Annual Report 2009

Centre for Image Analysis

Centrum för bildanalys

Cover: Illustrations from two of the PhD theses presented at CBA during 2009. Further information in Section 4.2.

Top
Amalka Pinidiyaarachchi — Mouse embryonic fibroblast cell nuclei segmentation in 3D

Bottom
Maria Axelsson — Volume rendering of the estimated three-dimensional fibre orientation in a wood fibre composite (plastic reinforced with wood fibres). The plastic material is made transparent and the fibres are coloured according to the estimated orientation in each voxel neihbourhood.

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1 Introduction

1.1 General background

The Centre for Image Analysis (CBA) carries out research and graduate education in computerized image analysis and scientific visualization. Some of our research is purely theoretical, some of it has the goal of developing better methods, algorithms and systems for applications, primarily within biomedicine, forestry and the environmental sciences.

CBA is a collaboration between Uppsala University (UU) and the Swedish University of Agricultural Sciences (SLU). This year we celebrated our 20th anniversary with two events: a presentation of our work with coffee and cake for our neighbours at Polacksbacken and a reception for invited VIPs that had special importance for CBA over the years.

During 2009, a total of 35 persons have been working at CBA: 18 researchers, 16 PhD students and one administrator. Additionally, seven Master thesis students have finished their thesis work with supervision from CBA. This does, however, not mean that we have had 42 full-time persons at CBA; many have split appointments, part time at CBA and part time elsewhere, most commonly at the Dept. of Information Technology. Two senior researchers, Stina Svensson and Carolina Wählby, have almost left us, taking on positions at other organisations, but retaining a small position at CBA to fulfil supervising their PhD students until graduation. If we sum up the time working for CBA for all of us, then we had the about 23 full-time full-year equivalents excluding undergraduate teaching and not counting Master thesis students. The employees are formally employed at either university. The whole of CBA is administered through UU. Most of us at CBA also pursue some undergraduate teaching, which is organized by the Dept. of Information Technology at UU.

On average we have 3-4 PhD dissertations per year with significant variations over time. In 2009 we had two dissertations: Amalka Pinidiyaarachchi at UU and Maria Axelsson at SLU. We were also happy to have one of our researcher, Carolina Wählby, qualify as a docent, bringing the total number of CBA docents up to seven. Robin Strand received the Benzelius award from the Royal Society of Sciences in Uppsala and Erik Wernersson received the best paper award at the international conference ISPA'09.

Image processing is highly interdisciplinary, its foundations being in mathematics, statistics, physics, signal processing and computer science, and with applications found in many diverse fields. We are working in a wide range of application areas, most of them related to life sciences and usually in close collaboration with experts from the particular application area. Our co-operation partners are found locally as well as nationally and internationally. For a complete list of our XX national and YY international co-operation partners, see Section 5.7. One of our co-operation partners is almost in-house since UPPMAX, Uppsala Multidisciplinary Center for Advanced Computational Science, is managed by Ingela Nyström and administrated by Lena Wadelius.

From a methodological point of view, our focus is on discrete geometry and multi-dimensional images, both spatially and spectrally. We have over the last several years expanded our activities in perceptualization, i.e. visualisation and haptics. Our studio 3DIS4U, 3D Image Studio for Uppsala, is used for our seminars and for some classes and external events. During 2009 we started a new major project in this area, under leadership of our visiting professor Ingrid Carlbom, with the goal of creating an augmented reality system in which you can see, feel, and manipulate virtual 3D objects as if they were real.

We also used our visualisation skills in creating the "CBA TV", a continuously running presentation of our work in the form of very short "trailers" on a LCD monitor facing the main entrance stairway. We often see students and colleagues from other departments stop a few moments to look at our latest project trailer.

We are very active in international and national societies. Ingela Nyström served as second vice-president of the International Association of Pattern Recognition (IAPR) and Gunilla Borgefors serves on its advisory committee. She is also Area Editor for Pattern Recognition Letters. Ingrid Carlbom is

co-chair of the editorial board of Graphical Models. Researchers at CBA also served on several other Journal editorial boards, boards of scientific organisations and conference committees. Ingela Nyström served on half a dozen dissertation committees, the rest of us managed about that many together. And we took a very active part in reviewing grant applications and scientific papers submitted to conferences and journals. Ewert Bengtsson served as chair of the Evaluation Panel for Medical Engineering for the Swedish Research Council. Locally he serves as senior advisor to the Rector of UU on information technology and also as Chair of the university IT-council, together with many other related appointments.

Since 1993/94, CBA assembles extensive annual reports, such as this document, that describes in some detail what we have achieved during the year. These annual reports are intended for anyone interested in our work. Note that each Section in this report starts with a short summary printed in a larger font than the following detailed material. This year the report has a very special feature, an original poem by Douglas Hofstadter. We had the pleasure of hosting him during his visit to Uppsala to give the prestigeous Celsius lecture, the topic of the poem.

Our annual reports have been available on the Internet since 1998. For this issue, see
http://www.cb.uu.se/verksamhet/annual_report/AR09html/

1.2 Summary of research

The objective of the CBA is to *"carry out research and graduate education in computerized image analysis and scientific visualization, both within image processing as such and with the goal of developing better methods, algorithms and systems for applications primarily within biomedicine, forestry and the environmental sciences."*

We are pursuing this objective by running a large number of research projects, ranging from fundamental mathematical methods development to application-tailored developments and testing, the latter mainly in biomedicine and forestry. We are also developing new methods for perceptualization, combining computer graphics, haptics and image processing in new ways.

Our research is organised in a large number, 53, projects of varying size, ranging from a single person part time a few months, to projects involving several persons over several years. There is a lot of interaction between different researchers, typically a person is involved in several different projects in different constellations with internal and external partners. In this context the university affiliation of the particular researchers seldom has any importance.

On the theoretical side, we are founding most of our work on discrete mathematics with fundamental work on skeletons, distances and tesselations in three and more dimensions. Another fruitful theoretical foundation is fuzzy methods.

A fairly large set of projects deal with light microscopy images, developing tools for modern quantitative biology and clinical cancer detection and grading. This has, in addition to many publications, also led to a patent application on improved spectral signal detection in fluorescent microscopy and to a publicly available software tool, BlobFinder, for detecting fluorescent signals in microscopic images.

Going beyond the resolution achievable with light microscopy we work with electron microscopy images. One application is to find viruses in EM images, here the vast search area and the small size of the target structures create great challenges. We are also developing methods for studying the 3D shape of large molecules based on electron tomography. Another imaging modality, providing 3D images of small structure, is X-ray micro-tomography. We are developing methods to use such images to study the internal structure of paper and composites, of trabecular bone as well as bone-implant integration.

On a more macroscopic scale we are working with interactive segmentation of 3D CT and MR images. For this we have developed a toolbox, WISH, which is publicly available. Part of that work also involves haptic interaction, and we have started a large interdisciplinary project aiming to create "the ultimate haptic system," a glove through which a person can feel and manipulate virtual objects. Our projects most clearly related to forestry deal with estimates of timber quality from cameras mounted under harsh

conditions in saw mills.

A new approach that we are using in several different application areas is to generate synthetic images that are sufficiently similar to real images to be used for testing algorithms. In that way it is easy to generate many images with known ground truth, solving a big common problem in many applications. Of course, the final programs still need to be tested on real images, but the synthetic images can be of great value in the development process.

Please, see Section 5 for details on our interesting research projects.

Another activity bridging over between research and education is supervision of master thesis projects. This year we had seven such projects completed. Three of those were in collaboration with GE Healthcare, Uppsala, dealing with improved techniques for PET image analysis. The other four spanned a wide range of topics. In Section 3.3, we present these theses.

1.3 How to contact CBA

CBA maintains a home page on the World Wide Web (WWW) both in English and in Swedish. The main structure contains links to a brief presentation, staff, vacant positions (if any), etc. It contains information on courses, seminars (*Note* that our Monday 15:15 seminar series is open to anyone interested), a layman introduction to image analysis, this annual report (as .html and .pdf versions), lists of all publications since CBA was created in 1988, and other material.

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

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

Centre for Image Analysis (Centrum för bildanalys, CBA) can be contacted in the following ways:

Visiting address:	Lägerhyddsvägen 2 Polacksbacken, building 2, south entrance, floor 1 Uppsala
Postal address:	Box 337 SE-751 05 Uppsala Sweden
Telephone:	+46 18 471 3460
Fax:	+46 18 553447
E-mail:	cb@cb.uu.se

2 Organization

CBA is a joint entity belonging equally to Uppsala University (UU) and Swedish University of Agricultural Sciences (SLU), but administered through UU. Over the years the number of people working at CBA has varied considerably. We have now come back to the levels from 10 years ago with figures in the mid thirties. About 60% are employed by UU, the other 40% by SLU. The activity at CBA is similar to any department within a single university, but the administration becomes more complicated due to our close relation to two different universities. Our total turnover for 2009 was 18 million SEK which is up 0.7 million compared to 2008. Roughly speaking UU, SLU and external grants each provide one third of our income. For 2009 the proportions were more exactly: 38% from UU, 27% from SLU, and 35% from external sources.

2.1 Constitution

The CBA was founded in 1988 and is an independent entity within the Faculty of Science and Technology (TN-faculty) at UU and within the Faculty of Forest Sciences (S-faculty) at SLU, respectively. CBA is supposed to be managed by a board and a director. The latter having the executive power. During 2005, there was an administrative review of all centers at UU and as a result of this some minor changes of the CBA constitution were negotiated between the universities during 2006-2007. The mandate for the previous board ended at the end of 2006. What now remains is for the new constitution to be formally adopted and put into operation by the TN-faculty board. In the end of 2009 there was finally a decision that the new constitution will be adopted so currently the different bodies are nominating members of the board. In the meantime the management of CBA rests solely with the director Ewert Bengtsson with Dr Olle Eriksson as Deputy Director. As advisors to the director, we have an informal management group consisting of the academic personnel with permanent positions plus our administrator.

The whole of CBA is administered through UU. The employees at either university are employed directly at CBA, with one exception, lecturers are employed at the IT department of UU even though their research is carried out at CBA. This has to do with the fact that we are not formally responsible for organizing undergraduate education even though we in practice organize and teach many courses, especially those in image analysis and computer graphics. Our PhD students are admitted at either the Faculty of Science and Technology (TN) at UU or at the Faculty of Forest Sciences (S) at SLU.

2.2 Finances

CBA is financed through the two universities and through research grants and contracts. A small part of the personnel expenses are covered by undergraduate education at UU, mostly by the PhD students of both universities, most of which teach 10-20% of their time. (The UU Lecturers' teaching appointments are not included in our finances.)

The summary in Table 1 describes our overall economy for 2009. 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 total expense turnover is thus 18 million SEK for 2009, up 0.7 million from 17.3 million SEK for 2008. The total income was was 17.4 million SEK so we had a small deficit this year. This was as expected since we had a surplus and we have been expanding our overall activities. Our administrative overhead turned out to cost somewhat less than budgeted so there we had a small surplus which can be balanced into next year's budget.

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. Project grants which have been received but not used are directly balanced to next year and are thus not included in the income-cost tables.

Table 1: CBA income and costs for 2009 in kSEK.

Income		**Costs**	
UU	5249	Personnel	11072
SLU	4727	Equipment	366
UU rent compensation	1310	Operating exp. 4)	2894
Governmental grants 1)	3751	Rent	1437
Non-governmental grants 2)	1400	University overhead	2326
Contracts 3)	955		
Financial netto	37		
Total income	**17429**	**Total cost**	**18095**

1) The Swedish Research Council, SIDA

2) Research foundations, EU

3) Internal invoices and compensations

4) Including travel and conferences

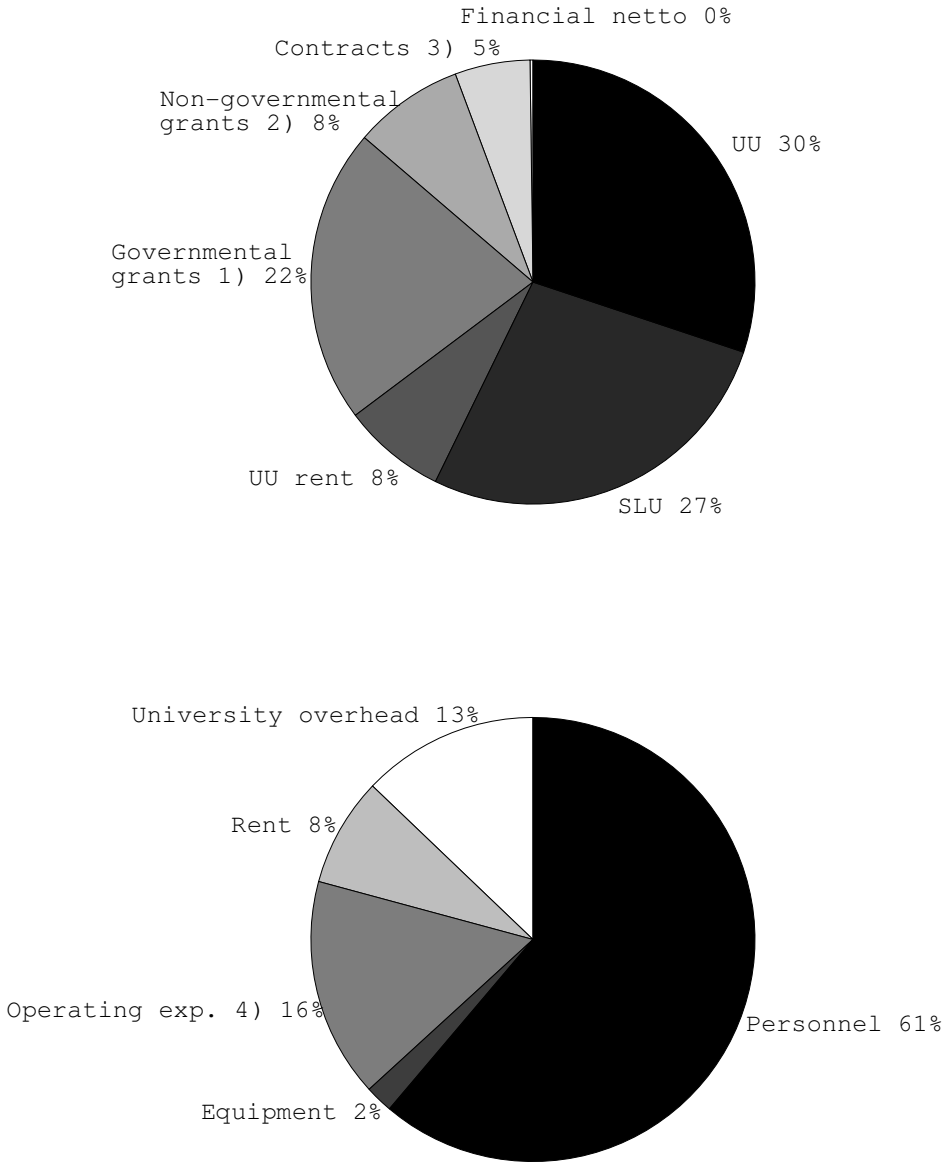


Figure 1: CBA income (top) and costs (below) for 2009.

2.3 Staff

Amin Allalou, Graduate Student, UU
Maria Axelsson, Graduate Student, –0430, SLU
Ewert Bengtsson, Professor, PhD, Director, UU
Gunilla Borgefors, Professor, PhD, SLU, UU
Anders Brun, Researcher, PhD, SLU
Ingrid Carlbom, Professor, PhD, UU
Hyun-Ju Choi, Researcher, PhD, UU
Vladimir Curic, Graduate Student, 0827–, UU
Olle Eriksson, Lecturer, PhD, Deputy Director, (part time) UU
Milan Gavrilovic, Graduate Student, UU
Magnus Gedda, Graduate Student, UU
Anders Hast, Researcher, PhD, (part time) UU
Gustaf Kylberg, Graduate Student, UU
Andreas Kårsnäs, Graduate Student, 0817–, UU
Joakim Lindblad, Researcher, PhD, (part time) SLU
Tommy Lindell, Docent, PhD, (part time) UU
Cris Luengo, Researcher, PhD, SLU
Patrik Malm, Graduate Student, UU
Filip Malmberg, Graduate Student, UU
Khalid Niazi, Graduate Student, UU
Bo Nordin, Researcher/Lecturer, PhD, (part time) UU
Kristin Norell, Graduate Student, SLU
Ingela Nyström, Docent, PhD, (part time) UU
Amalka Pinidiyaarachchi, Graduate Student, –0415, UU and University of Peradeniya, Sri Lanka
Hamid Sarve, Graduate Student, SLU
Stefan Seipel, Professor, PhD, (part time) UU and University of Gävle
Bettina Selig, Graduate Student, SLU
Ida-Maria Sintorn, Researcher, PhD, (part time) SLU, UU
Robin Strand, Researcher, PhD, 0201–, UU
Lennart Svensson, Graduate Student, SLU
Stina Svensson, Docent, PhD, (part time) SLU
Lena Wadelius, Administration
Erik Wernersson, Graduate Student, SLU
Carolina Wählby, Docent, Researcher, PhD, (part time) UU
Catherine Östlund, Researcher, (part time) SLU

Master Thesis students:
Erik Ahlberg, Christer Bergman, Anders Dånmark, Jens Heidrich, Kelly Hubble, Nils Lenngren, Johan Nysjö, Johan Olsson

In addition to the above Graduate Students, G. Borgefors was supervisor to
Hania Uscka-Wehlou, Dept. of Mathematics, UU
and is assistant supervisor to
Anders Larsolle, Dept. of Biometry and 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

Staff from CBA organizes and participates in many undergraduate courses at UU, even though we are not officially the unit responsible for them. Of course, we organize and teach the courses in image analysis and computer graphics, but we also teach other courses, such as programming (in C++ and Java).

We offer a number of Master thesis projects (examensarbeten) each year. Seven were completed during 2009.

