of the concentration of chlorophyll a and phaeophytine a (Chl), suspended particulate inorganic material (SPIM) and the absorption coefficient of Coloured Dissolved Organic Matter (CDOM), spanning more than 25 years, has been used together with the model to develop algorithms for the retrieval of these water quality parameters, for a site in Lake Malaren, Sweden. The model takes as input the optically active substances and outputs a reflectance spectrum just above the water surface. From the modelled reflectance, algorithms were derived for Chl, SPIM and CDOM absorption at 420 nm. The algorithms were applied to atmospherically corrected remote sensing data, which were collected by the Compact Airborne Spectrographic Imager, CASI. The radiative transfer code 6S was used for the atmospheric correction of the data. Distribution maps for the three retrieved parameters were

constructed and Chl and SPIM were validated by continuous field measurements of fluorescence and beam attenuation. The continuous data were calibrated with water analysis results from nine water samples. The time lag between the image acquisition and the ground data measurements was never more than 3 hours. Even though the model parameter values were collected at different times from that of the CASI over-flight, and from a larger geographic region of Lake Malaren than that used for the CASI measurements, the independently developed algorithms predicted the concentrations of the optically active substances within a reasonable level of accuracy, allowing spatial variations in the substances to be predicted.

2. **Slice Based Digital Volume Assembly of a Small Paper Sample**
   Authors: Aronsson, M.; Henningsson, O. (1); Sävborg, Ö. (1)
   (1) StoraEnso Research, Falun
   Journal: Nordic Pulp and Paper Research Journal, 17(1), 2002
   Abstract: Digital volume images can be created by assembling a stack of 2D images. By using a microtome for slicing, a Scanning Electron Microscope for imaging and digital analysis tools, we were able to create a small digital volume from a paper sample of Duplex-board. Imaging the surface of the embedding rather than the cut-off slices, was crucial in minimizing geometrical distortions. The use of reference threads ensured a good registration with small errors and reasonable effort. For visualization purposes, we used a surface renderer based on the Marching Cube algorithm. Although the reconstruction process is time consuming, it is a viable methods for creating volume images of paper with micrometer resolution.

3. **A Segmentation Technique to Determine Fat Content in NMR Images of Beef Meat**
   Authors: Ballerini, L.; Högberg, A. (1); Borgefors. G.; Bylund, A.-C. (1); Lindgård, A. (1); Lundström, K. (1); Rakotonirainy, O. (2); Soussi, B. (2)
   (1) Dept. of Food Science, SLU, Uppsala;
   (2) Wallenberg Laboratory, Sahlgrenska University Hospital, Göteborg
   Journal: IEEE Transactions on Nuclear Science, 49(1):195–199, 2002
   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 describe an image processing technique to determine fat content in beef meat. To achieve this, NMR (Nuclear Magnetic Resonance) images of beef meat have been used. The inherent advantages of NMR images are many. Chief among these are unprecedented contrasts between the various structures present in meat, such as muscle, fat, and connective tissue. Moreover, the three-dimensional nature of the NMR method allows the analysis of isolated cross-sectional slices of the meat and the measure of volumetric content of fat, and it is not limited to measurements of the superficially visible fat. We propose a segmentation algorithm for the detection of fat and a filtering technique to remove intensity inhomogeneities in NMR images, caused by non-uniformities of magnetic field during acquisition. Measurements have been successfully correlated with chemical analysis and digital photography. We also propose a method to quantify the distribution of fat. Our results show that NMR technique is a promising non-invasive method to determine fat content in meat.

4. **Individual Tree-based Species Classification in High Spatial Resolution Aerial Images of Forests using Fuzzy Sets**
   Author: Brandtberg, T.
   Journal: Fuzzy Sets and Systems, 132(3):371–387, 2002
   Abstract: This paper presents an application of fuzzy set theory for classification of individual tree crowns into species groups, in high spatial resolution colour infrared aerial photographs. In this type of digital image, the trees are visible as individual objects. The number of individuals to classify might be very large in the acquired set of photographs, but the applied grade of membership (GoM) model, which this paper focuses on, is suitable for dealing with large datasets. The extent of each tree crown in the image is defined using a previously published procedure. Based on colour information (hue), an optimal fuzzy thresholding technique divides the tree crown universal set into a dominant set and its minor complement. Nine different features of each image object are estimated, and transformed using principal component analysis (PCA). The first three or four PCs are subsequently used in the GoM model. Furthermore, the concept of fuzzy relation is applied to one of the descriptors: to predict a centroid of the star-shaped pattern of Norway spruce. The GoM model needs initial membership values, which are estimated using an unsupervised fuzzy clustering approach of small subareas (branches in the tree crowns) and their corresponding digital numbers in each colour band (RGB-images). The complete classification system comprises three independent com-

ponents: decisions on coniferous/deciduous, Scots pine/Norway spruce, and Birch/Aspen. The accuracies (ground patches excluded), using the supervised GoM model with crossvalidation, are 87%, 76%, and 79%, respectively. The accuracy for the compounded system is 67%.

5. **Using Weighted Fixed Neural Networks for Unsupervised Fuzzy Clustering**
   Author: Hamid Muhammed, H.
   Journal: International Journal of Neural Systems, 12(6):425–434, 2002
   Abstract: A novel algorithm for unsupervised fuzzy clustering is introduced. The algorithm uses a so-called Weighted Fixed Neural Networks (WFNN) to store important and useful information about the topological relations in a given data set. The algorithm produces a weighted connected net, of weighted nodes connected by weighted edges, which reflects and preserves the topology of the input data set. The weights of the nodes and the edges in the resulting net are proportional to the local densities of data samples in input space. The connectedness of the net can be changed, and the higher the connectedness of the net is chosen, the fuzzier the system becomes. The new algorithm is computationally efficient when compared to other existing methods for clustering multi-dimensional data, such as colour images.

6. **Tripeptide Interference with Human Immunodeficiency Virus Type 1 Morphogenesis**
   Authors: Höglund, S. (1); Su, J. (2); Sundin Reneby, S. (1); Végvári, Á. (1); Hjertén, S. (1); Sintorn, I.-M.; Foster, H. (1); Wu, Y.-P. (2); Nyström, I.; Vahlne, A. (2)
   (1) HIV structure group, Dept. of Biochemistry, UU
   (2) Div. of Clinical Virology, The Karolinska Institut, Huddinge University Hospital, Stockholm
   Journal: Antimicrobial Agents and Chemotherapy, 46(11):3597–3605, 2002
   Abstract: Capsid assembly during virus replication is a potential target for antiviral therapy. The Gag polyprotein is the main structural component of retroviral particles, and in human immunodeficiency virus type 1 (HIV-1), it contains the sequences for the matrix, capsid, nucleocapsid, and several small polypeptides. Here, we report that at a concentration of 100 M, 7 of 83 tripeptide amides from the carboxyl-terminal sequence of the HIV-1 capsid protein p24 suppressed HIV-1 replication (¿80%). The three most potent tripeptides, glycyl-prolyl-glycine-amide (GPG-NH2), alanyl-leucyl-glycine-amide (ALG-NH2), and arginyl-glutaminyl-glycine-amide (RQG-NH2), were found to interact with p24. With electron microscopy, disarranged core structures of HIV-1 progeny were extensively observed when the cells were treated with GPG-NH2 and ALG-NH2. Furthermore, nodular structures of approximately the same size as the broad end of HIV-1 conical capsids were observed at the plasma membranes of treated cells only, possibly indicating an arrest of the budding process. Corresponding tripeptides with nonamidated carboxyl termini were not biologically active and did not interact with p24.

7. **A New Shape Descriptor for Surfaces in 3D Images**
   Authors: Sanniti di Baja, G. (1); Svensson, S..
   (1) Istituto di Cibernetica, National Research Council of Italy (CNR), Arco Felice (Napoli), Italy
   Journal: Pattern Recognition Letters, 23(6):703–711, 2002
   Abstract: We introduce a linear shape descriptor for (open) surfaces in 3D images. To extract the shape descriptor, the border of the surface is first identified. Then, the distance transform of the surface is computed, where each voxel in the surface is labelled with the minimum distance to its closest border voxel. On the distance transform, the centres of the maximal geodesic discs (CMGDs) are detected. These voxels are suitably linked to each other by growing paths in the direction of the steepest gradient, to finally obtain the linear shape descriptor of the surface. The shape descriptor can be extracted from any open surface-like object, i.e., an object with thickness at most two-voxel.

8. **Digital Distance Transforms in 3D Images Using Information from Neighbourhoods up to** $5 \times 5 \times 5$
   Authors: Svensson, S.; Borgefors, G.
   Journal: Computer Vision and Image Understanding, 88(1):24–53, 2002
   Abstract: 3D distance image, or a distance transform, is an image where each feature voxel is labeled with the distance to its closest nonfeature voxel. Distance transforms are useful for many binary (shape) image analysis tasks. The distance transform can be computed by propagating local distance information between neighboring voxels. In a weighted distance transform, the local distances are optimized to make the distance transform more stable under rotation. We present results from optimization for 3D images when using from one to six local distances, all in the $5 \times 5 \times 5$ neighbourhood of a voxel.

9. **Distance Transforms in 3D using Four Different Weights**
Authors: Svensson, S.; Borgefors, G.
Journal: Pattern Recognition Letters, 23(12):1407–1418, 2002
Abstract: Digital distance transformations provide helpful tools for representation and description of object shape in digital images. The resulting distance transforms should be stable under trans ation and rotation. To this end, the Euclidean distance is approximated. We present results for distance transforms for 3D images, where the four weights, or local distances, are used, the three weights from the $3 \times 3 \times 3$ neighbourhood together with one weight from the outer part of the $5 \times 5 \times 5$ neighbourhood.

10. **Curve Skeletonization of Surface-Like Objects in 3D Images Guided by Voxel Classification**
Authors: Svensson, S.; Nyström, I.; Sanniti di Baja, G. (1)
(1) Istituto di Cibernetica, National Research Council of Italy (CNR), Arco Felice (Napoli), Italy
Journal: Pattern Recognition Letters, 23(12):1419–1426, 2002
Abstract: Skeletonization is a way to reduce dimensionality of digital objects. Here, we present an algorithm that computes the curve skeleton of a surface-like object in a 3D image, i.e., an object that in one of the three dimensions is at most two-voxel thick. A surface-like object consists of surfaces and curves crossing each other. Its curve skeleton is a 1D set centred within the surface-like object and with preserved topological properties. It can be useful to achieve a qualitative shape representation of the object with reduced dimensionality. The basic idea behind our algorithm is to detect the curves and the junctions between different surfaces and prevent their removal as they retain the most significant shape representation.