3.1 UU courses

1. **Programming Techniques 1, 7.5hp**
   Hamid Sarve
   Period: 090112–0331
2. **Projekt IT, 30 hp**
   Bettina Selig
   Period: 090119–0605
   Comment: Building and programming a RoboCup Rescue Robot
3. **Computers and Programming, 10 hp**
   Bo Nordin
   Period: 090120–0615
   Comment: Distance course; C++ programming, 1st course
4. **Computer Graphics, first course, 10 hp**
   Ingela Nyström, Filip Malmberg, Martin Ericsson
   Period: 090120–0317
   Comment: Invited lecturers: Anders Hast, Gustav Taxen. Computer exercises: Filip Malmberg, Martin Ericsson
5. **Software Architecture with Java, 7.5 hp**
   Olle Eriksson
   Period: 090125–0310
6. **OOP with C++, 10 hp**
   Bo Nordin
   Period: 090301–0531
   Comment: Distance Course: C++ programming, 2nd course
7. **Computerized Image Analysis, 7.5 hp**
   Amin Allalou, Milan Gavrilovic, Hamid Sarve, Patrik Malm, Gustaf Kylberg
   Period: 090323–0528
8. **Computer Programming I, 5 hp**
   Olle Eriksson
   Period: 090325–0604
9. **Script Programming, 7.5 hp**
   Erik Wernersson
   Period: 090609–0909
10. **Computers and Programming, 10 hp**
    Bo Nordin, Kristin Norell
    Period: 090901–100116
    Comment: Distance course; C++ programming, 1st course
11. **Computerized Image Analysis NV2, 7.5 hp**
    Anders Brun, Gustaf Kylberg, Joakim Lindblad, Cris Luengo, Patrik Malm, Robin Strand
    Period: 090901–1015

12. **Programming, bridging course, 10 hp**
    Olle Eriksson, Lennart Svensson
    Period: 091027–1217

13. **Scientific Visualization, 5hp**
    Ingela Nyström, Filip Malmberg, Martin Ericsson, Patrik Malm, Stefan Seipel
    Period: 091028–1211

14. **Advanced Visual Interface, 5hp**
    Stefan Seipel
    Period: 091109–100115

3.2 SLU courses

1. **Computerized Image Analysis, 5 hp**
   Amin Allalou, Milan Gavrilovic, Hamid Sarve, Patrik Malm, Gustaf Kylberg
   Period: 090323–0528
   Comment: SLU course

3.3 Master theses

1. **Realtime scene analysis in infrared images**
   Student: David Forslund
   Supervisors: Per Cornvall and Jacob Roll
   Subject supervisor: Joakim Lindblad
   Publisher: CBA Master Thesis No. 106 / UPTEC F09 010
   Abstract: The vehicle industry is, as society in general, evolving towards increasing machine intelligence. A large step in vehicle intelligence would be for the vehicle to be aware of the scene in which it is located. Scene classification is a growing field in image analysis, and much progress has been made in the last few years. This thesis aims at employing scene classification in real-time to images constructed from an infrared sensor that is mounted at the front of a vehicle. The images are greyscale, and the specific task studied is the two-class task of separating city and rural road scenes. Several image representation methods for scene classification, such as 'Edge Direction Histograms', and 'Invariant Moments' have been evaluated, but most focus has been turned toward the 'Bag of Words' algorithm for image representation. This algorithm has been implemented using both sparse and dense extraction of image elements and using both descriptors based on simple representation of square grey patches and the popular SIFT representation. Using the 'Bag of Words' algorithm, a method for fast two-class scene classification, suitable for a real-time application is proposed. The proposed method uses grey patch based image elements, a modified floating search algorithm for visual word selection and an SVM classifier for the final classification.

2. **A Sense-and-Avoid Algorithm for Manned Aircrafts**
   Student: Erik Ahlberg
   Supervisor: Harald Klomp
   Subject supervisor: Gunilla Borgefors
   Publisher: CBA Master Thesis No. 107 / UPTEC F09 021
   Partner: IMINT Image Intelligence, Uppsala
   Abstract: As the civilian air traffic keeps on growing, new and innovative solutions are needed to handle the increase of traffic, especially with regard to safety. This is emphasized as unmanned aerial vehicles are currently in the verge of being integrated into the already highly congested general airspace. An autonomous sense-and-avoid system has the possibility of revolutionizing air safety by offering additional safety measures for manned aircrafts and allowing for unmanned aerial vehicle integration. In this paper we explore this technology further and commit to the design of a sense-and-avoid system centred on the electro-optical hardware technology. The aim is to achieve successful detection and tracking of objects from an image sequence. This is achieved by object detection from motion and tracking through the implementation of a linear Kalman filter.

By extensively using an open-source public computer vision library and off-the-shelf hardware components we managed to keep the solution relatively inexpensive. Simulations on two separate scenarios were performed with mixed results. Although the performance of the constructed algorithm did not completely meet the expectations laid out before it, the simulation results showed great promise for future improvements.

3. **Automated Methods for Generation of Input Function in PET Studies Using MVW-PC Images**
   Student: Johan Olsson
   Supervisor: Pasha Razifar
   Subject supervisor: Ewert Bengtsson
   Examiner: Anders Jansson
   Publisher: CBA Master Thesis No. 108 / IT 09 001
   Partner: GE Healthcare, Uppsala
   Abstract: Modeling is an approach for extracting quantitative values from PET. The signal from a reference region or from blood samples is used as reference. Since blood sampling is risky, this report presents an automated method based on MVW-PCA for using blood data from the images.

   The study was performed on clinical PET data from several human brains using the tracer PIB. Two veins were found in a MVW-PC and an average of the TACs from the relevant locations was formed. Finally, a correcting function was calculated.

   The curves generated from the image data were very similar to the curves generated from blood samples, with the largest errors in the beginning of the scan.

   The used method shows potential for generating very good results if worked on more. One of the strengths of the approach is that it is not limited to a specific tracer or time protocol, since the MVW-PC will be chosen depending on the weights for the first 60 seconds.

4. **Low Cost Real-Time Gaze Tracker Using a Web Camera**
   Student: Christer Bergman
   Supervisor: Gustav Öqvist
   Subject supervisor: Ewert Bengtsson
   Publisher: CBA Master Thesis No. 109 / UPTEC F09 048
   Partner: Bernadotte Laboratory, St. Erik Eye Hospital
   Abstract: Gaze tracking means to detect and track the direction in which a person look. Gaze tracking can for instance be used in human computer interaction and in medicine. Most gaze trackers today are expensive and some are invasive. The idea of this thesis is to make a cheap and user friendly gaze tracker.

   The approach is to use feature based image analysis to find and track the eyes, Hough circle transform is used to find the eyes. A simple calibration is done to get positions on the screen as output.

   An experiment is done on ten volunteers to evaluate the gaze tracker. The experiment shows that the gaze tracker is robust and its resolutions are sufficient for some applications.

5. ***k*-Uniform Tilings by Regular Polygons**
   Student: Nils Lenngren
   Supervisor: Gunilla Borgefors
   Subject Supervisor: Vera Koponen
   Publisher: CBA Master Thesis No. 110 / U.U.D.M Project Report 2009:23
   Abstract: k-uniform tilings by regular polygons are tilings with k equivalence classes of vertices with respect to the symmetries of the tiling. The enumeration of all k-uniform tilings for specific values of k is a far from trivial problem. In this paper, I review the most important steps in the investigation of k-uniform tilings: Kepler's enumeration of the 1-uniform tilings in 1619, the rediscovery of the 1-uniform tilings by Sommerville in 1905, the complete enumeration of the k-homogeneous tilings (a set of tilings which includes the 1-uniform and 2-uniform tilings) by Krötenheerdt in 1969-1970, Chavey's enumeration of the 3-uniform tilings in 1984, and Galebach's enumeration of the 4-uniform, 5-uniform and 6-uniform tilings in 2002-2003. I also discuss some approaches that might be used in future work on k-uniform tilings.

6. **Signal Extraction and Separation in PET Studies With Different Time Protocols Using MVW-PCA**
   Student: Fredrik Engbrant
   Supervisor: Pasha Razifar
   Subject Supervisor: Ewert Bengtsson

Examiner: Tomas Nyberg
Publisher: CBA Master Thesis 111/ UPTEC F09018
Partner: GE Healthcare, Uppsala
Abstract: Positron Emission Tomography (PET) is a non-invasive imaging modality used to visualize the functionality in tissues and organs in vivo in medical and research applications. PET is based on measuring the concentration of a tracer molecule, labeled with a radionuclide, designed to follow a specific physiological and biochemical path. PET can be used to detect neurological disorders such as Parkinson's disease, Alzheimer's Disease, phobia and schizophrenia by studying dynamic PET image sequences. However the PET data suffers from noise and the different areas and tissues can be hard to discern. Previously it has been shown that the application of Masked Volume Wise Principal Component Analysis (MVW-PCA) can be used to separate and extract the different kinetics of the PET tracer. The time protocol in a regular dynamic PET scan cannot be changed after the scan. The list mode storing option, available on some newer PET cameras gives the opportunity to reconstruct the data into any or several different time protocols after the scan. It is important for any method used to study PET data to be more dependent on the signal than the choice of time protocol. In this study the result from MVW-PCA using different time protocols have been studied. The result showed that MWV-PCA is a stable method, depending more on the acquired data than on the frame lengths. There is however a possibility to improve the result slightly by using shorter frames, yielding the result that similar kinetics are more clearly separated.

7. **Characterization and Reduction of Noise in PET Data Using MVW-PCA**
Student: Per-Edvin Svensson
Supervisor: Pasha Razifar
Subject Supervisor: Ewert Bengtsson
Examiner: Anders Jansson
Publisher: CBA Master Thesis 112/ IT 09 003
Partner: GE Healthcare, Uppsala
Abstract: Masked Volume-Wise Principal Component Analysis (MVW-PCA) is used in Positron Emission Tomography (PET) to distinguish structures with different kinetic behaviours of an administered tracer. In the article where MVW-PCA was introduced, a noise pre-normalization was suggested due to temporal and spatial variations of the noise between slices. However, the noise pre-normalization proposed in that article was only applicable on datasets reconstructed using the analytical method Filtered Back-Projection (FBP). This study aimed at developing a new noise pre-normalization that is applicable on datasets regardless of whether the dataset was reconstructed with FBP or an iterative reconstruction algorithm, such as Ordered Subset Expectation Maximization (OSEM).

   A phantom study was performed to investigate the differences of expectation values and standard deviations of datasets reconstructed with FBP and OSEM. A novel noise pre-normalization method named "higher-order principal component noise pre-normalization" (HOPC noise pre-normalization) was suggested and evaluated against other pre-normalization methods on both synthetic and clinical datasets.

   Results showed that MVW-PCA of data reconstructed with FBP was much more dependent on an appropriate pre-normalization than analysis of data reconstructed with OSEM. HOPC noise pre-normalization showed an overall good performance with both FBP and OSEM reconstructions, whereas the other pre-normalization methods only performed well with one of the two methods.

   The HOPC noise pre-normalization has potential for improving the results from MVW-PCA on dynamic PET datasets independent of used reconstruction algorithm.

8. **Image Analysis for Marker-less Facial Tracking**
Student: Wenlan Yang
Supervisor: Christian Sjöström
Subject Supervisor: Ewert Bengtsson
Examiner: Anders Jansson
Publisher: CBA Master Thesis 113/ IT 09 042
Partner: Imagination Studios
Abstract: Tracking of facial features is increasingly used in game and film industry as well as for other applications. Most tracking systems are currently using markers which unfortunately are tedious and cumbersome. Marker-less facial tracking is supposed to eliminate the disadvantages of the marker-based approaches. This thesis investigates different algorithms for marker-less tracking and presents how to apply

them in a robust way. View-based and component sensitive normalized face images can achieve accurate tracking results based on the Active Appearance Algorithm. Post processing the parameters of global motions of the model smoothes the synthesized video sequence. Tracking results for faces and a tool developed for creating training images are also presented.

4 Graduate education

We had as many as three PhD exams in 2009, where the supervision came from CBA staff. Two of them were by PhD students belonging to CBA, while one was from the Dept. of Mathematics at UU. We gave two PhD courses of interest to our own students that also enticed external students. CBA staff also organized the course Application Oriented Image Analysis for PhD students. The aim of this course is to give PhD students in other areas sufficient knowledge to be able to use image analysis in their research. At the end of 2009, we were main supervisors for 14 PhD students, nine at UU and five at SLU. Borgefors is also assistant supervisor for a PhD student at the Dept. of Biometry and Engineering, SLU.

4.1 Graduate courses

1. **Digital Imaging Systems, 8 hp**
   Ewert Bengtsson, Cris Luengo
   Period: 081118–090131
   Comment: Bengtsson organized this course. Several external lecturers were invited.

2. **Research Methodology for Image Analysis, 4 hp**
   Gunilla Borgefors, Ewert Bengtsson
   Period: 091124–100120
   Comment: This course is intended for PhD students who started their research career recently. The goal is to give general and useful knowledge about how to become a good and published researcher in image analysis and/or various applications thereof. Ingrid Ogenhall, Ångström library gave one lecture.

3. **Application Oriented Image Analysis, 7.5 hp**
   Robin Strand, Lennart Svensson, Erik Wernersson, Khalid Niazi, Gustaf Kylberg, Patrik Malm, Petra Philipson, Gunilla Borgefors, Vladimir Curic
   Period: 091014–1216
   Comment: Strand organized this course. The aim of this course is to give PhD students in other areas sufficient knowledge to be able to use image analysis in their research. The course is application oriented in the meaning that it does not go too deeply into fundamental mathematics, but concentrates on basic concepts and general methodology.

4.2 Dissertations

1. *Date:* 090227
   Digital Image Analysis of Cells: Applications in 2D, 3D and Time
   Student: Amalka Pinidiyaarachchi
   Supervisor: Carolina Wählby
   Assistant Supervisor: Ewert Bengtsson
   Opponent: Arvid Lundervold, Dept. of Biomedicine and Molecular Imaging Center, University of Bergen, Norway
   Committee: Jos Buijs, Division of Biochemical Engineeering, Mälardalen University; Lennart Björkesten, GE Healthcare; Maria Magnusson Dept. of Electrical Engineering, Linköping University; Cris Luengo CBA; Ingela Nyström CBA
   Publisher: Universitetsbiblioteket Uppsala, ISBN: 978-91-554-7398-3
   Abstract: Light microscopes are essential research tools in biology and medicine. Cell and tissue staining methods have improved immensely over the years and microscopes are now equipped with digital image acquisition capabilities. The image data produced require development of specialized analysis methods. This thesis presents digital image analysis methods for cell image data in 2D, 3D and time sequences.

   Stem cells have the capability to differentiate into specific cell types. The mechanism behind differentiation can be studied by tracking cells over time. This thesis presents a combined segmentation and tracking algorithm for time sequence images of neural stem cells. The method handles splitting and merging of cells and the results are similar to those achieved by manual tracking.

Methods for detecting and localizing signals from fluorescence stained biomolecules are essential when studying how they function and interact. A study of Smad proteins, that serve as transcription factors by forming complexes and enter the cell nucleus, is included in the thesis. Confocal microscopy images of cell nuclei are delineated using gradient information, and Smad complexes are localized using a novel method for 3D signal detection. Thus, the localization of Smad complexes in relation to the nuclear membrane can be analyzed. A detailed comparison between the proposed and previous methods for detection of point-source signals is presented, showing that the proposed method has better resolving power and is more robust to noise.

In this thesis, it is also shown how cell confluence can be measured by classification of wavelet based texture features. Monitoring cell confluence is valuable for optimization of cell culture parameters and cell harvest. The results obtained agree with visual observations and provide an efficient approach to monitor cell confluence and detect necrosis.

Quantitative measurements on cells are important in both cytology and histology. The color provided by Pap (Papanicolaou) staining increases the available image information. The thesis explores different color spaces of Pap smear images from thyroid nodules, with the aim of finding the representation that maximizes detection of malignancies using color information in addition to quantitative morphological parameters.

The presented methods provide useful tools for cell image analysis, but they can of course also be used for other image analysis applications.

2. *Date:* 090327
Image Analysis for Volumetric Characterisation of Microstructure
Student: Maria Axelsson
Affiliation: Faculty of Forest Sciences, SLU
Supervisor: Gunilla Borgefors
Assistant supervisor: Stina Svensson
Opponent: Carl-Fredrik Westin, Laboratory of Mathematics in Imaging, Dept. of Radiology, Harvard Medical School, Brigham and Women's Hospital, Boston, USA
Committee: Josef Bigun, Dept. of Information, Computer and Electrical, Högskolan Halmstad; Magnus Borga, Dept. of Biomedical Engineering, Linköpings University, Markku Kataja, Dept. of Physics, University of Jyväskylä, Finland
Publisher: Acta Universitatis agriculturae Sueciae, ISBN: 978-91-86195-66-3
Abstract: Digital image analysis provides methods for automatic, fast, and reproducible analysis of images. The main contribution of this thesis is new image analysis methods for volumetric characterisation of microstructure with application in the field of material science. The methods can be used as tools to characterise material microstructure, in particular the structure of fibre-based materials, such as paper, wood fibre composites, and press felts. More information about the material microstructure enables design of new materials with more specialised properties.

Volume images have recently become available to characterise material microstructure. Manual inspection of material properties using volume images is both non-reproducible and expensive. The methods presented in this thesis are developed to meet the growing need for automated analysis. The focus has been on 3D methods for high-resolution volume images, such as X-ray microtomography images.

New methods for characterisation of both the fibre structure and pore structure in fibre-based materials are presented. The fibre structure can be characterised by measuring either individual fibres or the local structure of the material. A method for tracking individual fibres in volume images is presented. The method is designed for wood fibres, but can also be applied to other types or fibres or in other areas where tubular or elongated structures are analysed in volume images. A method for estimating 3D fibre orientation of both tubular and solid fibres is also presented. Both methods have been evaluated on real volume images acquired using X-ray microtomography with good results. Two new pore structure representations and corresponding measurements are introduced. The usefulness of the methods is illustrated on real data. A method for estimating the pore volume at the interface between press felt and fibre web is presented. It has been applied in a case study of press felts under load using confocal microscopy images.

In addition to the methods for fibre-based materials, a general method for reducing ring artifacts in X-ray microtomography images is presented. The method is evaluated on real data with good results. It is also applied as a preprocessing step before further analysis of the X-ray microtomography images.

3. *Date:* 090925
Digital Lines, Sturmian Words, and Continued Fractions
Student: Hanna Uscka-Wehlou
Supervisor: Maciej Klimek, Dept. of Mathematics, UU
Assistant Supervisor: Christer Kiselman, Dept. of Mathematics UU; Gunilla Borgefors CBA; Mikael Passare, Dept. of Mathematics, Stockholm University
Opponent: Damien Jamet, Henri Poincaré University, Nancy, France
Committee: Petter Brändén, KTH and Stockholm University; Rikard Bøgvad, Dept. of Mathematics, Stockholm University; Isabelle Debled-Rennesson, Henri Poincaré University, Nancy, France; Anders Heyden, Centre for Mathematical Sciences, Lund University; Warwick Tucker, Dept. of Mathematics, UU
Publisher: Matematiska institutionen UU, ISBN: 978-91-86195-66-3
Abstract: How to construct a digitization of a straight line and be able to recognize a straight line in a set of pixels are very important topics in computer graphics. The aim of the present paper is to give a mathematically exact and consistent description of digital straight lines according to Rosenfeld's definition. The digitizations of the lines with slopes $0 < a < 1$, where a is irrational, are considered. We formulate a definition of digitization runs, formulate and prove theorems containing necessary and sufficient conditions for digital straightness. The proof was successfully constructed using only methods of elementary mathematics. The developed and proved theory can be used in the research into the theory of digital lines, their symmetries, translations etc.

4.3 Docent degrees

1. *Title:* Segmentering och klassificering av fluorescensmikroskopibilder – hur man undviker att snubbla på trösklar
(*Segmentation and classification in fluorescence microscopy images – how to avoid stumbling on thresholds*)
Carolina Wählby
Date: 090122
Abstract: Highly specific staining methods and fluorescent biological markers emitting light at different wavelengths together with fluorescence microscopy allow for detailed studies of the spatial distribution, localization, and interaction of biomolecules. Quantification of colocalization of biomolecules includes not only calculating a global measure of the degree of colocalization within an image, but also a classification of each image pixel showing colocalized signals or not. Common methods for automated quantification of colocalization require manual input of thresholds, and will give results strongly biased by the user. I present a novel, automated method for quantification of colocalization and classification of image pixels based on hue rather than intensity. The hue distribution is presented as an angle histogram created by a series of steps that compensate for the quantization noise always present in digital image data. Classification rules are thereafter based on the shape of the angle histogram, and detection of colocalized signals is thus only dependent on hue, making it possible to classify also low-intensity objects in noisy images, and decouple image segmentation from detection of colocalization. A number of examples from real biological applications are also presented.
Comment: The docent lecture was held in Swedish.

Docent degrees from CBA

1. Lennart Thurfjell, 1999
2. Ingela Nyström, 2002
3. Lucia Ballerini, 2006
4. Stina Svensson, 2007
5. Tomas Brandtberg, 2008
6. Hans Frimmel, 2008
7. Carolina Wählby, 2009

5 Research

CBA is conducting a whole range of Projects ranging from basic image analysis research to direct application work, and increasingly in scientific visualization. By keeping close touch both with theoretical front line research and with real life application Projects, we believe that we make the best contribution to our field. On the theoretical side, we are especially strong in volume and multispectral image analysis. In line with the stated goal for CBA, we give priority to applications in the fields of biomedicine and the environmental sciences, including the forest industry; we are part of the Faculty of Forest Sciences at SLU.

In this Section, we list the 53 research Projects that were active during 2009. Some are large Projects that have been active for a long time, while others are smaller and short-lived. We started eleven new Projects this year, while eight were completed since last year.

The list of Projects is roughly grouped into image analysis theory; medical image applications (from proteins to organs); computer graphics and visualization; forest and agricultural Projects; and finish with aquatic remote sensing and some miscellaneous Projects. For each Project, we list who at CBA is involved, where the funding comes from, when the Project started (and finished), and who our cooperation partners outside CBA are.

As is obvious from the descriptions, most of the Projects are carried out in close cooperation with researchers from other universities and from other research areas. In Section 5.7, we list the 39 international groups in 17 countries and 41 national groups with which we have had active cooperation in 2009.

5.1 Theory: Discrete Geometry, Volumes and Fuzzy Methods

1. **Distance Functions and Distance Transforms in Discrete Images**
   Robin Strand, Gunilla Borgefors
   Partners: Benedek Nagy, Dept. of Computer Science, Faculty of Informatics, University of Debrecen, Hungary
   Period: 9309–
   Abstract: The distance between any two grid points in a grid is defined by a distance function. In this Project, weighted distances have been considered for many years. A generalization of the weighted distances is obtained by using both weights and a *neighborhood sequence* to define the distance function. The neighborhood sequence (ns) allows the size of the neighborhood to vary along the paths. In a paper by Strand that appeared in Discrete Applied Mathematics in 2009, weighted ns-distances are defined in a general framework including, e.g., the standard square grid, the face-centered cubic grid, and the body-centered cubic grid. Optimal weights and neighborhood sequences, condition for metricity, and algorithms are presented. In another paper, written by Strand and Nagy, also published in 2009 in Discrete Applied Mathematics, the special-case of n-dimensional generalizations of the fcc and bcc grids are considered. Strand and Nagy also published results on distance functions in the *diamond* grid in the June-issue of International Journal of Imaging Systems and Technology and at the International Workshop on Combinatorial Image Analysis.

2. **Comparison of Grey-Weighted Distance Measures**
   Magnus Gedda
   Funding: UU TN-faculty
   Period: 0601–
   Abstract: In several application Projects we have discovered the benefit of computing distances weighted by the grey levels traversed, e.g., Project 12. There are many ways of doing this, and

in this Project we have made a thorough comparison of the most popular distances calculated that take grey-level information into account; GRAYMAT, Distance On Curved Spaces (DOCS) and the Weighted Distance On Curved Spaces (WDOCS). Already in 2006 we published a theoretical comparison describing the different aspects of the definitions. We are currently investigating the implementational details to form guidelines on which algorithms and datastructures are best suited for different scenarios.

3. **Image Processing and Analysis of 3D Images in the Face- and Body-Centered Cubic Grids**
Robin Strand, Gunilla Borgefors
Partners: Benedek Nagy, Dept. of Computer Science, Faculty of Informatics, University of Debrecen, Debrecen, Hungary
Period: 0308–
Abstract: The main goal of the Project is to develop image analysis and processing methods for volume images digitized in non-standard 3D grids. Volume images are usually captured in one of two ways: either the object is sliced (mechanically or optically) and the slices put together into a volume or the image is computed from raw data, e.g., X-ray or magnetic tomography. In both cases, voxels are usually box-shaped, as the within slice resolution is higher than the between slice distance.
Before applying image analysis algorithms, the images are usually interpolated to the cubic grid. However, the cubic grid might not be the best choice. In two dimensions, it has been demonstrated in many ways that the hexagonal grid is theoretically better than the square grid. The body-centered cubic (bcc) grid and the face-centered cubic (fcc) grid are the generalizations to 3D of the hexagonal grid. In the bcc grid, the voxels consist of truncated octahedra, and in the fcc grid, the voxels consist of rhombic dodecahedra. The fcc grid is a densest packing, meaning that the grid points are positioned in an optimally dense arrangement. The fcc and bcc grids are reciprocal, so the Fourier transform on an fcc grid results in a bcc grid. In some situations, the densest packing (fcc grid) is prefered in the frequency domain, resulting in a bcc grid in spatial domain. In some cases, the densest packing is prefered in the spatial domain.
In 2009, the Project has focused on properties of sampling and interpolation on these non-Cartesian grids. Numerical experiments on sampling analytic functions have been performed, for example using the 3D Shepp-Logan Phantom in Figure 2.

Figure 2: A three-dimensional version of the Shepp Logan phantom.

4. **Skeletonization in 3D Discrete Binary Images**
   Robin Strand, Ingela Nyström, Gunilla Borgefors
   Partner: Gabriella Sanniti di Baja, Istituto di Cibernetica, CNR, Pozzuoli, Italy
   Period: 9501–
   Abstract: Skeletonization is a way to reduce dimensionality of digital objects. A skeleton should have the following properties: topologically correct, centred within the object, thin, and fully reversible. In general, the skeleton cannot be both thin and fully reversible. We have been working on 3D skeletonization based on distance transforms for the last decade.
   By finding the set of centers of maximal balls (CMBs) and keeping these as anchor-points in the skeletonization process, the reversibility is guaranteed. In 2009, a special invited paper, *On Maximal Balls in Three Volume Grids* written by Borgefors and Strand, was presented at the conference Pattern Recognition and Information Processing, Minsk, Belarus.

5. **Spel Coverage Representations**
   Joakim Lindblad, Vladimir Curic
   Partners: Nataša Sladoje, Faculty of Engineering, University of Novi Sad, Serbia; Csaba Domokos, and Zoltan Kato, Dept. of Computer Science, Szeged University, Hungary
   Funding: S-faculty, SLU, Graduate School in Mathematics and Computing (FMB)
   Period: 0801–
   Abstract: This Project concerns the study and development of partial pixel/voxel coverage models for image object representation, where spatial image elements (spels) are allowed fractional coverage by the object. The Project involves both development of methods for estimation of partial spel coverage (coverage segmentation) as well as development of methods for properly utilizing the information contained in such segmented images (feature extraction). The Project builds on previous experience and knowledge from more general fuzzy representations, where the restriction to coverage representations enables derivation of strong theoretical results.

   A method for precise boundary length estimation from a pixel coverage representation has been developed. Description and evaluation of the method, together with a suggested approach for pixel coverage segmentation based on a double thresholding scheme, is published in IEEE Transactions on Pattern Analysis and Machine Intelligence in February 2009. A coverage segmentation method based on a local statistical model was developed and presented at the International Conference on Image Analysis and Processing (ICIAP) in Sept. 2009. Application of the developed framework, i.e., the combination of coverage segmentation and subsequent high precision feature extraction, was successfully demonstrated on histological images of bone implants. Benefits of precise feature estimation from a fuzzy representation are further confirmed when a method for registration of digital X-ray images of hip implants is improved by utilizing geometric moments of a fuzzy representation. This work was presented at the Scandinavian Conference on Image Analysis (SCIA) in June 2009.

6. **Set Distances and Their Application in Image Analysis**
   Vladimir Curic, Joakim Lindblad, Gunilla Borgefors
   Partners: Nataša Sladoje, Faculty of Engineering, University of Novi Sad, Serbia
   Funding: Graduate School in Mathematics and Computing (FMB)
   Period: 0908–
   Abstract: Methods for measuring distances between sets can be useful for solving various image analysis related problems, such as registration, image retrieval and segmentation evaluation. Depending on how the distance measure is defined, it exhibits different properties, such as metricity, monotonicity, continuity, sensitivity to noise, complexity and speed of computation. It is therefore of interest to study and further develop different set distance measures, to be able to select appropriate distances for the different applications.

An initial goal of this Project is to evaluate existing and possibly develop new set distances which are useful in image registration problems. We have proposed variations on Sum of Minimal Distances as well as Complement set distances, and are currently exploring, and evaluating their appropriateness for image registration. Of particular interest are properties of monotonicity and continuity.

During 2009 we worked on the application of set distances for registration of 2D binary shapes. See Figure 3. The work was presented at the International Symposium on Image and Signal Processing and Analysis (ISPA2009).

We intend to further extend this work within the framework of mathematical morphology towards more general methods for shape description and analysis.

Figure 3: Examples of test shapes.

7. **Dimensionality-Independent Path Openings**
   Cris Luengo
   Funding: S-faculty, SLU
   Period: 0904–0907
   Abstract: Path openings and closings are morphological operations with flexible line segments as structuring elements. These line segments have the ability to adapt to local image structures, and can be used to detect lines that are not perfectly straight. They also are a convenient and efficient alternative to straight line segments as structuring elements when the exact orientation of lines in the image is not known. These path operations are defined by an adjacency relation, which typically allows for lines that are approximately horizontal, vertical or diagonal. However, because this definition allows zig-zag lines, diagonal paths can be much shorter than the corresponding horizontal or vertical paths. This undoubtedly causes problems when attempting to use path operations for length measurements.

   We have extended the definition of path openings and closings to make them dimensionality-independent. This allows us to apply this operation to the 3D images used in many applications at CBA. We have also proposed a way to constrain the path operations to improve their ability to perform length measurements. Both techniques are described in a paper that has been accepted for publication in IEEE Transactions on Image Processing.

5.2 Analysis of Microscopic Biomedical Images

8. **New Objective Quantitative Analysis Techniques for Quantification of Tissue Regeneration Around Medical Devices**
   Hamid Sarve, Joakim Lindblad, Vladimir Curic, Gunilla Borgefors
   Partners: Carina Johansson, Dept. of Clinical Medicine, Örebro University; Nataša Sladoje, Faculty of Engineering, University of Novi Sad, Serbia
   Funding: Swedish Research Council; S-faculty, SLU
   Period: 0503–
   Abstract: With an aging and increasingly osteoporotic population, bone implants are becoming

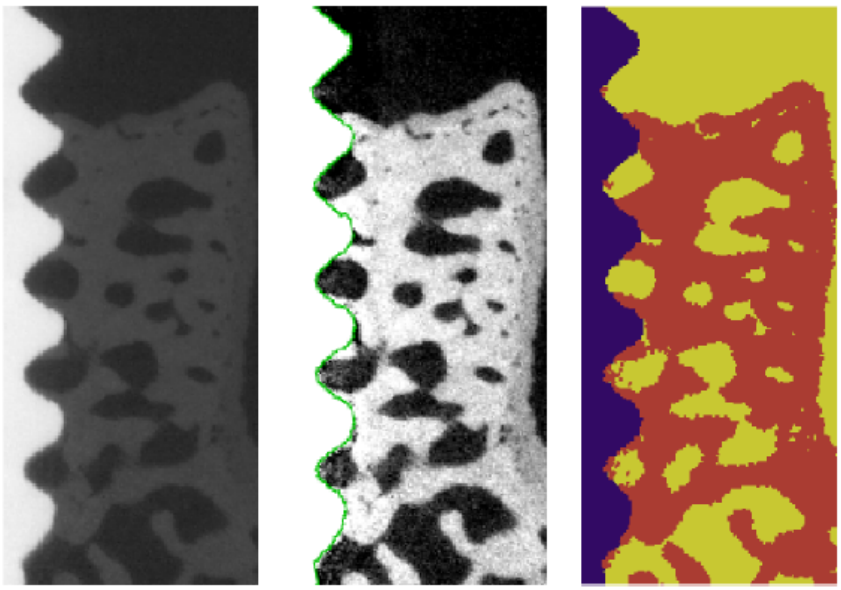


Figure 4: (Left) A slice from the SRμCT image volume (middle) Artifact corrected slice with the interface region marked and the implant in white to the left (right) A slice from the segmented image volume, showing three classes: the bone (red), the soft tissue (yellow) and the implant (blue).

more important to ensure the quality of life. In order to evaluate how tissue reacts on implants, the interface at the implant and tissue must be studied. Today, this is done manually in a microscope which is a costly and time-consuming procedure.

The aim of this Project is to develop automatic image analysis methods for evaluating images of implant in situ. These methods would provide faster and more objective measurements on how well the implant is integrated in the bone compared to today's manual methods. The analysis involves segmentation of the images into different tissue-types and measures such as bone contact length, area and volume.

The Project encompasses parallel development and comparison of methods for 2D analysis of histological sections as well as 3D analysis of SRμCT volumes. To facilitate comparison of results from the two imaging modalities, a 2D-3D registration method has been developed. During 2009, methods for segmentation and feature extraction of 3D volume data were developed. Segmentation methods for the 2D histological sections were further improved using a fuzzy set framework. This progress was presented in two publications at the 16th Scandinavian Conference on Image Analysis (SCIA'09). See Figure 4.

9. **Assessing Bone Implant Integration From Synchrotron micro-CT Data**
   Hamid Sarve, Joakim Lindblad, Gunilla Borgefors
   Partners: Carina Johansson, Dept. of Clinical Medicine, Örebro University; AstraTech, Mölndal
   Funding: The Knowledge Foundation
   Period: 0906–
   Abstract: This Project aims to develop new techniques for interactive 3D visualization of bone anchored implants, in order to facilitate improved understanding of the mechanisms of implant integration. To enable good communication between the people involved in development, production and use of medical devices – computer scientists, material scientists, and medical doctors – each with their own special knowledge, it is of highest importance to provide a common visual platform for a mutual understanding of the problems of implant integration. Being able to actually

see the 3D structure around the implant for the first time will no doubt inspire new measures of the implant integration quality.

We base the visualization on data from non-destructive 3D SRμCT imaging; this technique yields more accurate tomographic reconstruction at higher resolution compared to standard μCT. Furthermore, SRμCT-imaging is more suitable for samples containing metal as the artefacts caused by the metal is significantly lower compared to traditional μCT. Initial tests show that existing visualization software is rather useless for this type of complex and highly detailed data, requiring the development of special purpose methods and software.

The combination of this Project and Project 8 will improve both quantitative and qualitative analysis of bone implant integration and thereby support the development of more effective implants and diminish the number of malfunctioning devices.

10. **Analysis of Rat Embryo Heart Activity**
Khalid Niazi, Ewert Bengtsson
Partners: Mats Nilsson, Div. of Toxicology, Dept. of Pharmaceutical Biosciences, UU
Funding: COMSATS IIT, Islamabad
Period: 0711–0908
Abstract: Embryo cultures of rodents is an established technique for monitoring adverse effects of chemicals on embryonic development. The assessment involves determination of the heart rate of the embryo. We have modeled the movement of the heart as a sinusoid and developed a method to represent the heart motion as a function of time. Analysis of the heart beats were carried out using Emperical Mode Decomposition (EMD).

    EMD is a powerful data analysis technique which decomposes any complicated signal into intrinsic mode functions (IMF). EMD is usually combined with Hilbert transform to analyze the instantaneous frequency in non-stationary signals. This combination is commonly referred as Hilbert-Huang Transform (HHT). In this Project, we have used EMD with slight modification to detect periodic activity in rat embryo's heart. The normal embryo's heart activity can easily be detected by local maxima detection but it becomes a challenging task once the heart activity becomes abnormal.