11. **Using Distance Transforms to Decompose 3D Discrete Objects**
Authors: Svensson, S.; Sanniti di Baja, G. (1)
(1) Istituto di Cibernetica, National Research Council of Italy (CNR), Arco Felice (Napoli), Italy
Journal: Image and Vision Computing, 20(8):529–540, 2002
Abstract: Object decomposition into simpler parts greatly diminishes the complexity of a recognition task. In this paper, we present a method to decompose a 3D discrete object into nearly convex or elongated parts. Object decomposition is guided by the distance transform (DT). Significant voxels in DT are identified and grouped into seeds. These are used to originate the parts of the object by applying the reverse and the constrained distance transformations. Criteria for merging less significant parts and obtaining a perceptually meaningful decomposition are also given. This approach is likely to be of interest in future applications due to the increasing number and the decreasing cost of devices for volume image acquisition.

12. **Segmentation with Gray-Scale Connectedness can Separate Arteries and Veins in MRA**
Authors: Tizon, X.; Smedby, Ö. (1)
(1) Dept. of Medicine and Care, Linköping University Hospital
Journal: Journal of Magnetic Resonance Imaging, 15(4):438–445, 2002
Abstract:
Purpose: To describe and present some preliminary results for a novel algorithm for segmentation with gray-scale connectedness as a means to separate arteries and veins in magnetic resonance angiography (MRA).
Materials and Methods: The proposed algorithm, *SeparaSeed*, uses the gray-scale degree of connectedness as a tool to find the zone surrounding each vessel, in order to split the original volume into its different vessel components. In contrast to traditional segmentation methods, no gray-scale information is lost in the process. The segmentation is performed in one step, resulting in a partition of the initial volume into a chosen number of regions of interest (ROIs). Finally, visualization is achieved by projecting the 3D vessel trees to 2D using the common maximum intensity projection (MIP). The algorithm was tested in two MRA data sets of the vessels of the pelvis acquired after injection of an intravascular contrast agent and in one data set of the vessels of the neck with gadolinium.
Results: In all data sets, a large proportion of the venous signal was removed while preserving that of the arteries, thus improving visualization of the relevant vessels.
Conclusion: Separation of arteries and veins is feasible with the proposed algorithm with a moderate amount of interaction.

6.4 Refereed conference proceedings

1. **Estimating Fibre Twist and Aspect Ratios in 3D Voxel Volumes**
   Author: Aronsson, M.
   Conference: International Conference on Pattern Recognition (ICPR 2002)
   Editors: Kasturi, R.; Laurendeau, D.; Suen, C. (ed.)
   Publisher: IEEE Computer Society, vol. I, 218–221, 2002
   Abstract: Aspect ratios and twist measures can help us characterise paper fibre properties. Such measures, that need volume data, are presented here. To test the developed methods, simulated voxel volumes of fibres were created by defining each fibre as a spline curve with an elliptical cross sectional shape and a constant twist per length unit. This allows us to directly compare the measurements from the voxel volume to the properties of the original spline fibres.

2. **Ring Shaped Object Detector for Non-Isotropic 2D Images Using Optimized Distance Transform Weights**
   Authors: M. Aronsson, I.-M. Sintorn
   Conference: International Conference on Image Processing (ICIP 2002), Rochester, NY, USA
   Publisher: IEEE Publications, pp. 985–988, 2002
   Abstract: A detector for finding ring shaped objects occurring in clus-ters in 2D images with non-isotropic pixel dimensions have been developed. The rings are characterized as having a closed border and a void interior. We assume that the thick-ness of the rings should be approximately constant and their void shape smooth. We initially find candidates that could be possible ring voids, then by using a distance transform (DT) based technique, a DT histogram of the surrounding material is created. If the DT histogram fulfills certain con-straints, a ring has been found. A second DT based step will mark the pixels surrounding the void with a unique label. By this approach we impose only loose constraints on the shape of the rings. In addition to the ring detector itself, the paper illustrates that if proper DTs are used, non-isotropic images can be analysed without interpolation to a square grid.

3. **Segmentation of Liver Images by Texture and Genetic Snakes**
   Authors: Ballerini, L.; Bocchi, L. (1)
   (1) Dept. of Electronics and Telecommunications, University of Firenze, Italy
   Conference: European and Biological Engineering Conference (EMBEC'02), Vienna, Austria
   Proc. pp. 1096–1097, 2002
   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. 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 a new method to segment the liver based on textural properties of the image and active contour models.

4. **Determination of Pores in Pig Meat Images**
   Authors: Ballerini, L.; Bocchi, L. (1); Hullberg, A. (2)
   (1) Dept. of Electronics and Telecommunications, University of Firenze, Italy
   (2) Dept. of Food Science, SLU, Uppsala
   Conference: International Conference on Computer Vision and Graphics, Zakopane, Poland
   Proc. vol. 1, pp. 70–78, 2002
   Abstract: In this paper we present an image processing application for quantification of pores in pig meat images. We used digital camera photographs of slices of tumbled and non-tumbled processed loins of different RN genotype. We describe a method to extract and count the number and sizes of pores. The aim is to study the relationship between the amount of pores and process condition and genotype. Results show that image analysis can be useful in this field.

5. **Fuzzy Border Distance Transforms and their Use in 2D Skeletonization**
   Authors: Borgefors, G.; Svensson, S.
   Conference: International Conference on Pattern Recognition (ICPR 2002)
   Editors: Kasturi, R.; Laurendeau, D.; Suen, C.
   Publisher: IEEE Computer Society, vol. I, 180–183, 2002
   Abstract: Segmentation is always a difficult task in image analysis. In this paper, we propose a solution to computing distance transforms in images with fuzzy object borders. The difference from a standard distance

transform is in the initialisation, which takes the fuzziness of the border into account. As an example of its usefulness, the new fuzzy border distance transform is used in skeletonization.

6. **Surface Area Estimation of Digitized 3D Objects using Local Computations**
   Authors: Lindblad, J.; Nyström, I.
   Conference: Discrete Geometry for Computer Imagery (DGCI 2002)
   Editors: Braquelaire, A.; Lachaud, J.-O.; Vialard, A.
   Publisher: Springer-Verlag, Lecture Notes in Computer Science 2301, pp. 267–278, 2002
   Abstract: We describe surface area measurements based on local estimates of isosurfaces originating from a marching cubes representation. We show how improved precision and accuracy are obtained by optimizing the area contribution for one of the cases in this representation. The computations are performed on large sets (approximately 200,000 3D objects) of computer generated spheres, cubes, and cylinders. The synthetic objects are generated over a continuous range of sizes with randomized alignment in the digitization grid. Sphericity, a scale invariant measure of compactness, allows us, in combination with the improved surface area estimate, to distinguish among the test sets.

7. **Area of and Volume Enclosed by Digital and Triangulated Surfaces**
   Authors: Nyström, I.; Udupa, J.K. (1); Grevera, G.J. (1); Hirsch, B.E. (1)
   (1) MIPG, Dept. of Radiology, University of Pennsylvania, Philadelphia, USA
   Conference: SPIE Medical Imaging 2002: Visualization, Image-Guided Procedures, and Display
   Editor: Mun, S.K.
   Publisher: SPIE Proceedings 4681, pp. 669–680, 2002
   Abstract: We demonstrate that the volume enclosed by triangulated surfaces can be computed efficiently in the same elegant way the volume enclosed by digital surfaces is computed by digital surface integration. Although digital surfaces are good for visualization and volume measurement, their drawback is that surface area measurements are inaccurate. On the other hand, triangulated surfaces give more accurate surface area measurements, but volume measurements and visualization are less efficient. The T-shell data structure previously proposed retains advantages and overcomes difficulties of both the digital and the triangulated approaches. We create a lookup table with area and volume contributions for each of the 256 Marching Cubes configurations. When scanning the shell (e.g., while creating it), the surface area and volume are incrementally computed by using the lookup table and the current x co-ordinate, where the sign of the x component of the triangle normal indicates the sign of the volume contribution. We have computed surface area and volume for digital and triangulated surfaces for digitized mathematical phantoms, physical phantoms, and real objects. The computations show that triangulated surface area is more accurate, triangulated volume follows digital volume closely, and that the values get closer to the true value with decreasing voxel size.

8. **Weighted distance transforms for images using elongated voxel grids**
   Authors: Sintorn, I.-M.; Borgefors, G.
   Conference: Discrete Geometry for Computer Imagery (DGCI 2002)
   Editors: Braquelaire, A.; Lachaud, J.-O.; Vialard, A.
   Publisher: Springer-Verlag, Lecture Notes in Computer Science 2301, pp. 244–254, 2002
   Abstract: In this paper we investigate weighted distance transforms in 3D images using elongated voxel grids. We use a local neighbourhood of size $3 \times 3 \times 3$ and assume a voxel grid with equal resolution along two axes and lower along the third. The weights (local distances) in the local neighbourhood are optimized by minimizing the maximum error over linear trajectories, which is a completely digital approach. General solutions are presented, as well as numerical solutions for the cases when the voxels are 1.5 and 2.58 times longer in one direction. Integer solutions for both real and integer scale factors are presented. As an application example, the medial axis of an object is computed in an image with elongated voxels and compared to the medial axis computed on the same image interpolated to equal resolution along all axes.

9. **Using Grey-Level and Distance Information for Medial Surface Representation of Volume Images**
   Authors: Svensson, S.; Nyström, I.; Sanniti di Baja, G. (1); Arcelli, C. (1)
   (1) Istituto di Cibernetica, National Research Council of Italy (CNR), Arco Felice (Napoli), Italy
   Conference: International Conference on Pattern Recognition (ICPR 2002)
   Editors: Kasturi, R.; Laurendeau, D.; Suen, C.
   Publisher: IEEE Computer Society, vol. II, pp. 324–327, 2002

Abstract: A medial surface representation of a grey-level volume image is computed. The foreground is reduced to a subset topologically equivalent to the initial foreground and mainly consisting of surfaces centred within regions having locally higher intensities, here, regarded as more informative. This result is obtained by combining distance information with grey-level information. A surface skeleton is first computed, where excessive shortening is prevented by a regularity condition defined on the distance transform. The structure of the surface skeleton is then simplified by removing some peripheral surfaces, so obtaining the desired medial surface representation.

10. **Acquisition and Colour Correction of Underwater Multispectral and Hyperspectral Images**
    Author: Åhlén, J.
    Conference: 7th International Conference of Remote Sensing for Marine and Coastal Environments 2002, Miami, Florida, USA
    Publisher: Veridian ERIM International, CD-rom, 2002
    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. 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. No studies that could help efficiently reduce the negative effects of scatter and light absorption has been done on multi spectral or hyper spectral data taken under the water. Investigation of multi or hyper spectral data will give us more colour channels to work with. An image-processing algorithm that takes in pre-processed colour channels and enhance some characteristics depending on application is the result we would want to achieve. I will present a technique for acquisition of hyper and multivariate data under the surface in saltwater. The colour constancy problem will be discussed considering particular application.