    EMD decomposes the signal into different IMF functions; where each IMF function is believe to capture different frequency range. It is different from Fourier transform and Wavelet transform in the sense that it has got adaptive basis. Fourier transform relies on Cosine basis and requires a number of cutoffs if one needs to decompose a signal using a Fourier transform. Wavelet transform requires the selection of mother wavelet, and also the level of decompositions which is one of the most difficult tasks if one wants to automate a process. On the other hand, EMD generates the IMF functions from the underlying signal making it adaptive in nature. We have exploited this property to denoise the complicated signal which has resulted in easy detection of maxima during abnormal heart activity.

11. **Scoring of Developmental Stages of Morphological Features of Rat Embryos**
Khalid Niazi, Ewert Bengtsson
Partners: Mats Nilsson, Prof. Lennart Dencker, Div. of Toxicology, Dept. of Pharmaceutical Biosciences, UU
Funding: COMSATS IIT, Islamabad and Swedish Research Council
Period: 0909–
Abstract: The whole embryo culture assay is endorsed as one of few good in vitro embryotoxicity assays available. The goal of the Project is to improve the objectivity and sensitivity in the measurements with the help of image and data analysis methods in the assay using three clinical relevant anti-epileptic drugs as model embryotoxicants.

The scoring methods used for morphology are generally semi-quantitative (categorical, score 15) and mainly associated with growth rate. Specific malformations are scored as either absent (=0) or present (=1). We propose to complement existing scoring systems that will improve embryotoxicity comparisons between labs and enable the creation of a database with cross-reference ability to molecular biology data and to automated image analysis system. Currently we are focused on extracting different morphological features during the development of rat embryos.

12. **Automated Localisation of Macromolecules in Cryo Electron Tomographic Data**
Stina Svensson, Magnus Gedda
Partners: Dept. of Cell and Molecular Biology (CMB), Karolinska Institutet, Stockholm
Funding: The Swedish Research Council (Project 621-2005-5540); SLU S-faculty; UU TN-faculty
Period: 0401-
Abstract: State of the art imaging techniques makes it possible to study individual proteins and other macromolecules from a structural point of view. Descriptions with respect to geometry and shape facilitates studying protein dynamics. This type of study is essential to increase the understanding of their biological role. CMB has developed methods, using cryo electron tomography (Cryo-ET), for 3D imaging of individual proteins at a resolution of a few nm. Localisation of the protein in the image has so far been done manually. For large-scale studies, computerized image analysis serves as an essential tool to automatically and objectively analyse image content. In this Project, we develop methods to automatically localise macromolecules from in vitro Cryo-ET images and thereby make large-scale studies of proteins possible. This is done by taking into account both grey-level information (which reflects the internal structure of the protein) and 3D shape information.

    Earlier in the Project we have built a system to localise proteins which consist of a set of roundish subunits of equal size and proteins which consist of one elongated and one roundish subunit. During 2009 we have evaluated the various aspects of the system in a controlled environment using simulated data. The simulated data were produced by constructing phantoms from the Protein Databank (PDB) and running them through a transmission electron microscopy (TEM) simulator.

13. **Segmentation and Analysis of Point-like Fluorescent Signals in 2D and 3D Images of Cells**
Amalka Pinidiyaarachchi, Amin Allalou, Carolina Wählby, Ida-Maria Sintorn
Partners: Malin Jarvius, Chatarina Larsson, Carl-Magnus Clausson, Katerina Pardali, Ola Söderberg, Irene Weibrecht, Mats Nilsson, Agata Zieba, Dept. of Genetics and Pathology, UU
Funding: EU-Strep Project ENLIGHT; SIDA
Period: 0305–
Abstract: The interior of a cell is elaborately subdivided into many functionally distinct compartments, often organized into intricate systems. One way of studying such compartments is by the use of different fluorescent markers that bind specifically to the objects of interest, in this case padlock- and proximity probes. This type of staining followed by imaging through a fluorescence microscope results in point-source signals, together with compartment-specific stains, background noise and autofluorescence. 3D images are acquired by making non-invasive serial optical sections of the object. Analysis of spatial relationships in 2D and 3D requires pre-processing followed by signal detection and segmentation of cell compartments combining intensity and shape information. During 2009 a paper describing a method of detecting signals in 3D was published (Allalou et al, Cytometry part A). Once the signals are detected, the goal is to analyze spatial relationships and non-random patterns in the signal distribution. Sometimes images have large number of signals that are clustered together. This poses a problem in the detection of signals, and an initial investigation has been made on how to resolve this issue.

14. **Image Based Measurements of Single Cell mtDNA Mutation Load**
Amin Allalou, Carolina Wählby
Partners: Anton K. Raap, Frans M. van de Rijke, Roos Jahangir Tafrechi, Dept. of Molecular Cell Biology, Leiden University Medical Center, The Netherlands; Visiopharm, Hörsholm, Denmark
Funding: EU-Strep Project ENLIGHT, Swedish Research Council
Period: 0608–0907
Abstract: Cell cultures as well as cells in tissue always display a certain degree of variability, and measurements based on cell averages will miss important information contained in a heterogeneous population. An automated method for image based measurements of mitochondiral DNA (mtDNA) mutations in individual cells has been implemented and integrated as a part of the VIS image analysis platform. The methods are used on a daily bases in the continued work on mutation load analysis at Leiden University Medical Center in the Netherlands. The development of image based single cell analysis will continue to be in focus also after the ENLIGHT Project.

15. **Quantification and Localization of Colocalization**
Milan Gavrilovic, Carolina Wählby
Funding: EU-Strep Project ENLIGHT
Period: 0611– 0907
Abstract: In fluorescence microscopy, during image acquisition of multiply labeled specimen, two or more of the emission signals can often be physically located in the same area or very near to one another in the final image due to their close proximity within the microscopic structure. This is known as colocalization. Colocalization is particularly important for revealing information on how and where bio-molecules such as proteins and protein complexes interact within a cell, as well as in which sub-cellular structures they are present. If red and green fluorochromes are selected colocalization will appear as yellow emission. Existing methods for quantification and localization of colocalized pixels have been implemented and compared. We show that robustness of detection of colocalization can be improved by separating color information from intensity information. Color can then be represented using an angle histogram, created by compensating for discretization noise. Standard methods for histogram-based classification are thereafter applied to detect red, green, and colocalized pixels.

16. **Blind Spectral Unmixing in Fluorescence Microscopy**
Milan Gavrilovic, Carolina Wählby
Funding: EU-Strep Project ENLIGHT; TN-faculty, UU
Period: 0901–
Abstract: Background fluorescence, also known as autofluorescence, and cross-talk are two problems in fluorescence microscopy that stem from similar phenomena, often solved by spectral unmixing. When biological specimens are imaged, the detected signal often contains contributions from fluorescence originating from sources other than the imaged fluorophore. This fluorescence could either come from the specimen itself (background fluorescence), or from fluorophores with partly overlapping emission spectra (cross-talk or bleed-through). In order to resolve spectral components at least two distinct wavelength intervals have to be imaged or used for excitation. To perform classical spectral unmixing, spectral signatures, a representation of the emission spectra, need to be recorded beforehand for all relevant fluorophores. In situations when spectral signatures are unknown, the method based on spectral decomposition is employed for extraction of parameters for blind linear or nonlinear spectral unmixing. The algorithm also saves time and space for storage of multispectral images as only two channels need to be recorded and processed.

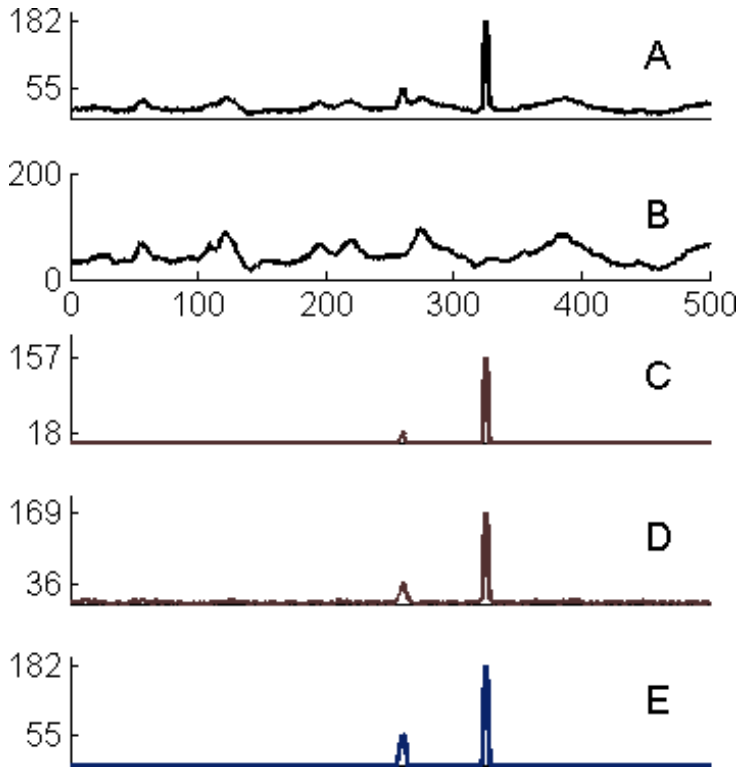


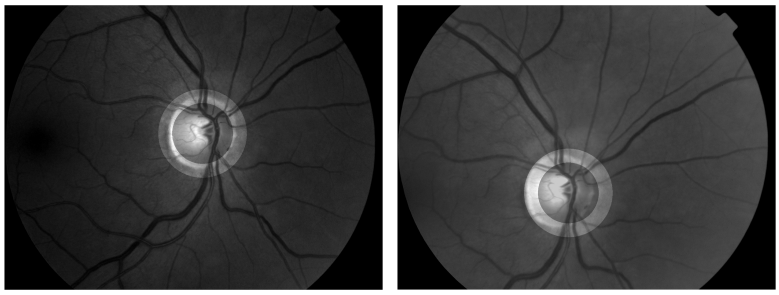
Figure 5: An example taken from the study of protein complex formation in brain tissue. Intensity distribution over one spatial dimension shows: (A) two signals over the background (one weak and one strong); (B) background; (C, D) the result of linear unmixing with two different parameter settings – either the weak signal is suppressed or fluorescence background is not completely suppressed; (E) the result of nonlinear unmixing indicating that original signal intensities were preserved and background completely suppressed.

17. **Spectral Image Analysis in Biomedical Applications**
    Milan Gavrilovic, Carolina Wählby
    Partners: Irene Weibrecht, Tim Conze, Malin Jarvius, Ola Söderberg, Ulf Landegren, Dept. of Genetics and Pathology, UU
    Funding: EU-Strep Project ENLIGHT; TN-faculty, UU
    Period: 0807–
    Abstract: Methods developed in Projects 15 and 16 were applied in a variety of biological applications in cooperation with Molecular Tools group at the Dept. of Genetics and Pathology. One application of the method for detection of colocaliziation deals with detection of double and single coloured point-like fluorescent signals. The aim is precise quantification of DNA-protein interactions that could help biologists deciding if a gene is missregulated in a disease or how a certain treatment affects the expression of a target gene. In a similar biomedical application of image analysis methods, angle histograms are used to estimate the quality in oligonucleotide production. We were recently investigating differences between synthetic oligonucleotide probes and enzymatically prepared clones. Finally, algorithms for blind spectral unmixing were used for automated suppression of background fluorescence due to presence of lipofuscin and hemoglobin in brain tissue. Fig. 5 shows the result of background suppression and amplification of the true signals.

18. **Monitoring Cell Growth by Wavelet Based Texture Classification**
Amalka Pinidiyaarachchi, Carolina Wählby
Partner: Hans Claesson, Histogenics Corporation, Waltham, MA, USA.
Funding: SIDA IT-Project
Period: 0806–0904
Abstract: Monitoring cell confluence is valuable for optimization of cell culture parameters and cell harvest. In this Project, we are developing an automatic method for quantifying cell confluence of a time sequence of fibroblasts imaged using phase contrast microscopy. Using wavelet based texture features we classify images into regions consisting of interphase cells and proliferating and/or necrotic cells. The results agree with direct observations of the cell culture and the method shows the potential of being part of an automatic cell culturing system indicating when the cells have reached the desired level of confluence. The ability to detect necrosis also provides a warning system that indicates if the cultures are failing.

19. **Parallax Error Correction in Retinal Image Registration**
Khalid Niazi, Bettina Selig, Ewert Bengtsson, Ingela Nyström
Partners: Albert Alm, Dept. of Neurosciences, Ophthalmology at UU
Funding: COMSATS IIT, Islamabad
Period: 0711–
Abstract: Retinal imaging is one of the main sources in ophthalmology to study the optical nerve head and the retina. Retinal images are often used for analyzing, diagnosing and treating a number of diseases of the human retina. Image registration plays an important role in determining the progression of retinal illness. In the current Project, we are developing a method which will help in evaluation of glaucoma progression. We are especially concentrating on correction of parallax error, which is normally produced due to a change in the angular position of the camera.

Retinal image registration can be performed between either the full images or within sub-regions. The movement of vessels makes it illogical to perform registration between full images. Using a sub-region which is least effected by vessel movement will present a true picture of the vessel movement. The vessels inside the optic disc, which lie close to the origin, move with time and often get overexposed during imaging. It has also been reported that the end of the vessel gets detached from the surface of the retina due to loss of the nerve fibers which leaves us to use the area around the border of the optic disc as shown in Figure 6 for registration. Retinal images are normally suffering from noise. We have used bilateral filtering for noise removal. Bilateral filtering is well-known to reduce noise while preserving the edges at the very same time. This process is followed by edge detection which is performed using first order absolute moment (FOAM). FOAM is good at edge detection and localization but is very sensitive to noise. Preprocessing by bilateral filtering makes FOAM an ideal candidate for edge detection. In order to detect the optical disc boundary, a snake is initialized at the image border, where the edge image will serve as potential function for the snake. The introduction of bilateral filtering and FOAM has given us the freedom to initialize the snake quite far away from the optical disc. Thereafter a sub-region is defined automatically around the optic disc as shown in Figure 6. We have successfully used particle swarm optimization (PSO) for area-based registration of these sub-regions. The study has also resulted in development of a modified version of PSO. The modified version utilizes benefits from the Gaussian and the uniform distribution, when updating the velocity equation in the PSO algorithm. Which one of the distributions is selected depends on the direction of the cognitive and social components in the velocity equation. This direction checking and selection of the appropriate distribution provide the particles with an ability to jump out of local minima. The registration results achieved by this new version proves the robustness and its ability to find a global minimum.



(a) Reference image (b) Floating image

Figure 6: The superimposed circular sub-regions are used for registration.

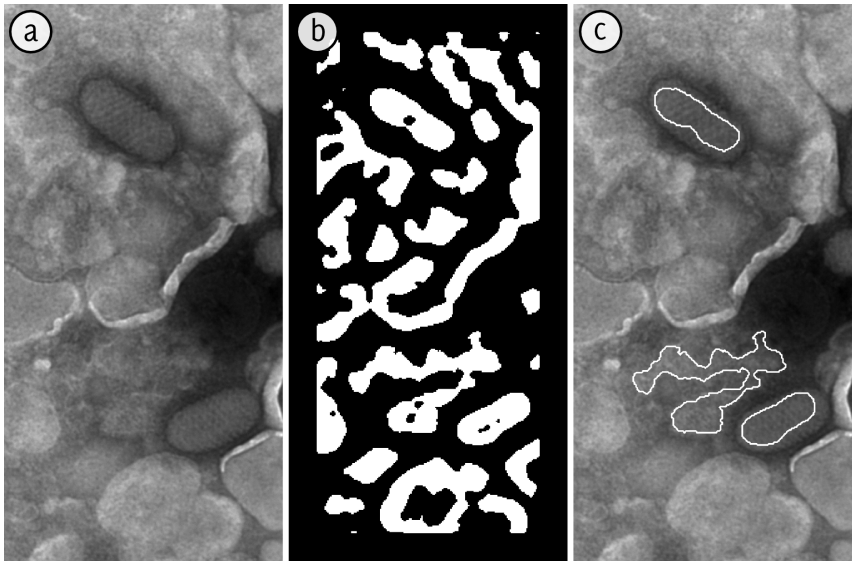


Figure 7: A sample result of the local intensity based segmentation method. a) original image, b) segmentation and c) final, postprocessed, segmentation result overlaid on the original image. The two ovals, top and bottom, are viruses.

20. **Identification of Highly Pathogenic Viruses in Transmission Electron Microscopy Images**
Gustaf Kylberg, Ida-Maria Sintorn, Ewert Bengtsson, Gunilla Borgefors
Partners: Vironova AB; Ali Mirazimi, Kjell-Olof Höglund, Centre for Microbiological Preparedness; Swedish Institute for Infectious Disease Control (SMI)
Funding: Swedish Emergency Management Centre (KBM), Swedish Defense Materiel Administration (FMV), Swedish Agency for Innovative Systems (VINNOVA)
Period: 0801–
Abstract: This Project aims at automating the virus identification process in high resolution TEM images and thereby creating a rapid, objective, and user independent virus diagnostic system. The task consists of method development for segmenting virus particles with different shapes and sizes in high magnification images, see Figure 7, and extracting descriptive features to enable classifying the virus species. The automatic acquisition process of high magnification images is developed in Project 21. The Project was presented orally at the 6th International Symposium on Image and Signal Processing and Analysis (ISPA) in Salzburg, Austria.

21. **Detection of Regions of Interest for Automated Image Acquisition in Virus Diagnostics**
Gustaf Kylberg, Ida-Maria Sintorn, Ewert Bengtsson, Gunilla Borgefors
Partners: Vironova AB; Ali Mirazimi, Kjell-Olof Höglund, Centre for Microbiological Preparedness; Swedish Institute for Infectious Disease Control (SMI)
Funding: Swedish Emergency Management Centre (KBM), Swedish Defense Materiel Administration (FMV), Swedish Agency for Innovative Systems (VINNOVA)
Period: 0801–
Abstract: Transmission electron microscopy (TEM) is an important virus diagnostic tool. The main drawback is that an expert in virus appearance in electron microscopy is needed to perform the search for virus particles and identification at the microscope. Especially the search for virus particles is often a very time consuming task. This Project aims at identifying regions likely to contain viruses in low magnification images to enable automation and making the image acquisition process more efficient. This is one step towards automating the diagnostic process and thereby creating a rapid, objective, and user independent virus diagnostic system. Using our region identification, we can concentrate the analysis on only 0.01% of the total sample area. The subsequent segmentation and classification process is developed in Project . The Project was presented orally at the 16th Scandinavian Conference on Image Analysis (SCIA) in Oslo, Norway.

22. **Analysis of Virus Morphology in Electron Microscopy Images**
Ida-Maria Sintorn
Partner: Vironova AB
Funding: VINNMER programme, Swedish Agency for Innovative Systems
Period: 0801–
Abstract: Electron Microscopy allows for studying virus morphology at the nm level. This means that structural differences between virus maturation stages, related virus species, wild type virus and virus treated with a potential drug or a small molecule can be analyzed. Both external (shape and protein patterns on the virus surface) and internal structural differences can be analyzed. In this Project methods for identifying and quantifying such structural differences are developed.

23. **High Content Analysis (HCA) Method Development for Cellular Screening**
Ida-Maria Sintorn
Partners: Adrian Baddeley, Michael Buckley, Leanne Bischof, CSIRO Mathematical and Information Sciences, Australia, Stephen Haggarty, Broad Institute of Harvard and MIT, USA
Funding: SLU, VINNMER programme, Swedish Agency for Innovative Systems
Period: 0901–
Abstract: In biological research and in the drug development process when screening for new drugs, HCA systems are often used. Such a system is a fully automatized microscopy system that acquires hundreds or thousands of images in an experiment and automatically extracts information from the image data. In this Project we develop pre-processing tools to allow for improved comparison of image content within and across cellular screening experiments. We also develop methods and new statistical analysis tools for so called co-culture HCA experiments i.e., when more than one celltype are cultured together to allow for investigating their interaction in response to added substrates.

24. **A Multidisciplinary Approach to Establish Mechanisms for Mitochondrial DNA Segregation in Human Disease**
Amin Allalou and Carolina Wählby
Partners: Nils-Göran Larsson, Karolinska Institute; Mats Nilsson, Dept. of Genetics and Pathology, UU
Funding: The Swedish Research Council, Collaboration Grant, Medicine

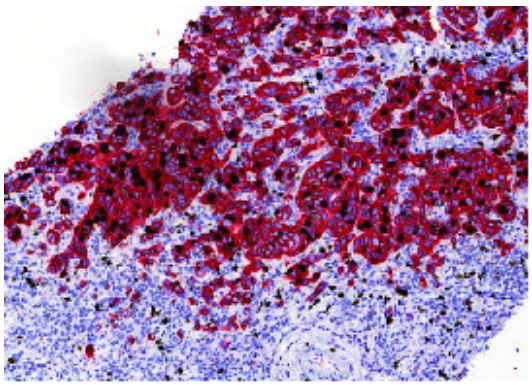


Figure 8: Sample of sentinel lymph node stained for analyzing the proliferation rate of cancer cells. This specific staining is a Immunohistochemic double-staining using Ki-67 and KL-1.

Period: 080101–
Abstract: Mutations of mitochondrial DNA (mtDNA) cause genetic syndromes with widely varying phenotypes and are also implicated in many age-associated diseases and the ageing process itself. Our knowledge of the principles governing segregation of mtDNA mutations in somatic tissues and in the germ line is very limited. In this collaborative Project we combine a powerful technique for detection of individual mtDNA molecules with image analysis. We work with a variety of mouse models and the goal is to develop image analysis software to do three-dimensional (3D) reconstruction of the distribution of mutated mtDNA molecules in mammalian tissues. We want to use this technology to study segregation of mtDNA mutations in mouse tissues and to study the mtDNA bottleneck by visualizing the distribution of mutated mtDNA during oogenesis. The ultimate goal is to study the distribution of mtDNA mutations in embryos and placenta to establish principles for prenatal diagnosis.

25. **Combating Breast Cancer by Digital Pathology**
Andreas Kårsnäs, Robin Strand, Ewert Bengtsson, Stefan Seipel
Partners: Visiopharm, Hörsholm, Denmark and Clinical Pathology Division, Vejle hospital, Vejle, Denmark
Funding: NordForsk Private Public Partnership PhD Programme and Visiopharm
Period: 0909–
Abstract: The results of analyses of tissue biopsies by pathologists are crucial for breast cancer patients. In particular, the precision of a patient's prognosis, and the ability to predict the consequences of various treatment opportunities before actually exposing the cancer patient, depend on the detection and quantification of biomarkers in tissue sections by microscopy. Experience from the last decade has revealed that manual detection and quantification of biomarkers by microscopy of tissue biopsies is highly dependent on the competencies and stamina of the individual pathologist. The aim of the present PhD Project is to develop software-based algorithms, which can facilitate the workflow and ensure objective and more precise results of the quantitative microscopy procedures in breast cancer. During the fall 2009, some initial steps have been taken to develop and evaluate user interfaces supporting pathologists and ensuring objective and more precise results of the quantitative microscopy procedures in breast cancer. In collaboration with Vejle hospital and Visiopharm, a method for determining the possibilities to automatically analyze the proliferation rate of cancer cells using color segmentation has been developed.

26. **Automatic, Quantitative Malignancy Grading of Prostate Cancer using Image Analysis**
Ingrid Carlbom, Ewert Bengtsson
Partners: Christer Busch, University Research Hospital, Uppsala, Marene Landström, University Research Hospital
Funding: Swedish Research Council
Period: 090415–
Abstract: The goal of this Project is to replace subjective diagnosis of prostate cancer with automatic severity grading using image analysis. This will be done by combining methods for tissue staining with image analysis methods that makes it possible to distinguish cancer from normal tissue and to extract morphological features that are linked to aggressive cancer. An objective quantitative method would greatly improve prognostication and provide a firm basis for selecting the best possible course of treatment for each patient. During 2009 we secured three years of funding from the Swedish Research Council.

5.3 3D Analysis and Visualization

27. **Improved Interactive Medical Image Analysis Through Haptic Display methods**
Filip Malmberg, Erik Vidholm, Ingela Nyström, Ewert Bengtsson, Stefan Seipel
Partners: Lennart Thurfjell, GE Healthcare, Uppsala/London, UK; Gunnar Jansson, Dept. of Psychology, UU;
Funding: Swedish Research Council; TN-faculty, UU
Period: 0301–
Abstract: Modern medical imaging techniques provide 3D images of increasing complexity. Better ways of exploring these images for diagnostic and treatment planning purposes are needed. Combined stereoscopic and haptic display of the images form a powerful platform for such image analysis. In order to work with specific patient cases, it is necessary to be able to work directly with the medical image volume and to generate the relevant 3D structures as they are needed for the visualization. Most work so far on haptic display use predefined object surface models. In this Project, we are creating the tools necessary for effective interactive exploration of complex medical image volumes for diagnostic or treatment planning purposes through combined use of haptic and 3D stereoscopic display techniques. The developed methods are tested on real medical application data. Our current applications are interactive liver segmentation from CT images, see Project 36, hardware assisted visualization of breast MR images, see Project 28, and interactive segmentation of back muscles in MR images, see Project 29. A software package for interactive visualization and segmentation developed within this Project has been released under an open-source license. The package is available for download at `http://www.cb.uu.se/research/haptics`. In 2009, this Project was presented at the International Conference on Pattern Recognition and Information Processing (PRIP 2009), where Nyström was invited speaker.

28. **Analysis of Dynamic Breast MRI**
Ewert Bengtsson, Ingela Nyström
Partners: Stuart Crozier, Andrew Mehnert, ITEE Dept., University of Queensland, Brisbane, Australia
Funding: TN-faculty, UU; The Australian Research Council
Period: 0503–
Abstract: The pattern of change of signal intensity over time in contrast enhanced magnetic resonance (MR) images of the breast is a useful indicator of malignancy. The methods used for assessing and visualizing this in current clinical practice are tedious; it is difficult to visualize and evaluate 4D (3D volumes over time) data effectively. During his sabbatical at the University of Queensland in 2004–2005, Bengtsson joined a new Project in this area which developed into a

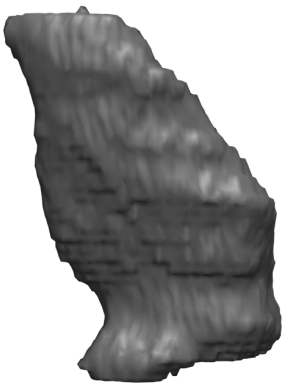


Figure 9: Surface rendering of a segmented Quadratus Lumborum muscle.

collaborative Project which is continuing. A basic concept for the visualization is to convert the time course for each voxel into a colour coded representation where intensity and saturation represents the uptake of contrast and hue represents the washout which is different for normal and malignant tissue. We thus obtain a colour coded volume image. A program where this is visualized with hardware accelerated maximum intensity Projection (MIP) in the hue-saturation-value (HSV) colour space has been developed. Currently the resulting visualizations are being evaluated on a larger material collected in Brisbane.

29. **Interactive Segmentation of Back Muscles in MR Images**
Filip Malmberg, Ewert Bengtsson, Ingela Nyström
Partners: Andrew Mehnert and Craig Engstrom, ITEE Dept., University of Queensland, Brisbane, Australia
Funding: TN-faculty, UU; The Australian Research Council
Period: 0803–
Abstract: In cricket fast bowlers, substantial volume asymmetries of the quadratus lumborum (QL) muscle have been associated with a significantly increased risk of developing lumbar spine stress fractures. In this Project, we aim to measure such asymmetries by segmenting the QL muscle in MR images. At the University of Queensland, an automatic segmentation method has been developed for this purpose. The method uses a shape atlas, built from a large number of reference segmentations, to segment a specific muscle. Currently, we are investigating if interactive segmentation methods can be used to accelerate the creation of reference segmentations. By accelerating this process, we make it easier to adapt the atlas-based automatic segmentation method to other interesting muscles. A 3D visualization of a segmented QL muscle is shown in Figure 9

30. **Orbit Segmentation for Craniomaxillofacial Surgery Planning**
Filip Malmberg, Ewert Bengtsson, Ingela Nyström
Partners: Jan Michael Hirsch and Elias Messo, Dept. of Surgical Sciences, UU Hospital
Funding: TN-faculty, UU. NovaMedTech
Period: 0912–
Abstract: A central problem in cranio-maxillofacial (CMF) surgery is to restore the normal anatomy of the skeleton after defects, i.e., malformations, tumors and trauma to the face. This is particularly difficult when a fracture causes vital anatomical structures such as the bone segments to be displaced significantly from their proper position, when bone segments are missing, or when a bone segment is located in such a position that any attempt to restore it into its original position

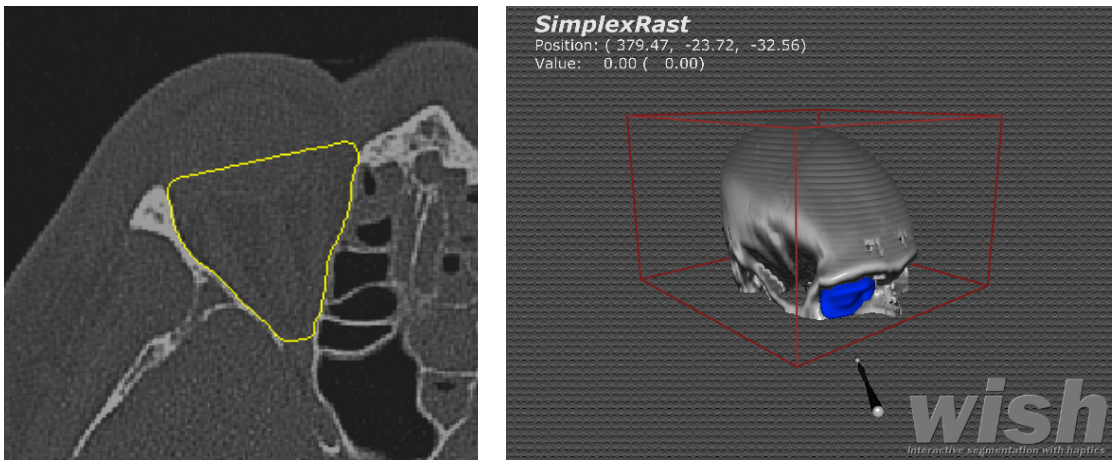


Figure 10: (Left) A segmentation of the orbit in a 2D slice from a CT volume. (Right) A preliminary 3D segmentation of the orbit in a CT volume.

poses considerable risk for causing further damage to vital anatomical structures such as the eye or the central nervous system. There is ample evidence that careful pre-operative planning can significantly improve the precision and predictability and reduce morbidity of the craniofacial reconstruction. In addition, time in the operating room can be reduced. An important component in surgery planning is to be able to accurately measure the extent of certain anatomical structures. Of particular interest in CMF surgery are the shape and volume of the orbits (eye sockets) comparing the left side with the right side. These properties can be measured in CT images of the skull, but this requires accurate segmentation of the orbits. Today, segmentation is usually performed by manual tracing of the orbit in a large number of slices of the CT image. This task is very time-consuming, and sensitive to operator errors. Semi-automatic segmentation methods could reduce the required operator time significantly. In this Project, we are developing a prototype of a semi-automatic system for segmenting the orbit in CT images. Segmentations obtained with an early version of this system are shown in Figure 10.

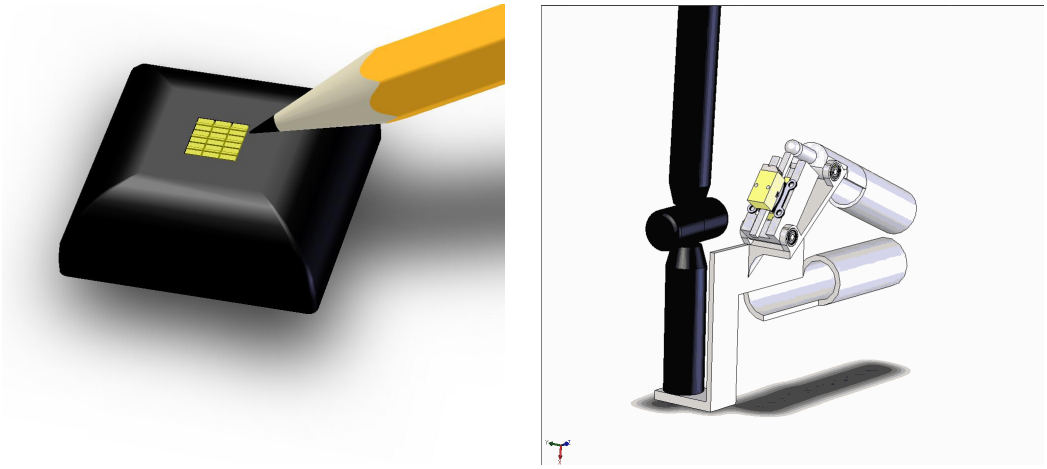
31. **Efficient Algorithms for Computer Graphics**
Ewert Bengtsson, Anders Hast
Partner: Tony Barrera, Uppsala
Funding: TN-faculty, UU
Period: 9911–
Abstract: Computer graphics is increasingly being used to create realistic images of 3D objects for applications in entertainment, (animated films, games), commerce (showing 3D images of products on the web), industrial design and medicine. For the images to look realistic high quality shading and surface texture and topology rendering is necessary. A proper understanding of the mathematics behind the algorithms can make a big difference in rendering quality as well as speed. We are in this Project re-examining some of the established algorithms and are finding new mathematical ways of simplifying the expressions and increasing the implementation speeds without sacrificing image quality. We have also invented a number of completely new algorithms. The Project is carried out in close collaboration with Tony Barrera, an autodidact mathematician. It has been running since 1999 and resulted in more than 25 international publications and a PhD thesis.

32. **Feeling is Believing**
Ingrid Carlbom, Ewert Bengtsson, Robin Strand
Partners: Stefan Johansson (Teknovest AB), Roland Johansson, Dept, of Neurophysiology, Umeå Uni-

versity; PiezoMotors AB.
Funding: Knowledge Foundation (KK Stiftelsen)
Period: 090501–
Abstract: Preliminary study of a tactile fingertip actuator array. We are building an interaction device that will form an experimental prototype for a tactile fingertip actuator array that generates a texture. See Project 33, Whole Hand Haptics with True 3D Displays.

33. **Whole Hand Haptics with True 3D Displays**
Ingrid Carlbom, Ewert Bengtsson, Robin Strand, Martin Ericsson, Filip Malmberg, Ingela Nyström, Stefan Seipel
Partners: Jonny Gustafsson and Lars Mattson, Industrial Metrology and Optics Group, KTH; Jan-Michaél Hirsch, Dept. of Surgical Sciences, Oral & Maxillofacial Surgery, at UU and Consultant at Dept. of Plastic- and Maxillofacial Surgery, UU Hospital; Gunnar Jansson, Dept. of Psychology, UU; Stefan Johansson (Teknovest AB), Roland Johansson, Dept, of Neurophysiology, Umeå University; Håkan Lanshammar, Dept. of Information Technology, UU; PiezoMotors AB, Imagination Studios; SenseGraphics AB.
Funding: Knowledge Foundation (KK Stiftelsen)
Period: 090810–
Abstract: We are building an augmented reality system which will allow users to touch and manipulate high contrast, high resolution, three-dimensional (3D) virtual objects suspended in space using a glove that gives realistic whole hand haptic feedback both in terms of force feedback to the finger joints and tactile feedback to the fingertips. Three-dimensional visualization and haptics are very active research areas and there are numerous commercial products and research papers discussing various aspects of these topics. However, none of these systems provide anywhere near the functionality that we are aiming for in terms of haptic fidelity and of unaided 3D visual perception for multiple users. Our driving application is cranio-maxillofacial surgery, giving a surgeon the ability to plan complex procedures, moving bone and implants into their desired positions and then stretching the soft tissue to accommodate the structural changes. However, the system is not limited to this application but will significantly enhance other applications in, for example, computer-aided design, training simulators for object assembly, and 3D games. During 2009 we acquired the robot arm from which we will attach the haptic glove. We have also acquired and tested the Projectors for the display system. Finally we completed the designs of the first generation of the holographic display and as well as the first prototypes of the touch pad and one joint for the glove (see Figure 11).