6.5 Non-refereed conferences and workshops

1. **Curvature Measurements for Fibres in 3D Images of Paper**
   Authors: Aronsson, M.; Svensson, S.
   Conference: Swedish Society for Automated Image Analysis Symposium – SSAB 2002
   Editor: Åström, K.
   Publisher: Centre for Mathematical Sciences, Lund University, pp. 165–168, 2002

2. **Determination of Holes in Pig Meat Images**
   Authors: Ballerini, L.; Bocchi, L. (1)
   (1) Dept. of Electronics and Telecommunications, University of Firenze, Italy
   Conference: Swedish Society for Automated Image Analysis Symposium – SSAB 2002
   Editor: Åström, K.
   Publisher: Centre for Mathematical Sciences, Lund University, pp. 53–56, 2002

3. **The Plenoscope Concept and Image Formation**
   Author: Bergholm, F.
   Conference: Swedish Society for Automated Image Analysis Symposium – SSAB 2002
   Editor: Åström, K.
   Publisher: Centre for Mathematical Sciences, Lund University, pp. 75–78, 2002

4. **Determination of Holes and Cracks in Meat with Image Analysis**
   Authors: Bocchi, L. (1); Ballerini, L.
   (1) Dept. of Electronics and Telecommunications, University of Firenze, Italy
   Conference: 48th International Congress of Meat Science and Technology, Rome, Italy
   Proc. vol. 1, pp. 336–337, 2002

5. **Colour Segmentation of Individual Tree Crowns in Aerial Images**
   Author: Erikson, M.
   Conference: Swedish Society for Automated Image Analysis Symposium – SSAB 2002
   Editor: Åström, K.
   Publisher: Centre for Mathematical Sciences, Lund University, pp. 177–180, 2002

6. **Unsupervised Image Segmentation Using New Neuro-Fuzzy Systems**
   Author: Hamid Muhammed, H.
   Conference: Swedish Society for Automated Image Analysis Symposium – SSAB 2002
   Editor: Åström, K.
   Publisher: Centre for Mathematical Sciences, Lund University, pp. 83–87, 2002

7. **Unsupervised Hyperspectral Image Segmentation Using a New Class of Neuro-Fuzzy Systems Based on Weighted Incremental Neural Networks**
   Author: Hamid Muhammed, H.
   Conference: 31st Applied Imagery Pattern Recognition Worshop (AIPR 2002), Washington DC, USA
   Publisher: IEEE Computer Society Press, 7 p., 2002

8. **Using Hyperspectral Reflectance Data for Discrimination Between Healthy and Diseased Plants, and Determination of Damage-Level in Diseased Plants**
   Author: Hamid Muhammed, H.
   Conference: 31st Applied Imagery Pattern Recognition Worshop (AIPR 2002), Washington DC, USA
   Publisher: IEEE Computer Society Press, 6 p., 2002

9. **Reconstruction Filters for Bump Mapping**
   Authors: Hast, A.; Barrera, T. (1); E. Bengtsson
   (1) Cycore AB, Uppsala
   Conference: WSCG'02, Plzen, Czech Republic, pp. 9–12, 2002.

10. **Improved Bump Mapping by using Quadratic Vector Interpolation**
    Authors: Hast, A.; Barrera, T. (1); E. Bengtsson
    (1) Cycore AB, Uppsala
    Conference: Eurographics02, Bristol, UK, 2002

11. **Snow Accumulation in Real-time**
    Authors: Haglund, H. (1); Hast, A.
    (1) Dept. of Mathematics, Natural Sciences, and Computing, University College of Gävle
    Conference: Sigrad 2002, Norrköping, pp. 11–15, 2002

12. **Animation of Water Droplet Flow on Structured Surfaces**
    Authors: Jonsson, M. (1); Hast, A.
    (1) Dept. of Mathematics, Natural Sciences, and Computing, University College of Gävle
    Conference: Sigrad 2002, Norrköping, pp. 17–22, 2002

13. **Surface Construction with Near Least Square Acceleration based on Vertex Normals on Triangular Meshes**
    Authors: Barrera, T. (1); Hast, A.; E. Bengtsson
    (1) Cycore AB, Uppsala
    Conference: Sigrad 2002, Norrköping, pp. 43–48, 2002

14. **Reconstruction Filters for Bump Mapping**
    Authors: Hast, A.; Barrera, T. (1); E. Bengtsson
    (1) Cycore AB, Uppsala
    Conference: Second Conference for Promotion of Research in IT at New Universities and University Colleges, Skövde, pp. 244–256, 2002

15. **Nuclear Egress of Human Cytomegalovirus Capsids by Budding through the Nuclear Membrane**
    Authors: Homman, M. (1), Sintorn, I.-M., Hultenby, K. (1), Borgefors, G., Söderberg-Naucler, C. (1)
    (1) Centre for Molecular Medicine, The Karolinska Hospital, Stockholm
    Conference: Int. Conf. on Electron Microscopy, Durban, South Africa, 2002

16. **A Simple and Possibly Efficient Approach to Automatic License Plate Recognition**
    Author: Karlsson, P.
    Conference: Swedish Society for Automated Image Analysis Symposium – SSAB 2002
    Editor: Åström, K.
    Publisher: Centre for Mathematical Sciences, Lund University, pp. 57–60, 2002

17. **A Comparison of Neuro-Fuzzy and Traditional Image Segmentation Methods for Automated Detection of Buildings in Aerial Photos**
Authors: Knudsen, T.(1) ; Hamid Muhammed, H.; Olsen, B.P. (1)
(1) Kort & Matrikelstyrelsen, Copenhagen, Denmark
Conference: Photogrammetric Computer Vision (PCV'02), Graz, Austria, 2002
Publisher: ISPRS, International Archives of Photogrammetry and Remote Sensing, Vol. B, 2002

18. **Automated Change Detection of Bleached Coral Reef Areas**
Authors: Lindell, L.T.; Philipson, P.
Conference: 7th International Conference, Remote Sensing for Marine and Coastal Environments, Ann Arbour, Miami, USA *Publisher:* Veridian 1066-3711, 2002

19. **Mapping of Coral Bottoms from Different High Resolution Satellite Images**
Authors: Lindell, L. T.; Philipson, P.
Conference: International Symposium on Remote Sensing of Environment, Buenos Aires, Argentina
Proc. 4 p., 2002

20. **Description, Segmentation and Classification of Human Cytomegalovirus Capsids**
Authors: Sintorn I.-M.; Homman, M. (1)
(1) Centre for Molecular Medicine, The Karolinska Hospital, Stockholm
Conference: Swedish Society for Automated Image Analysis Symposium – SSAB 2002
Editor: Åström, K.
Publisher: Centre for Mathematical Sciences, Lund University, pp. 21–24, 2002

21. **Surface Skeletonization of 3D Objects having a Fuzzy Border**
Authors: Svensson, S.; Borgefors, G.
Conference: Swedish Society for Automated Image Analysis Symposium – SSAB 2002
Editor: Åström, K.
Publisher: Centre for Mathematical Sciences, Lund University, pp. 157–160, 2002

22. **Concurrent Grayscale Connectedness: Application to Arteries-Veins Separation in Magnetic Resonance Angiography**
Author: Tizon, X.
Conference: Swedish Society for Automated Image Analysis Symposium – SSAB 2002
Editor: Åström, K.
Publisher: Centre for Mathematical Sciences, Lund University, pp. 37–40, 2002

23. **Acquisition of Hyperspectral Data Under the Ocean surface**
Author: Åhlén, J.
Conference: Second Conference for Promotion of Research in IT at New Universities and University Colleges, Skövde, 2002

6.6 Other publications

See also Sections 4.2 and 4.3 where the Licentiates and the Doctoral theses presented during 2002, respectively, are listed. See also Section 3.3 for the completed Master theses.

1. **CBA Annual Report 2001**
Editors: Aronsson, M.; Borgefors, G.; Nyström, I.; Wadelius, L.
Publisher: Centre for Image Analysis, 87 pages, 2002

2. **A report on 10th Summer School on Image Processing**
Author: Sladoje, N.
Publisher: CBA Internal Report No. 23, 18 pages, 2002

3. **Reviews on Scientific Papers on Application of Fuzzy Set Theory in Image Segmentation**
Author: Sladoje, N.
Publisher: CBA Internal Report No. 24, 43 pages, 2002

4. **The future of Italian doctors**
   Author: Ballerini, L.; Piazza, E.
   Conference: European Conference of Doctoral Students (Eurodoc 2002), Girona, Spain
   Comment: Popular science

5. **Swedish Universities Prepare Students for Entry into Industry**
   Authors: V. Zdravkovic (1), E. Carling (1), S. Seipel (1), A. Hast
   (1) Dept. of Mathematics, Natural Sciences, and Computing, University College of Gävle
   Journal: Computer Graphics, Newsletter of ACM SIGGRAPH. 36(2), 2002
   Comment: Journalistic report

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 organise 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 2002. 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.

Stina Svensson is one of two founding co-chairs of the International Association for Pattern Recognition Technical committee for Discrete Geometry. Prof. Ewert Bengtsson has served as advisor to the Rector of UU on information technology and also served as Chair of the Virtual Faculty of information technology, together with many other related appointments. Ingela Nyström has served as President of the Swedish Society for Automatic Image Analysis and Stina Svensson as its Secretary and Treasurer. Fredrik Bergholm has been the executive programme Director for the national research programme VISIT.

To give some figures: We held 14 seminars outside CBA, in places from downtown Uppsala to Philadelphia, USA. This is less than last year, but 2001 was exceptional. There were also four lectures held at CBA by scientists from Korea, France/Japan, and USA, respectively. In addition we held 40 seminars in our "Monday seminar series." We have given one special invited presentation at a scientific conference; one oral and eight poster presentations at international reviewed conferences; and 22 other conference presentations. The number of oral reviewed presentations is exceptionally low, but the total number of presentations is higher than usual.

We have had one long term visitors from abroad, both Uganda. Stina Svensson has made two extended visits as guest scientist abroad, in Napoli, Italy, and Delft, The Netherlands. We have also received a large number of national and international visitors at many different occasions and have visited others ourselves.

Finally, we have listed 18 international and 38 national "committees" of the most varying types in which we have served.

Except for the comments above, all these figures make 2002 a "normal" year for these activities.

7.1 Awards

Petra Philipson
Award: "Special Recognition Award"
Comment: Awarded at the 7th Internatinal Conference, Remote Sensing for Marine and Coastal Environments, for the paper *Automated change detection of bleached coral reef areas.*

7.2 Organised conferences and workshops

VISIT Workshop on the Future Development of Image Analysis
Organiser: Fredrik Bergholm, Lena Wadelius
Date: 021010–11
Address: Lejondals Slott, Bro
Attendees: 46
Comment: The VISIT research programme is a programme within the field of visual information technology funded by SSF 1997–2003. The underlying goal was to strengthen Sweden's position in the fields of image

analysis, computer graphics, image coding, tomography, medical imaging, physics-based image analysis, biometrics to mention a few. This workshop was the last big meeting of VISIT pariticipants.
The first day of the workshop included presentations in biomedicine, sensors in processing industry, and image coding of image sequences on the internet. A panel debate under the theme "Cooperation between academia and industry" was held. The second day of the workshop was devoted to summing up the results and experiences within the VISIT project, with some emphasis on future usage of results, necessary developments of methods and ideas, and examples of interesting developing branches of research.