34. **ProViz – Interactive Visualization of 3D Protein Images**
Lennart Svensson, Stina Svensson, Ingela Nyström, Ewert Bengtsson, Ida-Maria Sintorn
Partners: Dept. of Cell and Molecular Biology, Karolinska Institute; SenseGraphics AB
Funding: The Visualization Program by Knowledge Foundation; Vaardal Foundation; Foundation for Strategic Research; VINNOVA; Invest in Sweden Agency
Period: 0807–
Abstract: The traditional methods for solving the structure of proteins are X-ray crystallography and NMR spectroscopy. An alternative approach, Molecular Electron Tomography (MET), has more recently gained interest within the field of structural biology as it enables studies of individual structures in tissue at nanometer scale, whereas the old methods only allowed studies in solution. Another important fact is that MET enables studies of the dynamics of proteins. As MET results in images of low resolution (lower than, e.g., X-ray crystallography) and low signal-to-noise ratio a new kind of software for postprocessing is required, which allows for proper visualization and analysis, as well as data fusion with measurements from X-ray crystallography and NMR. The target of the ProViz Project is to create these software tools. Our approach is to use stereo visual-



(a) (b)

Figure 11: Drawings of the first prototypes of the touch pad and one joint for the glove.

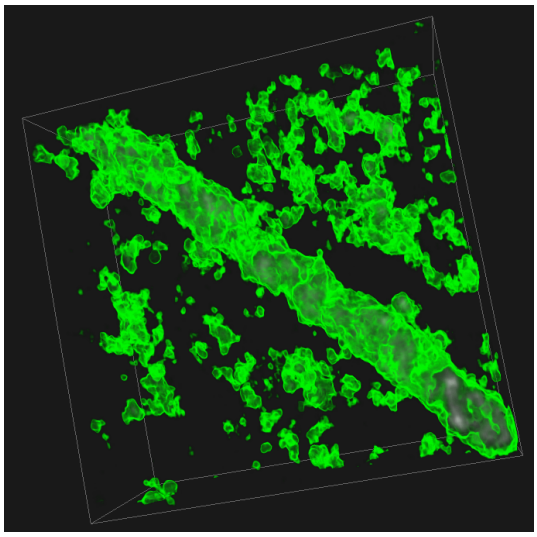


Figure 12: The Tobacco Mosaic Virus visualized according to an automatic visualization scheme, with a transfer function that consists of Gaussians and piecewise-linear primitives.

ization and haptic rendering of the images in order to facilitate a good understanding of the data as well as interactivity in semi-automatic methods. During 2009, our focus has been on methods for automatical parameter generation for transfer functions in the volume rendering of MET data-sets. One example of a MET data set rendered through these methods can be seen in Figure 12.

In October 2009, the ProViz Project was represented on a journey to Tokyo, Japan, organized by Invest in Sweden Agency and Knowledge Foundation through the Visualization program. One part of the journey was a *Visualization Seminar* with oral presentations and an exhibition. The seminar was held at the Swedish Embassy and had around seventy participants from Japanese Universities and companies. During the exhibition, we visualized MET data-sets, preprocessed by methods developed in the Project to facilitate the interpretation of the data, in stereo for the first time.

Figure 13: Lateral ventricles of a human brain, segmented from an MR volume image using 20 single-voxel seed-points. A polygonal surface was extracted from the segmented volume using the Marching Cubes algorithm, which takes sub-pixel information into account. Both segmentations were produced using the same seed-points. (Left) Surface extracted from crisp IFT segmentation. (Right) Surface extracted from sub-pixel IFT segmentation.

35. **Improved Methods for Interactive Seeded Segmentation**
Filip Malmberg, Ingela Nyström, Ewert Bengtsson
Funding: TN-faculty, UU
Period: 0901–
Abstract: Image segmentation, the process of identifying and separating relevant objects and structures in an image, is a fundamental problem in image analysis. Accurate segmentation of objects of interest is often required before further processing and analysis can be performed. Despite years of active research, fully automatic segmentation of arbitrary images remains an unsolved problem.

Seeded segmentation methods attempt to solve the segmentation problem in the presence of prior knowledge in the form of a partial segmentation. Given an image where a small subset of the image elements (called *seed-points*) have been assigned correct segmentation labels (e.g., object or background), an automatic algorithm completes the labeling for all image elements. The seed-points may be provided either by some automatic pre-processing algorithm, or by a human user in an interactive setting.

This Project concerns the development of general tools for interactive seeded segmentation. In particular, we are studying methods based on the Image Foresting Transform (IFT). In an article published at the 13th International Workshop on Combinatorial Image Analysis (IWCIA'09), we presented the sub-pixel IFT, which allows region boundaries to be located with sub-pixel precision. An illustration of a segmentation obtained with the sub-pixel IFT is shown in Figure 13.

36. **Interactive Organ Segmentation from Abdominal CT Images**
Filip Malmberg, Ingela Nyström, Ewert Bengtsson
Partners: Sven Nilsson, Milan Golubovic, Dept. of Oncology, Radiology, and Clinical Immunology, UU Hospital
Funding: Swedish Research Council; TN-faculty, UU
Period: 0501–
Abstract: The manual step in semi-automatic segmentation of medical volume images typically involves initialization procedures, such as placement of seed-points or positioning of surface models inside the object to be segmented. The initialization is then used as input to an automatic segmentation algorithm. We investigate how such initialization tasks can be facilitated by using

haptic feedback. In this Project, we develop interactive methods for segmenting the organs from abdominal CT scans. For example, liver segmentation is of importance in hepatic surgery planning, where it is a first step in the process of finding vessels and tumours, and the classification of liver segments. Liver segmentation may also be useful for monitoring patients with liver metastases, where disease progress is correlated to enlargement of the liver. We have developed a fully 3D liver segmentation method where high accuracy and precision is efficiently obtained via haptic interaction in a 3D user interface. Our method makes it possible to avoid time-consuming manual delineation, which otherwise is a common option prior to, e.g., hepatic surgery planning. Currently, we are incorporating and adapting region-based segmentation methods, such as the image foresting transform (IFT), into our software. Figure 14 illustrates interactive organ segmentation with IFT.

37. **CerviScan**
Ewert Bengtsson, Patrik Malm, Hyun-Ju Choi, Carolina Wählby, Bo Nordin
Funding: Vinnova
Period: 0801–
Abstract: Cervical cancer is killing a quarter million women every year. Screening based on so called PAP-smears have proven very effective to reduce cancer mortality but require much work of well trained cytotechnologist. For 50 years research to automate the screening has been in progress, Bengtsson was very active in this field 1973-1993. Since about 10 years, commercial automated systems have been in operation but unfortunately those systems have many limitations.

In India there is no effective screening program in operation and around 70,000 women die from the disease each year. Now an effort to develop a screening system adapted to Indian situation has started at the research institute CDAC in Thiruvananthapuram, Kerala in cooperation with the Regional Cancer Centre there. Based on our earlier experience in the field CBA has been invited to collaborate with this Project and we have received support from Vinnova and VR for this. We will in particular study whether the 3D chromatin texture of the cervical cells can be utilized as a robust feature for detecting (pre-) cancerous lesions.

Initial work on the Project started at CBA during 2008 but the main Project was kicked off at a meeting in India in early December 2009.

As always the image segmentation is a crucial part of solving the problem and a paper on a new approach to segmentation of cervical cells was presented at the International Symposium on Visual Computing in November 2009. One problem when developing new algorithms is to evaluate the performance and to compare the effects on different parameter settings. As a new approach to that problem a generator for synthesized PAP-smear images was created and described in a paper which was submitted to ISBI 2010.

Dr Hyun-Ju Choi from Korea has studied 3D nuclear texture for other applications and she has received a scholarship to be a visiting researcher at CBA November 2008 to November 2009, see Project 39. Her stay has been extended until May 2010 to make it possible to relate her results to this Project.

38. **Trabecular Bone Characterization from 3D Micro-CT Images**
Cris Luengo
Partner: Manuel Herrera Lara, University of Alicante, Spain
Funding: S-faculty, SLU
Period: 0908–
Abstract: Osteoporosis is a common disease among ageing adults that can be disabling when severe. In Europe, osteoporotic fractures are responsible for a higher disease burden (in terms of disability and excess mortality) than any common cancer except lung cancer. Women over 45

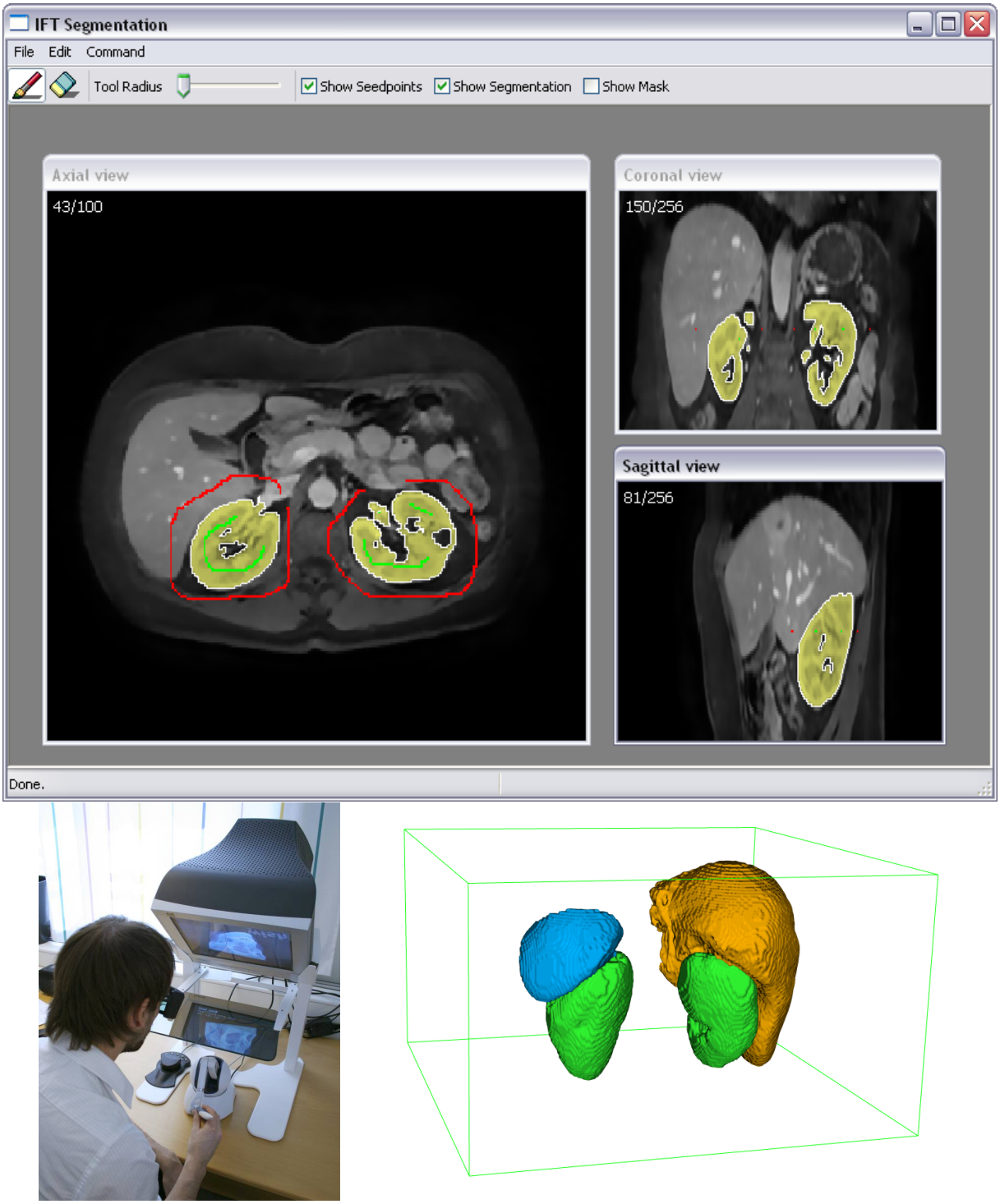


Figure 14: (Top) A user segments organs in a CT image by placing seed-points representing organ and background, respectively. The segmentation is updated dynamically in real-time. (Bottom left) A user working with the haptic display. (Bottom right) Final segmentation of a number of organs.

spend, on average, more days in hospital due to osteoporosis than due to many other diseases, including diabetes, breast cancer and myocardial infarction. In the year 2000, there were an estimated 3.79 million osteoporotic fractures in Europe, one fourth of which were hip fractures. Hip

fractures are associated with serious disability and estimated mortality rates of up to 24% in the first year after fracture. The incidence rate has increased significantly since then, and is expected to continue increasing due to our increased longevity.

Improved understanding of osteoporosis will lead to better screening, diagnosis, treatment and prevention of the disease. As a contribution to this understanding, the proposed Project aims at developing better methods to quantify structural properties of trabecular bone from micro-CT images. Osteoporosis affects primarily the trabecular bone, which undergoes structural changes. These changes are the main cause of bone fragility. Being able to characterise the trabecular structure is therefore of great importance when studying osteoporosis. This Project will initially provide tools for increased scientific understanding of the disease, but these same tools will likely soon also be applicable to clinical diagnosis, as the in vivo imaging techniques mature.

During this year, some preliminary data was obtained, and a Project proposal has been submitted to several funding agencies.

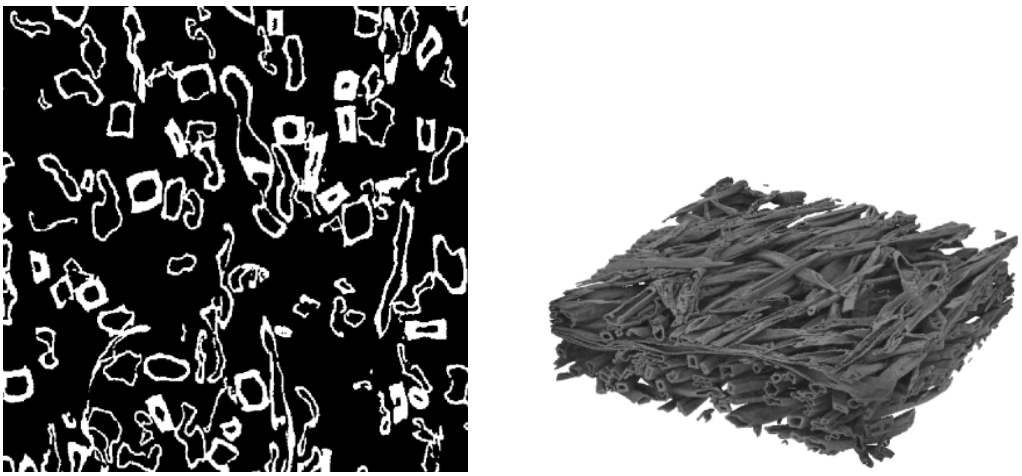
39. **3D Texture Measures for Cell Image Analysis**
Hyun-Ju Choi, Ewert Bengtsson
Funding: Korea Research Foundation and Swedish Research Council, VR
Period: 0811–1005
Abstract: Hyun-Ju Choi is a visiting researcher at CBA 2008-2010. During this time she is developing 3D texture analysis methods. The standard 2D texture analysis methods, GLCM and GLRLM, have been extended and implemented for 3D volume data. New feature sets based on fractal analysis and wavelet transform for describing quantitatively nuclear chromatin changes in 3 dimensions have been developed. The measures will during 2010 be used with real image stacks from PAP-smears to detect malignancy related changes. During 2009 earlier results from 3D texture analysis were published.

5.4 Forestry Related Applications

40. **Image Analysis of the Internal Structure of Paper and Wood Fibre Based Composite Materials in 3D images**
Maria Axelsson, Erik Wernersson, Anders Brun, Joakim Lindblad, Cris Luengo, Catherine Östlund, Gunilla Borgefors
Partners: Norwegian Pulp and Paper Research Institute (PFI), Trondheim, Norway; Innventia, Stockholm; Dept. of Fibre and Polymer Technology, KTH, Stockholm; Dept. of Physics, University of Jyväskylä (UJ), Finland; SINTEF Materials and Chemistry, Norway; Risø National Laboratory, Technical University of Denmark
Funding: S-faculty, SLU; WoodWisdom-Net
Period: 0406–
Abstract: The internal structure of paper is important because many material properties correspond directly to the properties of single fibres and their interaction in the fibre network. How single fibres in paper bond and how this affects paper quality is not fully understood, since most structure analysis of paper has been performed in cross-sectional, two-dimensional (2D) images and paper is a complex, three-dimensional (3D) structure, see Figure 15.

Another application for wood fibres that has recently gained interest is wood polymer composite materials. The properties of these materials do not only depend on the structure of the fibre network, but also on interaction between the fibres and the polymer matrix surrounding the fibres.

Advances in imaging technology has made it possible to acquire 3D images of paper and wood polymer composite materials. In this Project, image analysis methods for characterizing the 3D



(a) (b)

Figure 15: (a) A slice from a binarised volume image of a composite material and (b) a surface rendering of a sample of a composite material.

material structure in such images are developed. The detailed knowledge of the material structure attainable with these methods is useful for improving material properties and for developing new materials.