7.3 Seminars held outside CBA

1. **Ewert Bengtsson**
   Date: 020114, 020128
   Address: Internationella kursgården, Uppsala
   Title: IT-pedagogical support at UU
   Comment: Part of introductory lecture in the basic pedagogical course for new teachers (twice).

2. **Ewert Bengtsson**
   Date: 020129
   Address: MIC, UU
   Title: IT developments at UU
   Comment: SIDA seminar on IT-cooperation with developing countries. UU and the IT-faculty was hosting this national workshop on how we, through various kinds of collaboration projects, can support the IT development at universities in the third world countires and through this hopefully help their general development.

3. **Gunilla Borgefors**
   Date: 020214
   Address: Dept. of Informatics, University of Bergen, Norway
   Title: Digital distance transforms and their use in shape analysis

4. **Ewert Bengtsson**
   Date: 020225
   Address: Oscar II Conference Centre, Uppsala Science Park
   Title: The Uppsala Internet Protocol Academy (UIPA)
   Comment: Presentation of UIPA to a large audience (about 45) of invited business people attending a half day workshop on networking strategies.

5. **Ewert Bengtsson**
   Date: 020301
   Address: Royal Society of Sciences, Uppsala
   Title: Can the computer help us see what is important?
   Comment: Each month this old academy meets to listen to an invited presentation (in Swedish).

6. **Ingela Nyström**
   Date: 020304
   Address: Medical Image Processing Group, Dept. of Radiology, University of Pennsylvania, PA, USA
   Title: Area of and volume enclosed by digital and triangulated surfaces

7. **Gunilla Borgefors**
   Date: 020422
   Address: Annual General Meeting (AGM), IEEE Sweden Section, Electrum, Kista
   Title: Image processing in $\mathbb{Z}^n$ - not $\mathbb{R}^n$

8. **Ewert Bengtson**
   Date: 020507
   Address: White House, Uppsala
   Title: IT in working life
   Comment: Seminar in conjunction with the inaugeration of National IT User centre, 83 attendees.

9. **Ewert Bengtson**
   Date: 020507
   Address: Linneus house, Uppsala
   Title: Inaugeration of National IT User centre (NITA)
   Comment: Bengtsson gave one of the official speaches, together with the IT minister Mona Sahlin, in the inaugeration ceremony for NITA.

10. **Fredrik Bergholm**
    Date: 020515
    Address: Dept. of Scientific Computing, UU
    Title: An optical inverse problem

11. **Joakim Lindblad**
    Date: 020930
    Address: Amersham Biosciences, Cardiff, U.K.
    Title: Computerized image analysis for automated cell analysis

12. **Stina Svensson**
    Date: 021008
    Address: Pattern Recognition Group, Faculty of Applied Sciences, Delft University of Technology, The Netherlands
    Title: Shape analysis of 3D objects from bi-level and grey-level images

13. **Fredrik Bergholm**
    Date: 021114
    Address: Ångström Laboratory, UU
    Title: Three dimensional cameras
    Comment: Professor inauguration lecture (in Swedish).

14. **Ewert Bengtsson**
    Date: 021129
    Address: Uppsala Learning Lab
    Title: IT at UU
    Comment: Presentation at the visit of a delegation from University of Colombo, headed by professor V K Samaranayake, to discuss possible cooperation between UU and U of C.

7.4 Seminars at CBA with invited guest lecturers

1. **HyunJu Choi**
   Date: 020204
   Address: School of Information and Computer Engineering, Inje University, Korea
   Title: Wavelets for texture analysis

2. **Yukiko Kenmochi**
   Date: 020313
   Address: ESIEE, Noisy-Le-Grand, France
   Title: A survey of shape representation techniques for discrete image analysis

3. **Yukiko Kenmochi**
   Date: 020315
   Address: ESIEE, Noisy-Le-Grand, France
   Title: Discrete surface representation and 3D border tracking algorithm

4. **Prof. Jayaram K. Udupa**
   Date: 021211
   Address: Medical Image Processing Group, Dept. of Radiology, University of Pennsylvania, PA, USA
   Title: A framework for the evaluation of image segmentation algorithms

7.5 Seminars at CBA

Some of these seminars were held in Swedish.

1. **Per Bengtsson**
   Date: 020109
   Title: Image input in IMP
   Comment: Presentation of project work.

2. **Felix Wehrmann**
   Date: 020114
   Title: Is vision more than a good guess?

3. **Joakim Lindblad**
   Date: 020121
   Title: Surface area estimation of digitized 3D objects using local computations

4. **Ewert Bengtsson**
   Date: 020128
   Title: About feature sets for cytometry of digitized microscopic images

5. **Anna Persson**
   Date: 020211
   Title: Algorithms for registration of gel images produced in 2D electrophoresis experiments
   Comment: Master thesis presentation.

6. **Anders Hast**
   Date: 020218
   Title: Faster shading by equal angle interpolation of vectors

7. **Tommy Lindell**
   Date: 020304
   Title: New sensors for our coral reef mapping

8. **Hamed Hamid Muhammed**
   Date: 020311
   Title: Using a new class of neuro-fuzzy systems for unsupervised image segmentation

9. **Mattias Aronsson**
   Date: 020318
   Title: Some practicalities: Creating high-resolution PDF files from LaTeX source, and the new compression standard: JPEG2000?

10. **Julia Åhlen**
    Date: 020325
    Title: Acquisition and colour correction of underwater multispectral and hyperspectral images

11. **Ingela Nyström**
    Date: 020408
    Title: Area of and volume enclosed by digital and triangulated surfaces

12. **Pascha Razifar**
    Date: 020415
    Title: A brief introduction about functionality and physics of the animal PET camera

13. **Petra Ammenberg**
    Date: 020422
    Title: Bio-optical modelling in combination with remote sensing

14. **Xavier Tizon**
    Date: 020429
    Title: Plaque burden index measurement by whole body contrast enhanced MRA

15. **Stina Svensson**
    Date: 020506
    Title: Medial representations of greylevel images

16. **Mats Erikson**
    Date: 020513
    Title: Brownian motion and its usefulness in image analysis

17. **Ida-Maria Sintorn**
    Date: 020527
    Title: Difficulties in segmentation of HIV cores in 3D reconstructions from transmission electron micrographs

18. **Fredrik Bergholm**
    Date: 020603
    Title: Differences between 1D and 2D obstacle plates in lenses

19. **Ola Weistrand**
    Date: 020610
    Title: Parametrization of closed discrete surfaces, a new algorithmic approach

20. **Gunilla Borgefors**
    Date: 020617
    Title: Hierarchical decomposition of multi-scale skeletons

21. **Felix Wehrmann**
    Date: 020819
    Title: Illusions and optical delusions

22. **Joakim Lindblad**
    Date: 020826
    Title: Segmentation of fluorescence labeled cells

23. **Gunilla Borgefors and Ingela Nyström**
    Date: 020902
    Title: Report from ICPR2002, Québec City, Canada

24. **Stina Svensson**
    Date: 020909
    Title: Analysing the convex deficiency for a 3D object

25. **Pascha Razifar**
    Date: 020916
    Title: Partial volume effect in PET studies

26. **Hamed Hamid Muhammed**
    Date: 020923
    Title: Using hyperspectral reflectance data for discrimination between healthy and diseased plants

27. **Mattias Aronsson**
    Date: 020930
    Title: An example of 3D paper void analysis

28. **Roya Khomand**
    Date: 021002
    Title: Image analysis of cast-iron
    Comment: Master thesis presentation.

29. **Julia Åhlen**
    Date: 021007
    Title: Bottom reflectance and colour variability in underwater scenes

30. **Ida-Maria Sintorn**
    Date: 021014
    Title: Automatic identification and classification of Cytomegalovirus capsids in electron micrographs

31. **Mats Eriksson**
    Date: 021021
    Title: Error detecting and error correcting codes

32. **Petra Philipson**
    Date: 021028
    Title: Evaluation of Swedish lake water quality modeling from remote sensing

33. **Torgil Svensson**
    Date: 021108
    Title: Implementation and evaluation of image analysis based seed classification and sorting system
    Comment: Master thesis presentation.

34. **Anders Hast**
    Date: 021111
    Title: Improved shadows by modifying the Shadow Map Technique and the Phong-Blinn light model

35. **Natasa Sladoje**
    Date: 021118
    Title: Application of fuzzy set theory in image segmentation

36. **Tommy Lindell**
    Date: 021125
    Title: Can coral reefs be monitored from space?

37. **Xavier Tizon**
    Date: 021126
    Title: A short overview of two talks at the MIA'2002 conference in, Paris France

38. **Ola Weistrand**
    Date: 021202
    Title: How to balance a turbine?

39. **Ewert Bengtsson**
    Date: 021209
    Title: Some aspects of state of the art in cytometry and brain resarch, and Some inpressions from two workshops in California in October 2002, and What did Ewert do in California?

40. **Björn Johansson**
    Date: 021218
    Address: CBA
    Title: Road sign recognition from a moving vehicle
    Comment: Master thesis presentation.

7.6 Conference participation

7.6.1 Special invited speakers

1. *Conference:* VISIT Workshop on the Future Development of Image Analysis
   Ewert Bengtsson
   Date: 021010
   Address: Lejondals Slott, Bro
   Title: VISIT in the future of biomedical image analysis (in Swedish).

7.6.2 Oral presentations - refereed conferences

1. *Conference:* International Conference on Computer Vision and Graphics
   Lucia Ballerini
   Date: 020924–30
   Address: Zakopane, Poland
   Title: Determination of pores in pig meat images

7.6.3 Poster presentations - refereed conferences

1. *Conference:* SPIE Medical Imaging 2002
   Ingela Nyström
   Date: 020224–28
   Address: San Diego, CA, USA
   Title: Area of and volume enclosed by digital and triangulated surfaces
   Comment: Nyström Chaired a session on Visualization.

2. *Conference:* 10th International Conference on Discrete Geometry for Computer Imagery (DGCI 2002)
   Joakim Lindblad, Ingela Nyström
   Date: 020403–05
   Address: Bordeaux, France
   Title: Surface area estimation of digitized 3D objects using local computations
   Comment: Nyström attended DGCI steering committee meeting on DGCI future plans.

3. *Conference:* 10th International Conference on Discrete Geometry for Computer Imagery (DGCI 2002)
   Gunilla Borgefors, Ida-Maria Sintorn
   Date: 020403–05
   Address: Bordeaux, France
   Title: Weighted distance transforms for images using elongated voxel grids
   Comment: Borgefors was Session Chair and attended DGCI steering committee meeting on DGCI future plans.

4. *Conference:* International Conference on Pattern Recognition (ICPR 2002)
   Mattias Aronsson
   Date: 020811–15
   Address: Québec City, Québec, Canada
   Title: Estimating fibre twist and aspect ratios in 3D voxel volumes

5. *Conference:* International Conference on Pattern Recognition (ICPR 2002)
   Ingela Nyström
   Date: 020811–15
   Address: Québec City, Québec, Canada
   Title: Using grey-level and distance information for medial surface representation of volume images
   Comment: Attended the Governing Board meeting of the IAPR.

6. *Conference:* International Conference on Pattern Recognition (ICPR 2002)
   Stina Svensson
   Date: 020811–15
   Address: Quebec City, Québec, Canada
   Title 1: Fuzzy border distance transforms and their use in 2D skeletonization
   Title 2: Using grey-level and distance information for medial surface representation of volume images
   Comment: Attended the Governing Board meeting of the IAPR.

7. *Conference:* International Conference on Pattern Recognition (ICPR 2002)
   Gunilla Borgefors
   Date: 020811–15
   Address: Québec City, Québec, Canada
   Title: Fuzzy border distance transforms and their use in 2D skeletonization
   Comment: Session Chair. Attended the Governing Board meeting of the IAPR.

8. *Conference:* International Conference on Image Analysis (ICIP'02)
   Mattias Aronsson
   Date: 020922–25
   Address: Rochester, New York, USA
   Title: Ring Shaped Object Detector for Non-isotropic 2D Images using Optimized Distance Transform Weights

7.6.4 Oral presentations

1. *Conference:* Swedish Society for Automated Image Analysis Symposium (SSAB'02)
   Hamed Hamid Muhammed
   Date: 020307–08
   Address: Centre for Mathematical Sciences, Lund University
   Title: Unsupervised image segmentation using new neuro-fuzzy systems
2. *Conference:* Swedish Society for Automated Image Analysis Symposium (SSAB'02)
   Mattias Aronsson
   Date: 020307–08
   Address: Centre for Mathematical Sciences, Lund University
   Title: Curvature measurements for fibres in 3D images of paper
3. *Conference:* Swedish Society for Automated Image Analysis Symposium (SSAB'02)
   Lucia Ballerini
   Date: 020307–08
   Address: Centre for Mathematical Sciences, Lund University
   Title: Determination of holes in pig meat images
4. *Conference:* Swedish Society for Automated Image Analysis Symposium (SSAB'02)
   Mats Erikson
   Date: 020307–08
   Address: Centre for Mathematical Sciences, Lund University
   Title: Color segmentation of individual tree crowns in areal images
5. *Conference:* Swedish Society for Automated Image Analysis Symposium (SSAB'02)
   Stina Svensson
   Date: 020307–08
   Address: Centre for Mathematical Sciences, Lund University
   Title: Surface skeletonization of 3D objects having a fuzzy border
6. *Conference:* Swedish Society for Automated Image Analysis Symposium (SSAB'02)
   Ida-Maria Sintorn
   Date: 020307–08
   Address: Centre for Mathematical Sciences, Lund University
   Title: Description, segmentation and classification of human Cytomegalovirus capsids
7. *Conference:* Swedish Society for Automated Image Analysis Symposium (SSAB'02)
   Fredrik Bergholm
   Date: 020307–08
   Address: Centre for Mathematical Sciences, Lund University
   Title: The plenoscope concept and image formation
8. *Conference:* Swedish Society for Automated Image Analysis Symposium (SSAB'02)
   Xavier Tizon
   Date: 020307–08
   Address: Centre for Mathematical Sciences, Lund University
   Title: Concurrent grayscale connectedness - application to arteries-veins separation in Magnetic Resonance Angiography

9. *Conference:* Swedish Map days 2002
   Petra Ammenberg
   Date: 020417–19
   Address: ELMIA, Jönköping, Sweden
   Title: Bio-optical modeling and remote sensing in water quality monitoring

10. *Conference:* Medical Technical Conference 2002
    Ida-Maria Sintorn
    Date: 021009
    Address: Södertörns Högskola, Huddinge, Stockholm
    Title: Automatic identification and classification of Cytomegalovirus capsids in electron micrographs
    Comment: Abstract reviewed meeting.

11. *Conference:* 31st Applied Imagery Pattern Recognition Worshop (AIPR 2002)
    Hamed Hamid Muhammed
    Date: 021016–18
    Address: Washington DC, USA
    Title 1: Unsupervised hyperspectral image segmentation using a new class of neuro-fuzzy systems based on weighted incremental neural networks
    Title 2: Using hyperspectral reflectance data for discrimination between healthy and diseased plants, and determination of damage-level in diseased plants

12. *Conference:* 12th Cytometry Development Workshop
    Ewert Bengtsson
    Date: 021018–21
    Address: Monterey, CA, USA
    Title 1: High speed segmentation and feature extraction of fluorescent images
    Title 2: Tutorial: Some thoughts on the need for well defined features in cytometry
    Comment: An invitational workshop with about 40 active participants.

13. *Conference:* GIS-day
    Petra Philipsson
    Date: 021120
    Address: Ekonomikum, UU
    Title: Can coral reefs be monitored from space? (in Swedish)

14. *Conference:* RESE Final conference on Remote Sensing of Environment
    Petra Philipson
    Date: 021127–29
    Address: Vårgård, Saltsjöbaden, Stockholm
    Title 1: Lake water quality modeling from remote sensing
    Title 2: Can coral reefs be monitored from space?

7.6.5 Poster presentations

1. *Conference:* 29th International symposium on remote sensing of environment
   Tommy Lindell
   Date: 020406–18
   Address: Buenos Aires, Argentina
   Title: Mapping of coral bottoms from different high resolution satellite images

2. *Conference:* 7th International Conference, Remote Sensing for Marine and Coastal Environments
   Petra Ammenberg
   Date: 020520–24
   Address: Miami, Florida, USA
   Title: Automated change detection of bleached coral reef areas
   Comment: The paper received a “Special Recognition Award”.

3. *Conference:* ISPRS - Commission III Symposium 2002, Photogrammetric Computer Vision, (PCV'02)
   Hamed Hamid Muhammed
   Date: 020909–13
   Address: Graz, Austria
   Title: A comparison of neuro-fuzzy and traditional image segmentation methods for automated detection of buildings in aerial photos

4. *Conference:* 9th International Symposium on Remote Sensing
   Petra Philipson
   Date: 020922–27
   Address: Aghia Pelagia, Crete, Greece
   Title: Evaluation of Swedish lake water quality modeling from remote sensing

5. *Conference:* Medical Technical Conference 2002
   Joakim Lindblad
   Date: 021008–09
   Address: Södertörns Högskola, Huddinge, Stockholm
   Title: Applying watersheds to cell image analysis
   Comment: Abstract reviewed meeting.

6. *Conference:* Medical Technical Conference 2002
   Ewert Bengtsson
   Date: 021008–09
   Address: Södertörn Högskola, Huddinge Stockholm
   Title: Accurate and efficient measurements of surface area and volume in medical images
   Comment: Bengtsson presented Nyström's poster since she could not attend in person. Abstract reviewed meeting.

7. *Conference:* VISIT Workshop on Future Developments of Image Analysis
   Ewert Bengtsson, Carolina Wählby
   Date: 021010
   Address: Lejondals Slott, Bro
   Title: Applying watersheds to cell image analysis
   Comment: Co-author Joakim Lindblad.

8. *Conference:* GIS-day
   Ewert Bengtsson, Tommy Lindell, Petra Philipsson
   Date: 021120
   Address: Ekonomikum, UU
   Comment: Several posters about GIS-related activites at CBA were presented.

7.6.6 Attendee

1. *Conference:* SUN European Research Conference (SUN ERC)
   Ewert Bengtsson
   Date: 020205–07
   Address: Milano, Italy
   Comment: Invited representative of UU in Round table discussion with 12 academic computer users.

2. *Conference:* Swedish Society for Automated Image Analysis Symposium (SSAB'02)
   Gunilla Borgefors, Joakim Lindblad
   Date: 020307–08
   Address: Centre for Mathematical Sciences, Lund University

3. *Conference:* 10th International Conference on Discrete Geometry for Computer Imagery (DGCI 2002)
   Stina Svensson
   Date: 020403–05
   Address: Bordeaux, France
   Comment: Presented the next DGCI in Napoli 2003 at DGCI steering committe meeting.

4. *Conference:* WURC (Wood Ultrasctructure Research Center) symposium on Mechanical pulps, microscopy techniques and cellulose
   Mattias Aronsson
   Date: 020417
   Address: SLU, Ultuna

5. *Conference:* Coimbra General Assembly
   Ewert Bengtsson
   Date: 020418–19
   Address: Catholic University, Leuven, Belgium
   Comment: Bengtsson was the official delegate of UU at the Rector's meeting and general assembly. Coimbra is a prestigious association of the best old universties in Europe. This year the main theme of the general assembly was the use of IT in university education.

6. *Conference:* Promote IT 2002
   Ewert Bengtsson
   Date: 020422–24
   Address: Billingehus, Skövde
   Comment: Bengtsson was part of the Program Committe and Session Chair. This annual conference is arranged by the KK-foundation for all PhD students that they fund.

7. *Conference:* IT's Biotech
   Ewert Bengtsson
   Date: 020424
   Address: City Conference Centre Stockholm
   Comment: Conference about business opportunities in the intersection between IT and Biotech.

8. *Conference:* Research day of the IT department
   Ewert Bengtsson, Ingela Nyström
   Date: 020603
   Address: MIC Aula, UU

9. *Conference:* Eurohaptics 2002
   Ewert Bengtsson
   Date: 020708–10
   Address: Pollock Centre, University of Edinburgh, U.K.

10. *Conference:* MIA'2002 - Mathematics and Image Analysis
    Xavier Tizon
    Date: 020910–13
    Address: Institut Henri Poincaré, Paris, France
    Comment: Written Report available.

11. *Conference:* VISIT Workshop on the Future developement of Image Analysis
    Mattias Aronsson, Fredrik Bergholm, Gunilla Borgefors, Roger Lundqvist, Xavier Tizon, Lena Wadelius
    Date: 021010–11
    Address: Lejondals Slott, Bro
    Comment: Borgefors participed in a panel discussion on "How to create better future co-operation between researchers and users of Swedish image analysis".

12. *Conference:* Learning and Memory - from Brains to Robots
    Ewert Bengtsson
    Date: 021025–26
    Address: Wallenberg Hall, Stanford University, CA, USA
    Comment: An invitational workshop with about 60 active participants funded by the Peter Wallenberg Foundation.

13. *Conference:* 14th William Pecora Remote Sensing Symposium
    Tommy Lindell
    Date: 021110–16
    Address: Denver, USA

14. *Conference:* SSF-day
    Ewert Bengtsson
    Date: 021121
    Address: Stockholm University
    Comment: The Foundation for Strategic Reserach (SSF) invited researchers for a full day presentation about their current and planned future reserach programs.

15. *Conference:* IP-only release party
    Ewert Bengtsson
    Date: 021121
    Address: Telemuseum, Stockholm
    Comment: The IT operator IP-only presented their new National broadband infrastructure to an invited audience.