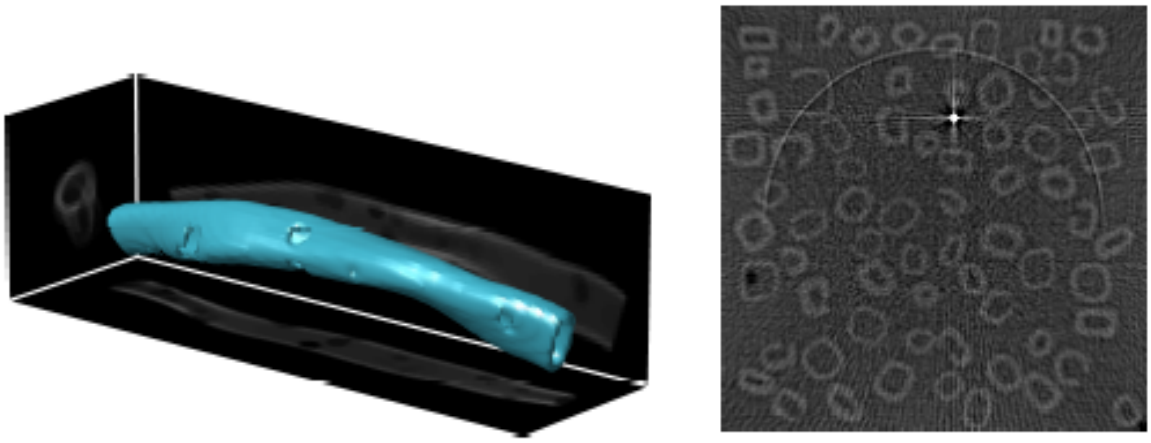
The Project objective is to achieve a complete segmentation of individual fibres and pores in volume images of the material. Given such a segmentation, any measurement of the internal structure is available. Measurements on individual fibres and the structural arrangement of fibres can then be related to macroscopical material properties.

In this Project, different volume images of paper and composite materials are available for the studies: one volume created from a series of 2D scanning electron microscopy (SEM) images at StoraEnso, Falun and X-ray microtomography volume images of paper and composite samples imaged at the European Radiation Synchrotron Facility (ESRF) in Grenoble, France, and at the Paul Scherrer Institut (PSI) in Villigen, Switzerland.

During 2009, the Project has resulted in a number of publications. A study on pore characterization of paper was published in Pattern Analysis and Applications. It includes new methods to characterize the pore network in paper materials and gives measurements that are important in understanding paper properties such as water absorption and print quality.

Two studies were presented at the 15th International Conference on Image Analysis and Processing. Among the results was a thorough study on how to select parameters when analyzing fibre directions of fibrous materials and a method to estimate the fibre radii of solid fibres and a novel segmentation algorithm.

We are also happy to announce that Maria Axelsson earned the PhD-degree with her dissertation *Image Analysis for Volumetric Characterisation of Microstructure* in March.



(a) (b)

Figure 16: (a) A synthetic and automatically generated fibre. (b) Cross section of a synthetic model with noise.

41. **Generation of Synthetic µCT Volumes**
Erik Wernersson, Cris Luengo, Anders Brun, Catherine Östlund, Gunilla Borgefors
Partners: Norwegian Pulp and Paper Research Institute (PFI), Trondheim, Norway; Innventia, Stockholm; Dept. of Fibre and Polymer Technology, KTH, Stockholm; Dept. of Physics, University of Jyväskylä (UJ), Finland; SINTEF Materials and Chemistry, Norway; Risø National Laboratory, Technical University of Denmark
Funding: S-faculty, SLU; WoodWisdom-Net
Period: 0901–
Abstract: It is of great importance to evaluate the performance and stability of new methods. Unfortunately, it is often hard to do so when working with natural materials. With this Project we aim to create highly realistic reference images that can be used to evaluate new and existing methods designed for µCT images of fibrous materials.

During this year, we developed a method to generate and pack synthetic wood fibres, and a software simulation of the µCT acquisition system that is capable of reproducing characteristic artifacts, see Fig, 16. Our paper, presented at the 6th International Symposium on Image and Signal Processing and Analysis, was the recipient of the *best paper award*.

42. **Log end Feature Extraction of Untreated Wood Logs in Saw Mill Environment.**
Kristin Norell, Stina Svensson, Gunilla Borgefors
Partners: The Swedish Timber Measurement Council (VMR), Dept. of Forest Products and Markets, SLU
Funding: The Swedish Timber Measurement Council (VMR); S-faculty, SLU
Period: 0505 –
Abstract: The wood quality of a log can be determined to some extent by examining the log end. Such analysis is performed manually at sawmills, where a grader has a couple of seconds to determine features like the approximate annual ring density, presence of rot and presence of compression wood and at the same time take into account information about size and shape of the log as it passes on a conveyor. By using computerized image analysis, grading the number of annual rings can be more robust and take some work load off the grader. In this Project, methods to measure properties of logs in saw mill environment using computerized image analysis is developed.

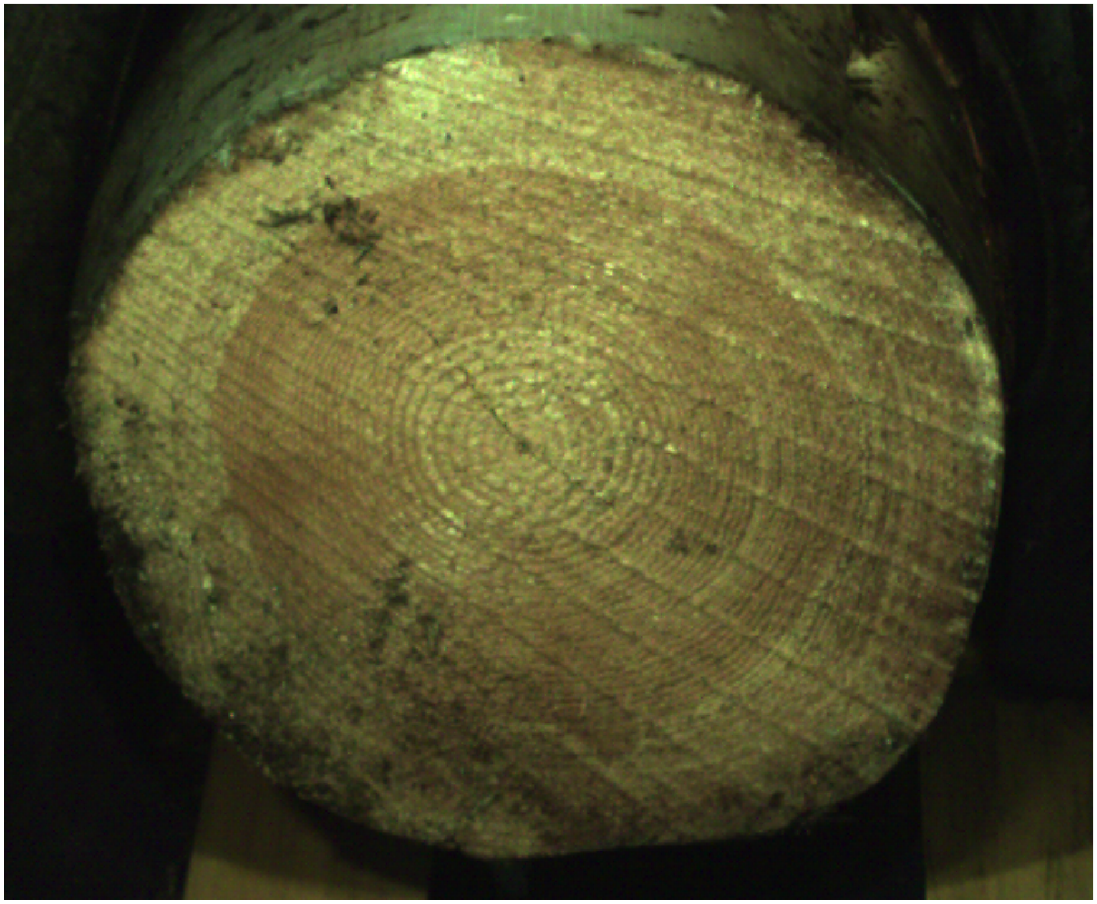


Figure 17: Example of an end face image. The image is captured at a sawmill measurement station using a mounted end face camera.

The images used are log end images of Norway spruce (*Picea abies* (L.) H.Karst) and Scots pine (*Pinus sylvestris* L.) captured in a sawmill environment. Logs are sawn with a regular harvester or chainsaw and stored for various times before imaging. The end faces are depicted using either a system camera or an a camera more suitable for industrial applications mounted at the measurement station at Setra Group Nyby sawmill.

During 2009 a article on annual ring measurements was published at the International Conference on Image Analysis and Processing (ICIAP'09). In this paper the number of rings is measured automatically in images captured using the mounted camera. A direction suitable for measurements is detected using local orientation and the Grey weighted polar distance transform (GWPDT) is applied in the chosen area to outline the annual rings. For developing the method end faces with annual ring pattern that could be delineated by visual inspection at least on some region of the end face where picked out from a larger dataset.

A thorough evaluation of the annual ring measurements was started during 2009 by capturing a dataset using the mounted end face camera. An example of an image from the dataset is shown in Figure 17. This dataset contains end faces with higher number of annual rings compared to the end faces handled in previous research which makes the task even more difficult. The included end faces were graded at the sawmill measurement station by a grader and a grading inspector for comparison, and ground truth was determined by the grading inspector. Preliminary measurements show that the automatic method performs as well as the manual grader at the measurement station.

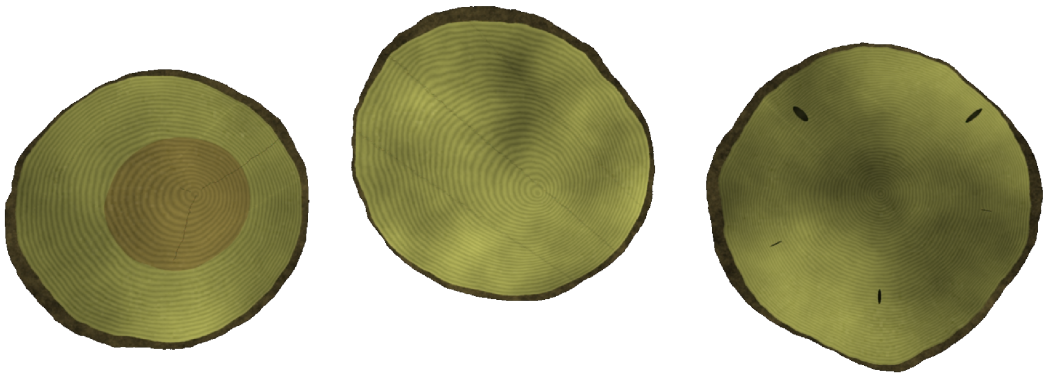


Figure 18: Image examples from the synthetic dataset.

43. **Generating Synthetic Log end Face Images**
Kristin Norell, Gunilla Borgefors
Partners: The Swedish Timber Measurement Council (VMR), Dept. of Forest Products and Markets, SLU
Funding: The Swedish Timber Measurement Council (VMR), SLU S-faculty
Period: 0901–
Abstract: A small dataset or lack of ground truth can be a problem when developing and evaluating image analysis methods. In such cases synthetic images can be useful as a complement to real data. In this Project a generator for synthetic end face images was developed.

    End face features are generated according to the procedure of tree growth, including annual rings, knots, heartwood and bark. Also other features are simulated, such as unevenness and roughness from harvesting, camera setup, illumination, and imaging, including colour noise due to Bayer filtering.

    An article was published during 2009 at the International Symposium on Image and Signal Processing and Analysis (ISISPA'09). Code for generating data was made public at `http://www.cb.uu.se/~kristin/research.html` together with 100 synthetic images. Three of these images are shown in Figure 18.

44. **Detection of Rot in End Faces of Wood Logs**
Kristin Norell, Stina Svensson, Gunilla Borgefors
Partners: Kim Dralle, Anders Björholm Dahl, Dralle A/S, Copenhagen, Denmark
Funding: S-faculty, SLU; Stiftelsen Mauritz Carlgrens fond
Period: 0612 –
Abstract: The focus of this Project is image analysis methods for identifying rot in log end faces. The purpose is to detect rot already while harvesting, or when the logs are in a stack waiting for transport. Logs are depicted using a standard color digital camera that can be mounted on a harvester or a vehicle. The goal is to find a robust method for detecting rot in timber suitable for practical use.

45. **Quantification of the Quality of Wood Fibres**
Bettina Selig, Cris Luengo, Gunilla Borgefors
Partners: Dept. of Forest Products, SLU
Funding: S-faculty, SLU
Period: 0709–
Abstract: The mechanical properties of wood fibres are important for many uses of this raw ma-

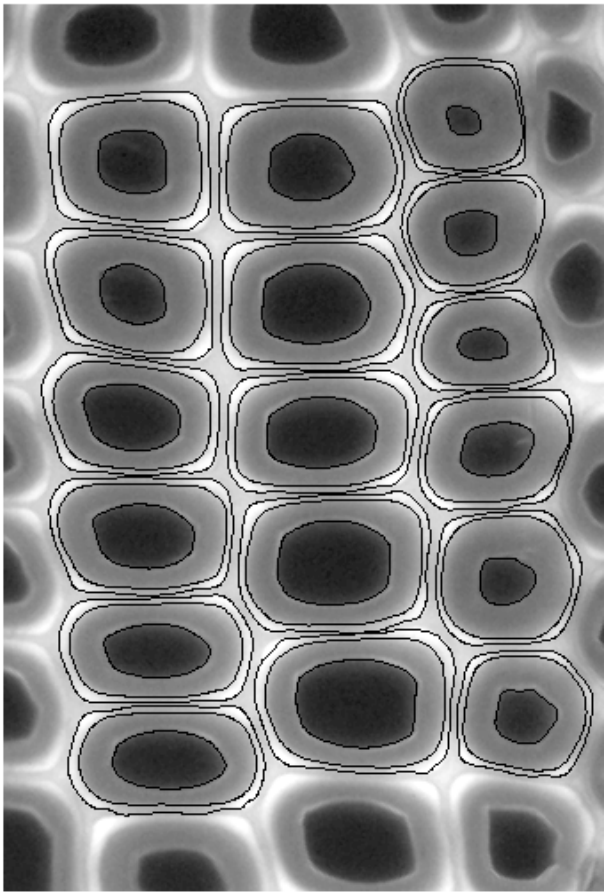


Figure 19: Segmentation of highly lignified wood fibres. The segmented areas are lumen (dark), normal lignified cell wall (medium) and highly lignified cell wall (light).

terial. In compression wood the fibres are strengthened due to their high lignin content. On the other hand, the fibres become stiffer and more difficult to collapse which is negative regarding paper production. By observing the autofluorescence of lignin on fibre cross-sections with a UV-light microscope, the highly lignified zones in the fibre walls can be made visible, as they emit more light than other parts of the fibre walls. The goal of this Project is to develop an automatic method to detect and measure highly lignified areas and relate them to the area of the whole cell wall. The task is much complicated by the fact that edges are notoriously fuzzy in flourescence images. We have presented our progress at the 16th Scandinavian Conference on Image Analysis (SCIA 2009) in Oslo with the paper *Segmentation of Highly Lignified Zones on Wood Fibre Cross-Sections* (Figure 19). The next step is to improve and apply this method on a larger amount of images. Eventually the measured data can be used to improve the knowledge about compression wood.

46. **Three-dimensional Paper Sheet Structure Analysis Based on Image Analysis**
Catherine Östlund
Partners: Innventia, Stockholm
Funding: VINNMER programme, Vinnova
Period: 0901–
Abstract: Studies of paper sheet structure characterisation, e.g. the distribution of fibres and fibre flocs, are commonly made using beta radiography or by splitting the paper in layers and study

each layer. The three-dimensional (3D) structure of the sheet can from such data in some cases be estimated. The focus of this research Project is to develop a 3D paper structure analysis method based on image analysis, and to compare the results from two-dimensional analysis methods to those achieved with a 3D method.

5.5 Remote Sensing

47. **Surtsey and Capelinhos, Two Contemporary Submarine Volcanoes**
Tommy Lindell
Funding: TN-faculty, UU
Period: 0703–
Abstract: Capelinhos, close to the Island of Faial in the Azores in the middle of the Atlantic, began to erupt on the 27 of September 1957 from 4 submarine vents after a couple of days with seismic activities. The outbreak of magma started a violent eruption of ash, lapilli and steam when it interacted with the sea water. This continued until May 1958. The first two cones collapsed after a few months but the third cone still remains. is located most westerly of the island of Faial.
The island of Surtsey was formed in a volcanic eruption which began 130 meters below sea level, and reached the surface on 14 November 1963. The eruption lasted until 5 June 1967, when the island reached its maximum size of 2.7 km^2. Wind and wave erosion has diminished the island in size to about 1.4 km^2 today. Like as for the Capelinhos, eruptions created more islands from the vents, Jlnir and Syrtlingur but as in the case for Capelinhos those two islands disappeared soon.
Wind and waves are the main factors eroding these two volcanic features. They are now approximately half a century old, resting in two similar locations but within two rather different climatological systems as to their wave and wind climate. One intriguing question is then of course if the environment may have had any major differentiating effect on the present shape of the islands. This is under investigation in this Project, based on satellite imagery and aerial photos and climatological data.

48. **Measurement of Water Volumes in Maps**
Anders Brun
Partners: Charlotte Lagerberg Fogelberg, The Centre for Sustainable Agriculture, SLU
Funding: The Centre for Sustainable Agriculture, SLU
Period: 0911–0912
Abstract: In this Project we have estimated the total water volume in a fishing area outside Chile from depth curves in maps. The results are used in a Project at the Centre for Sustainable Agriculture. The total time spent on this Project was about 3 days.

49. **Image Analysis for Landscape Analysis**
Anders Brun
Partners: Bo Malmberg and Michael Nielsen Stockholm University; Anders Wästfelt SLU
Funding: Riksbankens jubileumsfond
Period: 0901–0912
Abstract: This Project is a collaboration with researchers at SU and SLU. It aims to derive information about the landscape (rural and city) from satallite images. The Project has been in a pilot phase during 2009 and will be partly funded during 2010.