16. *Conference:* RESE Final conference on Remote Sensing of Environment
    Tommy Lindell
    Date: 021127–29
    Address: Vårgård, Saltsjöbaden, Stockholm

17. *Conference:* The Annual SIGRAD Conference
    Ewert Bengtsson
    Date: 021128
    Address: Kåkenhus, Norrköping

18. *Conference:* RESE Final conference on Remote Sensing of Environment, Project 5
    Tommy Lindell
    Date: 021217–18
    Address: Högbo Värdshus, Högbo
    Comment: Project 5 title: Method for detection of changes in aquatic ecosystems and monitoring.

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

1. **Stina Svensson**
   Host: Gabriella Sanniti di Baja
   Address: Istituto di Cibernetica, CNR, Pozzuoli (Napoli), Italy
   Date: 020529–0807
   Topic: Continuing research co-operation in digital shape and its representations. A new project was started (Arcelli, Sanniti di Baja, Svensson: analyzing the convex deficiency for a 3D object).

2. **Stina Svensson**
   Host: Pieter Jonker
   Address: Pattern Recognition Group, Faculty of Applied Sciences, Delft Technical University, The Netherlands
   Date: 021007–1211
   Topic: Starting cooperation with Jonker on skeletonization algorithms for 4D images.

7.8 Short visits to other research groups and meetings outside CBA

Note: Meetings occasioned by permanent appointments are listed in section 7.11

1. **Ewert Bengtsson**
   Address: MIC, UU
   Date: 020116
   Topic: Scientific Computing Dept., UU (TDB)-meeting
   Comment: Bengtsson attended this meeting about the current developments at the Scientific Computing Dept.

2. **Ewert Bengtsson**
   Host: Karin Markides
   Address: Biomedical Centre, UU
   Date: 020121
   Topic: Discussion about how virtual research can be created and supported through web-technology and about how UU should support such work

3. **All CBA personell**
   Address: Museum Gustavianum, Uppsala
   Date: 020123
   Topic: Guided demonstrations both of the general Gustavianum collections and to the temporary mummy exhibition. One part of the mummy exhibition was a virtual mummy shown on the dissecting table in the old anatomical theatre. Stefan Seipel gave us the computer graphics details of it.
   Comment: This was the traditional "Lucia"-visit of 2001 (sic).

4. **Ewert Bengtsson**
   Address: Uppsala Learning Lab
   Date: 020124
   Topic: Local start up meeting of the National IT User Centre (NITA).
   Comment: NITA has been created under the virtual IT faculty at UU. In this meeting the local group that had been involved in preparing for the project met with the new director, Anders Hector, to discuss the plans for the new centre. Bengtsson was Chair of the meeting.

5. **Ewert Bengtsson, Gunilla Borgefors**
   Host: Scientific Computing Dept., UU (TDB)
   Address: Gysinge Conference Centre
   Date: 020204
   Topic: Visited the biannual TDB conference for part of the activities

6. **Ewert Bengtsson**
   Address: Restaurant Sven Dufva, Uppsala
   Date: 020212
   Topic: Connect Pub
   Comment: Attended this meeting which has the goal of promoting high tech companies based on university research.

7. **Ewert Bengtsson**
   Host: Uppsala IP Academy
   Address: UU
   Date: 020213
   Topic: Uppsala Internet Protocol Academy (UIPA) planning workshop
   Comment: The Board of UIPA arranged this workshop to discuss the future strategies and priorities of UIPA. Bengtsson chaired the meeting.

8. **Ewert Bengtsson**
   Address: Centre for Interactive Design (CID), KTH, Stockholm
   Date: 020213
   Topic: Introductory meeting with NITA, (National IT User Centre) board.
   Comment: NITA has been created under the virtual IT faculty at UU. At this first meeting Bengtsson informed the NITA Board about the creation process and the intentions behind NITA.

9. **Mattias Aronsson, Gunilla Borgefors**
   Hosts: Christine Antoin, Per Nygård, et al.
   Address: Norwegian Pulp and Paper Research Institute (PFI), Trondheim, Norway
   Date: 020213
   Topic: Possible co-operation on three dimensinal imaging and image analysis of paper. Demonstrations of the work at PFI.

10. **Ingela Nyström**
    Host: Charlotte Erichsen
    Address: Dept. of Clinical Radiology, SLU, Uppsala
    Date: 020215
    Topic: Discussions on processing of SCINT images of horses' back bones.

11. **Ewert Bengtsson**
    Host: Planning committee for a new Information and Communication Technology (ICT)-pedagogy unit
    Address: University administration, UU
    Date: 020220
    Topic: Hearing about the future of ICT-pedagogy at UU

12. **Ingela Nyström**
    Host: Jayaram K. Udupa
    Address: Medical Image Processing Group (MIPG), Dept. of Radiology, University of Pennsylvania, PA, USA
    Date: 020301–08
    Topic: Continued collaboration with people at MIPG

13. **Ewert Bengtsson**
    Hosts: Björn Erik Erlandsson, Bo Sandhagen
    Address: Dept. of Medical Technology, University Hospital, Uppsala
    Date: 020305
    Topic: Discussion about cooperation between UU and the Hospital in medical IT in general and image analysis in particular. The use of haptic displays was identified as one area of common interests.

14. **Ewert Bengtsson**
    Address: Ångström Laboratory, UU
    Date: 020306
    Topic: GRID computing
    Comment: Discussion about applications for funding of GRID computing infrastructure and developments at UU.

15. **Ewert Bengtsson**
    Hosts: Ten leading Universities in Singapore, HongKong, China and Japan
    Address: The Far East
    Date: 020311–20
    Topic: A delegation trip with four persons headed by UU Rector Bo Sundquist to a number of leading Universities discussing their work and strategies mainly in the IT and biotech areas. The trip involved several meetings per day during the very intense ten days.

16. **Gunilla Borgefors**
    Host: Jan Lindner
    Address: Scania, Södertälje
    Date: 020314
    Topic: Discussions on Roya Khomand's master thesis. She will work at Scania on classifying cast iron.

17. **Gunilla Borgefors**
    Host: SLU
    Address: Ultuna
    Date: 020319, 020409
    Topic: "SLU Forum" where Dept. heads are given the latest news from the SLU Rector.

18. **Ewert Bengtsson**
    Hosts: Kajsa Karlsson, Leif Lundqvist
    Address: MOR-unit, UU
    Date: 020326
    Topic: Discussion about questions of joint interest between the virtual IT-Faculty and the MOR unit (unit on marketing, recruitment and external relations for the Faculty of science and technology)

19. **Ewert Bengtsson**
    Address: The County council conference centre, Uppsala
    Date: 020327
    Topic: City network collaboration
    Comment: A discussion about collaboration about an open broadband infrastructure in Uppsala. Representatives of all local authoriteis and large organisations were present. Bengtsson was one of two representatives of UU.

20. **Ewert Bengtsson**
    Host: KTH Learning Lab, Stockholm
    Date: 020412
    Topic: The future strategy of the Learning Lab project, discussed among the National Executive Board, the Swedish Learning Lab (SweLL) staff and the Directors of the Learning labs at UU, KI and KTH.

21. **Fredrik Bergholm**
    Address: Swedish Foundation for Strategic Research, SSF, Stockholm
    Date: 020422, 020528
    Topic: Participation in seminar and discussion on the entertainment industry (including tourism).
    Comment: SSF initiated, in the spring 2002, a working group for future scenarios 2002–2012, for the purpose of obtaining a picture of important future trends, as a support for decisions on research funding. A scenario for the "entertainment industry" based in this and earlier SSF-seminars (four) in the spring 2002, has been sent by Bergholm to Lars-Erik Eriksson.

22. **Ewert Bengtsson**
    Host: Tore Larsson
    Address: Uppsala City school authority
    Date: 020515
    Topic: Negotiations about the financing of the Uppsala Internet Protocol Academy project during the year 2003

23. **Mattias Aronsson, Gunilla Borgefors**
    Hosts: Arash Fayyazi, Björn Kruse
    Address: Dept. of Science and Technology, Linköping University, Campus Norrköping
    Date: 020516
    Topic: Attended Fayyazi's Licentiate seminar. Title: "Texture Based Duplex-Board Layer Segmentation"

24. **Ewert Bengtsson**
    Date: 020516
    Address: KTH new Library, Stockholm
    Topic: Inaugeration of the new library
    Comment: Bengtsson was an invited guest for the inaugeration of the new Learning Lab at KTH. It is co-llocated with the new library which was inaugerated at the same time.

25. **Ewert Bengtsson**
    Date: 020522
    Host: Sensys
    Address: Uppsala Science Park
    Topic: Start up meeting for the Master thesis project on pantograph inspection
    Comment: Participants from Banverket, Sensys and CBA.

26. **Tommy Lindell**
    Host: Sören Karlsson
    Address: Geosciences, UU
    Date: 020522
    Topic: Construction of a camera holder for digital air photo/video camera.

27. **Ewert Bengtsson, Gunilla Borgefors, Ida-Maria Sintorn, Stina Svensson**
    Host: Sidec Technologies AB
    Address: Sidec, Stockholm
    Date: 020523
    Topic: Discussion about possible cooperation: shape analysis of 3D objects

28. **Ewert Bengtsson**
    Date: 020524
    Address: UU
    Topic: A regional Cisco Academy in Uppsala?
    Comment: Bengtsson was Chair of this discussion between representatives of UU, local high schools and people from Cisco about the possibilities and requirements for establishing a regional Cisco Academy in Uppsala.

29. **Ewert Bengtsson**
    Host: Lena-Kajsa Siden
    Address: Swedish Foundation for Strategic Research, SSF, Stockholm
    Date: 020527
    Topic: Meeting with the work group on Medical informatics to discuss which projects should be given continued financing for the second half of the term.

30. **Petra Ammenberg**
    Host: Nadia Bood
    Address: Costal Zone Management, Authority and Institute, Belize City, Belize
    Date: 020527–0601
    Topic: Fieldwork on Bakers Rendezvous, located outside Placencia, Beliz

31. **Ewert Bengtsson**
    Date: 020528
    Address: University College of Gävle
    Topic: Seminar on visualisation of indoor climate
    Comment: Discussions between graphics and visualisation experts and indoor climate researchers about how temperature distributions, airflow and other factors of indor climate can be effectivly visualised.

32. **Stina Svensson**
    Host: Annick Montanvert
    Address: Laboratoire des Images et des Signaux, saint Martin d'Heres (Grenoble), France
    Date: 020627–0702
    Topic: Work on a proposal for a new IAPR (International Association for Pattern Recognition) technical committee: Discrete Geometry. The proposal was submitted during the period and was approved as TC 18 during the governing board meeting at ICPR in Québec City, Canada, 14 August 2002.
    resented the Swedish Society for Image Analysis.

33. **Ingela Nyström**
    Host: Gabriella Sanniti di Baja
    Address: Istituto di Cibernetica, CNR, Pozzuoli (Napoli), Italy
    Date: 020913–21
    Topic: Discrete 3D approach to 2D grey-level convex hull computations
    Comment: Initiated a new project with Sanniti di Baja and Borgefors.

34. **Gunilla Borgefors**
    Host: Gabriella Sanniti di Baja
    Address: Istituto di Cibernetica CNR, Pozzuoli (Napoli), Italy
    Date: 020915–25
    Topic: Joint research on grey-level convexity and work within IAPR Consitution and Bylaws committee.

35. **Ewert Bengtsson**
Host: Sensys AB
Address: Sensys AB, Uppsala Science Park
Date: 020919
Topic: Progress report for Master thesis project with Swedish Rail
Comment: Master thesis student Robin Strand presented his results so far.

36. **Ewert Bengtsson**
Address: MIC, UU
Date: 020920
Topic: Professor collegium IT Dept.
Comment: Discussion about graduate education organisation and strategy in the IT field

37. **Ewert Bengtsson, Pascha Razifar**
Hosts: Anders Grundström, Bengt Långström
Address: PET-centre, UU
Date: 020930
Topic: Discussion of progress in joint project carried out by PhD student Razifar
Comment: Agreement about continued joint financing

38. **Joakim Lindblad, Carolina Wählby**
Hosts: Nick Arini, Gareth Bray, Simon Port
Address: Amersham Biosciences, The Maynard Centre, Cardiff, U.K.
Date: 020930–1001
Topic: Presentation of methods and results of cell segmentation and classification and discussions on future cooperations.

39. **Ewert Bengtsson**
Address: Karolinska Learning Lab, Solna
Date: 021001
Topic: Board meeting and Directors group meeting for Swedish Learning Lab

40. **Ewert Bengtsson**
Address: Carolina, UU Library
Date: 021002
Topic: Reference group meeting for the Digital Publishing Project at UU

41. **Ewert Bengtsson**
Hosts: Lars-Elve Larsson, Gerolf Nauverck
Address: UU Unit for IT and telephones
Date: 021003
Topic: Discussion about strategies for developing web-portals for UU teachers

42. **Ewert Bengtsson**
Hosts: Rune Larsso, Ola Undeman, Hans Åhlen
Address: Optonova AB, Solna
Date: 021009
Topic: Visit to discuss progress in the Master thesis by Arvid Emtegren and presentation of high tech optics and image analysis company OptoNova.

43. **Tommy Lindell**
Hosts: Dale Carlson, Scott Rurtherford
Address: University of Washington, Seattle, WA, USA
Date: 021023–27
Topic: Discussions on Valle Scolarship and Scandinavian Exchange Program

44. **Ewert Bengtsson**
Host: Stanford Learning Lab
Address: Wallenberg Hall, Stanford University, California
Date: 021024
Topic: Official Inauguration of Wallenberg Hall at Stanford Learning Lab

45. **Ingela Nyström**
Hosts: Anders Ahnesjö, Björn Ivarsson
Address: MDS Nordion, Uppsala
Date: 021025
Topic: Presentation of the non-robust problem of measuring length of a line intersecting a volume.

46. **Tommy Lindell**
Host: Eugene B. Welch
Address: University of Washington, Seattle WA USA
Date: 021028–1108
Topic: Updating of out-of-print textbook for engeneering & university students "Ecological Effects of Waste Water" (for 3rd edition)

47. **Ewert Bengtsson**
Address: Uppsala Learning Lab
Date: 021104
Topic: Presentation of proposed research basis for EU application on IT supported learning. Ambjörn Naeve, Centre for Interactive Design (CID), KTH was the main presenter,

48. **Ewert Bengtsson**
Address: Ångström Laboratory, UU
Date: 021104
Topic: Learning Platforms
Comment: Mats Brenner, Gävle was the main presenter.

49. **Ewert Bengtsson**
Address: Gamla torget, Uppsala
Date: 021107
Topic: Think tank on IT in Uppsala. Six representatives of IT high tech companies and Bengtsson were asked to discuss how the Uppsala IT business profile can be described.

50. **Tommy Lindell**
Host: Christina Rappe
Address: The Swedish national environment protection board, Stockholm
Date: 021119
Topic: Discussion on a new project on coastal classification of Swedish coasts

51. **Ewert Bengtsson**
Hosts: Björn-Erik Erlandsson, Bo Sandhagen
Address: Medical Technology Dept. (MTA), UU Hospital
Date: 021122
Topic: Discussion about cooperation between CBA and MTA on haptic reserach for medical applications and in a broader context between the hospital and UU in medical informatics.

52. **Mats Eriksson**
Host: Kenneth Olofsson
Address: Dept. of Forest Resource Management and Geomatics, SLU, Umeå
Date: 021128–29
Topic: Cooperating project on forest inventory

53. **Ewert Bengtsson, Ingela Nyström, Erik Vidholm**
Hosts: Gösta Körlof, Johan Söderberg
Address: ReachIn Technologies AB, Stockholm
Date: 021206
Topic: Discussions on equipment for the project on haptics in medical image analysis.

54. **Ewert Bengtsson**
Address: The county council conference centre
Date: 021209
Topic: IT-cluster group meeting. Discussions about how to make the Uppsala IT competence widely known.

55. **Ewert Bengtsson**
Address: Uppsala Learning Lab
Date: 021213
Topic: The research results and current status in the Swedish Learning Lab (SweLL) projects presented to Lars Borin.

56. **Ewert Bengtsson**
Address: IT support seminar room, UU
Date: 021216
Topic: The Sweden Open Project
Comment: Björn Pehrsson presented the Swedish Open proposal and we discussed possible similar Uppsala activities in relation to our Uppsala Internet Protocol Academy (UIPA) network.

7.9 Visiting scientists (staying at least 2 weeks)

1. **Anthony Gidudu**
Host: Gunilla Borgefors
Address: Dept. of Surveying, Makerere University, Kampala, Uganda
Date: 021002–1220
Topic: Participation in PhD course in Application Oriented Image Analysis and learning in general.

7.10 Other visitors

1. **Gareth Bray, Simon Port, Dietrich Ruehlmann**
Host: Ewert Bengtsson
Address: Amersham Biosciences, Cardiff
Date: 020110–11
Topic: Discussion on collaboration project, funded by Amersham, on cell image analysis with Lindblad as main project worker

2. **Erik Vidholm**
Host: Ingela Nyström
Address: Under-graduate student, UU
Date: 020117
Topic: Planning a Master thesis project on design of Fourier filters in 2D and 3D

3. **Göran Hammer**
Host: Tommy Lindell
Address: Human geography, UU
Date: 020118
Topic: Satellite data for a geographical database

4. **Gabriella Sanniti di Baja**
Hosts: Gunilla Borgefors, Ingela Nyström, Stina Svensson
Address: Istituto di Cibernetica C.N.R., Pozzuoli (Napoli), Italy
Date: 020121–020128
Topic: Sanniti di Baja became Honorary Doctor (Doctor honoris causa) at the Faculty of Science and Technology, UU, on 25 Jan. 2002. Borgefors was her official host. In addition to the formal ceremony there were several receptions and a ball at Uppsala Castle. There was also work on various collaboration projects.

5. **John Norrman**
Host: Tommy Lindell
Adress: Uppsala
Date: 020125
Topic: Discussion on physical planning matters

6. **Inger Deutsl**
   Host: Gunilla Borgefors
   Address: UU administration
   Date: 020130
   Topic: Possibility of applying for money from Goal 3 - an EU initiativ to increase the competence of businesses.

7. **Håkan Hall, Ingrid Agartz, Stefan Arnborg**
   Hosts: Ewert Bengtsson, Roger Hult
   Address: Karolinska Hospital (KS)
   Date: 020130
   Topic: Discussion on cooperation between CBA and KS based on Roger Hults research work.

8. **Karen Write**
   Host: Tommy Lindell
   Address: University of Southhampton, England
   Date: 020205
   Topic: Advice to graduate student on shoreline changes on Jamaica

9. **Jocelyn Chanussot**
   Hosts: Ingela Nyström, Stina Svensson
   Address: Signal and Image Laboratory (LIS), National Polytechnical Institute of Grenoble (INPG), France
   Date: 020214
   Topic: Mutual presentations of current projects. Dr Chanussot will possibly visit for a 3 month period during Spring 2003.

10. **Lars Johansson**
    Hosts: Gunilla Borgefors, Xavier Tizon
    Address: Radiology, UU hospital
    Date: 020221
    Topic: Tizon's participation in a project to measure the total plaque load in full body MR angiography scans. Tizon will work 20% on developing measures.

11. **Bengt Hansson, Nina Kain**
    Host: Ewert Bengtsson
    Date: 020222
    Topic: Discussion about possible external commercial course projects in IT in general and image analysis in particular

12. **Sara Larsdotter, Yvonne Ridderstråle**
    Host: Joakim Lindblad
    Date: 020229
    Topic: Discussions on methods for analysis and measurements of sweat glands on horses

13. **Stefan Seipel**
    Host: Ewert Bengtsson
    Date: 020305
    Topic: Discussion about possible collaboration between Seipel and CBA in computer graphics, visualisation, man-machine interaction and medical image analysis.

14. **Yukiko Kenmochi**
    Hosts: Ingela Nyström, Stina Svensson
    Address: ESIEE, Noisy-Le-Grand, France
    Date: 020312–17
    Topic: Presentation of mutual projects. Kenmochi held two seminars.

15. **Mariette Manktelow**
Hosts: Gunilla Borgefors, Joakim Lindblad, Ida-Maria Sintorn, Xavier Tizon
Address: Dept. of Evolutionary Biology, UU
Date: 020320
Topic: Discussions on describing the inner three-dimensional structure of flowers in such a way that evolutionar shape changes can be described in and understood as a function of genetic change.

16. **Roya Khomand**
Host: Gunilla Borgefors
Address: Scania, Södertälje
Date: 020321, 020508
Topic: Discussions about Khomand's Master thesis on classifying cast iron using a commercial image analysis system.

17. **Don Pierson, Anu Reinhart and Antii Lindfors**
Hosts: Petra Ammenberg, Tommy Lindell
Address: Dept. of Evolutionary biology, Limnology, UU
Date: 020327
Topic: General discussion about present work and future cooperations.

18. **Catherine Östlund**
Hosts: Mattias Aronsson, Gunilla Borgefors
Address: STFI, Swedish Pulp and Paper Research Institute, Stockholm
Date: 020409
Topic: Scanning Electron Microscopy (SEM) segmentation and fibre measurements.

19. **Catherine Östlund**
Host: Ingela Nyström
Address: STFI, Swedish Pulp and Paper Research Institute, Stockholm
Date: 020409
Topic: Analyzing the Structure of Paper Sheet through Confocal Microscope Images
Comment: First discussions on a new project. Possible tools: fuzzy segmentation, convex hull, surface area and enclosed volume of cavities and concavities.

20. **Johanna Lundén, Catherine Östlund**
Hosts: Mattias Aronsson, Gunilla Borgefors
Address: STFI, Swedish Pulp and Paper Research Institute, Stockholm
Date: 020409
Topic: Lundén is going to do a Master thesis on segmentation of microscopic images of paper cuts. During the visit the experience of CBA was exuded.

21. **Stefan Pålsson, Anders Sjöberg**
Hosts: Ewert Bengtsson, Gunilla Borgefors
Address: TDB, Dept. of Information Technology, UU
Date: 020508
Topic: The CBA participation in undergraduate education at UU during Fall 2002 and Spring 2003 semesters.

22. **Students from the course "Modern Sensor Systems"**
Host: Ewert Bengtsson
Date: 020515
Topic: Bengtsson hosted the AIM PhD students visiting us. Aronsson, Lindblad, adn Tizon each held a 15 minute presentation of their image analysis projects. Thus, the visitors got a sample of what is being studied at CBA.

23. **Jonathan Walthoe**
Host: Ingela Nyström
Address: Cambridge University Press, Cambridge, United Kingdom
Date: 020516
Topic: Discussion on available and missing books wihtin the fields of mathematical sciences and IT.

24. **Martin Kempe, Curt L. Orbert, et al.**
Hosts: Bo Nordin, Ingela Nyström, Stina Svensson
Address: Tritech, Sundbyberg
Date: 020528
Topic: Presentation of possible shape quantification in voxel data

25. **Gareth Bray, Stuart Swinburne**
Hosts: Ewert Bengtsson, Joakim Lindblad
Address: Amersham Biosciences, Cardiff, U.K.
Date: 020530–31
Topic: Discussion and agreement on collaboration project, funded by Amersham, on cell image analysis with Lindblad as main project worker

26. **Sören Mikkelsen**
Host: Ewert Bengtsson
Address: Cyber Com Consulting Group
Date: 020607
Topic: Discussing possible collaboration between UU and the Cyber Com consulting group in networking between IT consultants and experts

27. **Klaus-Dieter Peschke**
Host: Ingela Nyström
Address: School of Information Science, Computer and Electrical Engineering, Halmstad University
Date: 020613
Topic: Presentation of some projects within biomedical applications in Uppsala
Comment: Bengtsson, Borgefors, Stefan Seipel, Tizon, and Wehrmann participated.

28. **Gareth Bray**
Host: Joakim Lindblad
Address: Amersham Biosciences, Cardiff, U.K.
Date: 020819
Topic: Discussion on collaboration project, funded by Amersham, on cell image analysis with Lindblad as main project worker

29. **Kenneth Olofsson**
Host: Mats Erikson
Address: Dept. of Forest Resource Management and Geomatics, SLU, Umeå
Date: 021003
Topic: Discussion about extension of project

30. **Christoffer Nilsson**
Host: Ewert Bengtsson
Date: 021014
Topic: The IT cluster in Uppsala. Bengtsson presented an overview of IT research at UU as a basis for creating a broschure about IT in Uppsala in a joint effort between local authorities

31. **Lars-Erik Persson**
Host: Gunilla Borgefors
Address: Dept. of Mathematics, Luleå University of Technology
Date: 021018
Topic: Discussion about possible future co-operation

32. **Catherine Östlund**
Host: Ingela Nyström
Address: STFI, Swedish Pulp and Paper Research Institute, Stockholm
Date: 021029
Topic: Grey-level convex hull computation utilized in paper pore analysis

33. **Björn Ivarsson**
Host: Ingela Nyström
Address: MDS Nordion, Uppsala
Date: 021030
Topic: Continued discussion of the non-robust problem of measuring length of a line intersecting a digital volume.

34. **Gunnar Jansson, Stefan Seipel, Lennart Thurfjell, Erik Vidholm**
Hosts: Ewert Bengtsson, Ingela Nyström
Date: 021103
Topic: First meeting of the steering group for the Medical Haptic Image Analysis project

35. **Alexander Medvedev**
Host: Gunilla Borgefors
Address: Signals and Systems Group, Dept. of Information Technology, UU
Date: 021105
Topic: Possible future co-operation

36. **Elin Johansson, Lars-Erik Persson**
Hosts: Gunilla Borgefors, Ida-Maria Sintorn, Carolina Wählby
Address: Luleå University of Technology
Date: 021108
Topic: Presentation of projects by Lindblad, Sintorn, Tizon, and Wählby. Discussions on future cooperation

37. **Gunnar Jansson, Stefan Seipel, Lennart Thurfjell**
Hosts: Ewert Bengtsson, Ingela Nyström, Erik Vidholm
Date: 021203
Topic: Kick-off for the new project on haptics in medical image analysis

38. **Peter Houtila**
Host: Ewert Bengtsson
Address: Arete Libro AB
Date: 021206
Topic: Discussion about IT at Uppsala University and possible coopration with Arete Libro Consulting

39. **Jayaram K. Udupa**
Hosts: Gunilla Borgefors, Ingela Nyström
Address: Medical Image Processing Group, Dept. of Radiology, University of Pennsylvania, Philadelphia, USA
Date: 021210–15
Topic: "Opponent" for Aronsson and continued research co-operation with Nyström.

40. **Tomas Wester**
Host: Ewert Bengtsson
Address: Cross Connect network group
Date: 021211
Topic: Discussion about IT at UU, our planned EU applications, and other projects. Former CBA PhD student Wester is now working as consultant in creating research and development networks

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

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. (4 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 "Rector's advisory council". (6 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. (5 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. (17 meetings.)
- Member of the national directors group of the Swedich Learning Lab project, SweLL, 2001–
  Comment: (7 meetings.)
- Chair of the WWW management board of UU, 200001–
  Comment: (5 meetings.)
- 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. (2 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. (7 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. (2 meetings.)
- 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. (6 meetings.)
- 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. (2 meetings.)

- Member of the Uppsala Chamber of Commerce IT board, representing UU. 200006–
  Comment: Working with various activities to promote cooperation researchers - companies. (6 meetings.)
- Project leader 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. (5 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. (2 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. (18 meetings.)
- Chair of the National Reference group of the VISIT research program, 199702–200212
  Comment: Responsible for coordination between the various research groups and the board of the VISIT research program financed by the Foundation for Strategic Research.(2 meetings.)
- The IT-cluster group, 200108–
  Comment: A group under the chairmanship of Uppsala municipality with the task of promoting the IT business activity in Uppsala by making the present competence and activity known to the local, national and international community. All kinds of organisations were represented on the committee. Bengtsson represented UU. (5 meetings.)
- IT Pub
  Comment: Bengtsson is responsible for promoting participation of UU researchers in the monthly "IT-Pub" activity where leading actors in the IT business and research community meet in an informal setting to discuss common interests, hopefully promoting increased cooperation. (4 meetings.)
- Expert on recruitment committee for professor in Visual Media technology for Halmstad University College, 20021127
  Comment: The date was for the first telephone conference of this committee. The expert evaluation task was ongoing 200211–200301.
- Dissertation committee (chair) for the degree of PhD of Gael Neuez, Image Processing Group, Chalmers, 20020604
  Comment: Title: Range camera imaging: From human body measurements to very large 3D point scenes visualization.
- Dissertation committee for the degree of PhD of Johan Steensland, Dept. of Systems and control, UU, 20021213
  Comment: Title: "Efficient partitioning of dynamic structured grid hierarchies" in scientific computing.

Fredrik Bergholm
National:

- Executive Programme Director of the National VISIT research program, 001211–
  Comment: (2 meetings.)
- Dissertation Committee for the degree of PhD of Mårten Björkman, NADA, KTH, 020614
  Comment: Title: Real-time motion and stereo cues for active visual observers.

Gunilla Borgefors
International:

- Fellow of the "International Association for Pattern Recognition" (IAPR)
  Comment: Secretary 1990–1994, 1st Vice President 1994–1996
- Chair of the 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.
- IAPR Governing Board, proxy for Hans-Christian Palm, Governing Board member for the Norwegian Society for Image Processing and Pattern Recognition
  Comment: Meeting in Québec City, Canada, 20020813
- Senior member of the "Institute of Electrical and Electronics Engineers", Inc. (IEEE), 1998–
- 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–
- Programme committee, 16th Int. Conference on Pattern Recognition (ICPR 2002), Track 2: Pattern Recognition, Neural Networks, and Document Analysis, Quebec, Canada, Aug. 2002, 200201-200208
- "Opponent" and Committee member for "Hovedoppgave" (Main task) of Lars Helge Stien, Dept. of Informatics, University of Bergen, Norway, 20020215
  Comment: Title: Automatic image analysis of salmon fillets (in Norwegian)

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–
  Comment: (5 meetings.)
- Permanent member, Docent Committee, Faculty of Forestry, SLU, 200207–
  Comment:(3 full day meetings.)
- Member of the Board of UpGIS, the net for Geographical Information Systems at UU, 199904–
  Comment: Representing Faculty of Science and Technology at UU. (3 meetings.)
- Member of National Reference group of the VISIT research program, 199702–
- "Opponent" for the degree of PhD of Anders Kaestner, School for Information Science, Computer and Electrical Engineering, Halmstad University and Dept. of Signals and Systems, Chalmers University of Technology, 20021008
  Comment: Title: Non-invasive Multidimensional Imaging Applied on Biological Substances
- Dissertation committee for the degree of PhD of Björn Ivarsson, Dept. of Mathematics, UU, 20020208
  Comment: Title: Regularity and boundary behavior of solutions to complex Monge-Ampère equations.
- Dissertation committee for the degree of PhD of Alf Kjartan Halvorsen, Systems and Control Group, Dept. of Information Technology, UU, 20021004
  Comment: Title: Model-based Methods in Motion Capture
- Expert evaluator for the position of Assistant Professor in Image Processing, especially Image Analysis, Umeå University, 200212

Tommy Lindell
International:

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

Ingela Nyström
International:

- Governing Board Member, International Association for Pattern Recognition, 200203–
  Comment: Meeting in Québec City, Canada, 20020813

National:

- President of Swedish Society for Automated Image Analysis (SSAB), 200203–
  Comment: Board member 200003–, (3 physical meetings, 3 telephone meetings.)
- Member of the Electorial Board ("elektorsförsamlingen") of the Faculty of Science and Technology, UU, (4 meetings.)
- Member of the recruiting board for Computer science, UU, (2 meetings.)
- Licentiate "opponent" for Lalith Premaratne, School of Information Science, Computer and Electrical Engineering, Halmstad University, 20020513
  Comment: Title: A Printed Sinhala Script Recognition System

Stina Svensson
International:

- Co-chair, IAPR TC 18 - Discrete Geometry, 200208–
  Comment: Founded this Technical Committee with Annick Montanvert.
- IAPR Governing Board, proxy for Kalle Åström, Governing Board member for the Swedish Society for Automated Image Analysis (SSAB)
  Comment: Meeting in Quebec City, Canada, 20020813

National:

- Board member, Swedish Society for Automated Image Analysis (SSAB), 200203–
  Comment: Secretary and Treasurer, (1 physical meeting, 3 telephone meetings.)