5.6 Other Projects

50. **The Development of a General Image Analysis Software Platform**
Bo Nordin, Ewert Bengtsson
Funding: TN-faculty, UU
Period: 8807–
Abstract: In image analysis research it is important to have a good platform for interactive work with digital images. We have therefore for many years had a supporting "background" Project in which we have been developing and maintaining a flexible platform for image analysis work to which new modules easily can be added. The first version of the system, IMP, created in the late 1980-ies, was based on a commericial collaboration Project in which around 10 man-years were invested and it has been used extensively in our research and education over the years. Some years ago a new C++ based version, Pixy, was initiated. It has been used to some extent even though the full initially planned system has not yet been implemented. Today a rapidly increasing number of software platforms for image analysis are becoming available so our work on IMP and Pixy is becoming limited to giving support and making specific additions as needed.

51. **Geodesic Computations in Sampled Manifolds**
Anders Brun
Partners: Ola Nilsson, Dept. of Science and Technolog, Linköping University, Martin Reimers, Centre of Mathematics for Applications, University of Oslo
Funding: S-Faculty, SLU
Period: 0806–0912
Abstract: The estimation of geodesic distances in sampled manifolds and surfaces, such as geometric mesh models in 3-D visualization or abstract sampled manifolds in image analysis, poses a difficult and computationally demanding problem. Despite the many advances in discrete mathematics and distance transforms, and fast marching and numerical methods for the solution of PDEs, the solution of the eikonal equation in a general manifold chart equipped with an arbitrary sampled metric known only in a discrete set of points has only recently beed adressed in 3-D and higher dimensions by researchers. In this Project we focus on accurate computations of geodesic distances and related mappings, such as the log map, in 2-D and 3-D. Applications for such methods are found in computer graphics (e.g. camera movement, texture mapping, tensor field visualization) and basic image analysis (e.g. skeletonization, manifold learning, clustering). During 2009, two articles have been submitted for journal publication.

52. **Deconvolution of Motion Blur in Photograph of Common Swift**
Cris Luengo
Partner: Olle Tenow
Funding: Olle Tenow, SLU
Period: 0902–0903
Abstract: Rare occurrences of animal behaviour in nature are sometimes observed and photographed. In this case, one single photograph contained evidence that might suggest an interspecies "spill-over" reaction. A Common Swift was observed making several fly-ins towards a perching newborn House Martin, while carrying feed in its pouch. In the photograph, the Swift was in flight and therefore it's features were obscured by motion blur. By deconvolving the portion of the photograph containing the Swift, it was possible to show that it, in fact, had a swollen pouch and was therefore carrying food and looking for a young to feed. Arguments and conclusions based on this deconvolution were published in Ornis Svecica 19(4):233-236, 2009.

53. **Image Analysis for Studying Horse Behavior**
Anders Brun
Partner: Lars Roepstorff, SLU
Funding: SLU
Period: 0901–0912
Abstract: In this Project, we track the hoof of the horse, filmed with high-speed cameras, when it hits the ground after a jump. We also analyze signals from a pressure sensor on the saddle. The work of CBA is mainly to help the veterinary group to analyze these signals.

5.7 Cooperation partners

International

School of ITEE, University of Queensland, Brisbane, Australia
CSIRO Mathematical and Information Sciences, North Ryde (Sydney), Australia
Risø National Laboratory, Technical University of Denmark, Denmark
Dralle A/S, Copenhagen, Denmark
Visiopharm, Hørsholm, Denmark
Clinical Pathology Division, Vejle hospital, Vejle, Denmark
Dept. of Mathematical Information Technology, University of Jyväskylä, Finland
Dept. of Physics, University of Jyväskylä, Finland
University of Stuttgart, Germany
Institute for Computational Visualistics, University of Koblenz-Landau, Germany
Dept. of Computer Science, University of Kaiserslautern, Germany
Dept. of Computer Science, Faculty of Informatics, University of Debrecen, Hungary
Dept. of Computer Science, Institute of Informatics, University of Szeged, Hungary
Istituto di Cibernetica, National Research Council, Pozzuoli (Napoli), Italy
School of computer engineering, Inje University, Republic of Korea
Ubiquitous Healthcare Research Center, Inje University, Republic of Korea
School of Medicine, Pusan National University, Republic of Korea
Dept. of Molecular Cell Biology, Leiden University Medical Center, The Netherlands
Faculty of Natural Sciences and Technology, Norwegian University of Science and Technology, Norway
Centre of Mathematics for Applications, University of Oslo, Norway
Norwegian Pulp and Paper Research Institute (PFI), Trondheim, Norway
SINTEF Materials and Chemistry, Norway
COMSATS, Institute of Information Technology, Islamabad, Pakistan
Faculty of Engineering, University of Novi Sad, Serbia
Dept. of Optics, Pharmacology and Anatomy, University of Alicante, Spain
Dept. of Signals and Communications, University of Las Palmas de Gran Canaria, Spain
Laboratory of Image Processing, University de Valladolid, Spain
Canary Islands Institute of Technology, Spain
University of Peradeniya, Sri Lanka
Signal Processing Institute Ecole Polytechnique Fédérale de Lausanne, Lausanne, Switzerland
Electrical-Electronics Eng. Dept, Bogazici University, Istanbul, Turkey
Ninewells Hospital and Medical School, University of Dundee, Scotland, UK
School of Information and Computer Sciences, University of California, Irvine, CA, USA
Dept. of Systems Biology, Harvard Medical School, Boston, MA, USA
Computer Science Division, University of California, Berkeley, CA, USA
Lawrence Berkeley National Laboratory, Berkeley, CA, USA
Imaging Platform, Broad Institute of Harvard and MIT, MA, USA
Computer Science Dept., University of California, Los Angeles, CA, USA
Histogenics Corporation, Waltham, MA, USA

National

Nyby Sawmill, Setra Group, Björklinge
Dept. of Mathematics, Natural Sciences, and Computing, University of Gävle, Gävle
SenseGraphics AB, Kista
Centre for Medical Imaging and Visualization, CMIV, Linköping
Dept. of Biomedical Engineering, Linköping University, Linköping
AstraTech, Mölndal
Dept. of Science and Technology, Linköping University, Norrköping
Vironova AB, Stockholm
Centre for Microbiological Preparedness, The Swedish Institute for Infectious Disease Control (SMI), Solna
Innventia, Stockholm
Dept. of Cell and Molecular Biology (CMB), Karolinska Institute, Stockholm
Dept. of Laboratory Medicine, Karolinska Institute, Stockholm
Bernadotte Laboratory, St. Erik Eye Hospital, Karolinska Institute, Stockholm
Dept. of Medicine, Centre for Molecular Medicine, Karolinska Institute, Stockholm
Dept. of Mathematics and NADA, Royal Institute of Technology, Stockholm
School of Technology and Health, KTH, Stockholm
Stokholms University, Stockholm
Industrial Metrology and Optics Group, KTH, Stockholm
Dept. of Fibre and Polymer Technology, KTH, Stockholm
Swedish Timber Measurement Council (VMR), Sundsvall
Dept. of Neurophysiology, Umeå University
GE Healthcare, Uppsala/London
Olink Bioscience, Uppsala
PiezoMotor AB, Uppsala
Dept. of Genetics and Pathology, UU
Dept. of Information Technology, UU
Dept. of Mathematics, UU
Dept. of Neuroscience, UU Hospital
Dept. of Oncology, Radiology, and Clinical Immunology, UU Hospital
Dept. of Pharmaceutical Biosciences, UU
Dept. of Surgical Sciences, Oral & Maxillofacial Surgery, UU Hospital
Dept. of Psychology, UU
University Research Hospital, UU
Dept. of Materials Chemistry, UU
Human-Computer Interaction, UU
Centre for Sustainable Agriculture, SLU, Uppsala
Dept. of Forest Products, SLU, Uppsala
IMINT Image Intelligence, Uppsala
Imagination Studios, Uppsala
TeknoVest AB, Uppsala
Dept. of Clinical Medicine, Örebro University, Örebro

6 Publications

We consider the publication of our results very important and a measure of the quality of our work. Hence, all research projects we are involved in, see Section 5, should result in one or more publications. Most often we publish in international scientific journals and fully refereed international conference proceedings; this is true for works both on theory and on different applications. In our research field, the impact factor of some of the conferences are in fact higher than well-reputed journals, so in some cases we favour to submit high-quality work to a conference rather than to a journal. In order to meet other scientists, we sometimes publish in non-reviewed conferences, but those results are usually eventually also published elsewhere. We also aim to produce some popular articles, but are less successful in this respect. However, we give a number of such seminars each year.

This list covers all publications with publication date in 2009. We have published 4 book chapters, 16 journal articles and as many as 27 articles in fully-reviewed international conference proceedings. In addition, we published 8 papers in non-refereed or abstract refereed conference proceedings and 2 other reports. The number of publications from CBA between 1997-2009 are shown in Figure 20. These numbers indicate a very productive year for CBA.

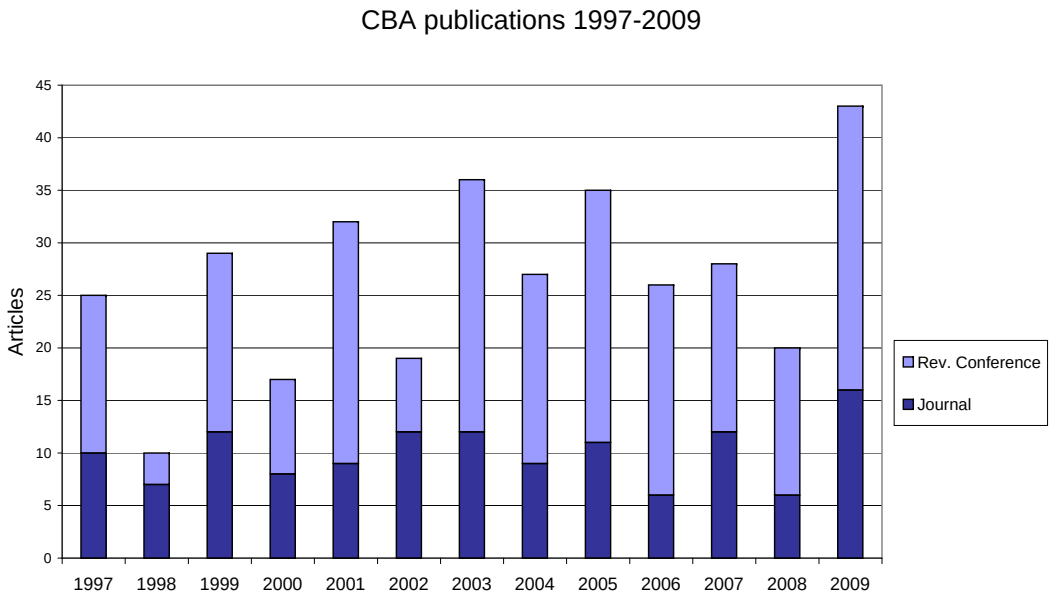


Figure 20: The number of publications from CBA.

6.1 Book chapters

1. **A Review of Tensors and Tensor Signal Processing**
   Authors: Leila Cammoun (1), Carlos Alberto Castaño-Moraga (2), Emma Muñoz-Moreno (3), Dario Sosa-Cabrera (4), Burak Acar (5), Anders Brun, Hans Knutsson (6) and Jean-Philippe Thiran (1)
   (1) Signal Processing Institute Ecole Polytechnique Fédérale de, Lausanne, Switzerland
   (2) Dept. of Signals and Communciations, University of Las Palmas de Gran Canaria, Spain
   (3) Laboratory of Image Processing, University de Valladolid, Spain
   (4) Canary Islands Institute of Technology, Spain
   (5) Electrical-Electronics Eng. Dept, Bogazici University, Istanbul, Turkey

(6) Dept. of medical engineering, Linköping University
Book: Tensors in Image Processing and Computer Vision, pp. 1–32
Publisher: Springer London
Abstract: Tensors have been broadly used in mathematics and physics, since they are a generalization of scalars or vectors and allow to represent more complex properties. In this chapter we present an overview of some tensor applications, especially those focused on the image processing field. From a mathematical point of view, a lot of work has been developed about tensor calculus, which obviously is more complex than scalar or vectorial calculus. Moreover, tensors can represent the metric of a vector space, which is very useful in the field of differential geometry. In physics, tensors have been used to describe several magnitudes, such as the strain or stress of materials. In solid mechanics, tensors are used to define the generalized Hooke's law, where a fourth order tensor relates the strain and stress tensors. In fluid dynamics, the velocity gradient tensor provides information about the vorticity and the strain of the fluids. Also an electromagnetic tensor is defined, that simplifies the notation of the Maxwell equations. But tensors are not constrained to physics and mathematics. They have been used, for instance, in medical imaging, where we can highlight two applications: the diffusion tensor image, which represents how molecules diffuse inside the tissues and is broadly used for brain imaging; and the tensorial elastography, which computes the strain and vorticity tensor to analyze the tissues properties. Tensors have also been used in computer vision to provide information about the local structure or to define anisotropic image filters.

2. **Tensor Glyph Warping: Visualizing Metric Tensor Fields using Riemannian Exponential Maps**
Authors: Anders Brun and Hans Knutsson (1)
(1) Dept. of medical engineering, Linköpings universitet
Book: Visualization and Processing of Tensor Fields: Advances and Perspectives, pp. 139–160
Publisher: Springer Berlin Heidelberg
Abstract: The Riemannian exponential map, and its inverse the Riemannian logarithm map, can be used to visualize metric tensor fields. In this chapter we first derive the well-known metric sphere glyph from the geodesic equation, where the tensor field to be visualized is regarded as the metric of a manifold. These glyphs capture the appearance of the tensors relative to the coordinate system of the human observer. We then introduce two new concepts for metric tensor field visualization: geodesic spheres and geodesically warped glyphs. These extensions make it possible not only to visualize tensor anisotropy, but also the curvature and change in tensor-shape in a local neighborhood. The framework is based on the exp p (v i) and log p (q) maps, which can be computed by solving a second-order ordinary differential equation (ODE) or by manipulating the geodesic distance function. The latter can be found by solving the eikonal equation, a nonlinear partial differential equation (PDE), or it can be derived analytically for some manifolds. To avoid heavy calculations, we also include first- and second-order Taylor approximations to exp and log. In our experiments, these are shown to be sufficiently accurate to produce glyphs that visually characterize anisotropy, curvature, and shape-derivatives in sufficiently smooth tensor fields where most glyphs are relatively similar in size.

3. **Similar Tensor Arrays: A Framework for Storage of Tensor Array Data**
Authors: Leila Cammoun (1), Carlos Alberto Castaño-Moraga (2), Emma Muñoz-Moreno (3), Dario Sosa-Cabrera (4), Burak Acar (5), Anders Brun, Hans Knutsson (6) and Jean-Philippe Thiran(1)
(1) Signal Processing Institute Ecole Polytechnique Fédérale de, Lausanne, Switzerland
(2) Dept. of Signals and Communciations, University of Las Palmas de Gran Canaria, Spain
(3) Laboratory of Image Processing, University de Valladolid, Spain
(4) Canary Islands Institute of Technology, Spain
(5) Electrical-Electronics Eng. Dept, Bogazici University, Istanbul, Turkey
(6) Dept. of medical engineering, Linköpings universitet
Book: Tensors in Image Processing and Computer Vision, pp. 407–428
Abstract: This chapter describes a framework for storage of tensor array data, useful to describe regularly sampled tensor fields. The main component of the framework, called Similar Tensor Array Core (STAC), is the result of a collaboration between research groups within the SIMILAR network of excellence. It aims to capture the essence of regularly sampled tensor fields using a minimal set of attributes and can therefore be used as a greatest common divisor and interface between tensor array processing algorithms. This is potentially useful in applied fields like medical image analysis, in particular in Diffusion Tensor MRI, where misinterpretation of tensor array data is a common source of errors. By promoting a strictly geometric perspective on tensor arrays, with a close resemblance to the terminology used in differential

geometry, (STAC) removes ambiguities and guides the user to define all necessary information. In contrast to existing tensor array file formats, it is minimalistic and based on an intrinsic and geometric interpretation of the array itself, without references to other coordinate systems.

4. **On Geometric Transformations of Local Structure Tensors**
   Authors: Björn Svensson (1), Anders Brun, Mats Andersson (1) and Hans Knutsson (1)
   (1) Dept. of biomedical engineering, Linköpings universitet
   Book: Tensors in Image Processing and Computer Vision, pp. 179–193
   Publisher: Springer London
   Abstract: The structure of images has been studied for decades and the use of local structure tensor fields appeared during the eighties. Since then numerous varieties of tensors and estimation schemes have been developed. Tensors have for instance been used to represent orientation, velocity, curvature and diffusion with applications to adaptive filtering, motion analysis and segmentation. Even though sampling in non-Cartesian coordinate system are common, analysis and processing of local structure tensor fields in such systems is less developed. Previous work on local structure in non-Cartesian coordinate systems include.

6.2 Journal articles

1. **Role of Fibre and Fibre-Matrix Adhesion in Stress Transfer in Composites made from Resin-Impregnated Paper Sheets**
   Authors: K.M. Almgren (1), E.K. Gamstedt (2), P. Nygård (3), Filip Malmberg, Joakim Lindblad, M. Lindström (1)
   (1) STFI-Packforsk AB
   (2) Dept. of Polymer and Fibre Technology, Royal Institute of Technology
   (3) FI Paper and Fibre Research Institute
   Journal: International Journal of Adhesion and Adhesives 29(5), pp. 551-557
   Abstract: Paper-reinforced plastics are gaining increased interest as packaging materials, where mechanical properties are of great importance. Strength and stress transfer in paper sheets are controlled by fibre bonds. In paper-reinforced plastics, where the sheet is impregnated with a polymer resin, other stress-transfer mechanisms may be more important. The influence of fibre-fibre bonds on the strength of paper-reinforced plastics was therefore investigated. Paper sheets with different degrees of fibre-fibre bonding were manufactured and used as reinforcement in a polymeric matrix. Image analysis tools were used to verify that the difference in the degree of fibre-fibre bonding had been preserved in the composite materials. Strength and stiffness of the composites were experimentally determined and showed no correlation to the degree of fibre-fibre bonding, in contrast to the behaviour of unimpregnated paper sheets. The degree of fibre-fibre bonding is therefore believed to have little importance in this type of material, where stress is mainly transferred through the fibre-matrix interface.

2. **Vectorized Table Driven Algorithms for Double Precision Elementary Functions Using Taylor Expansions**
   Authors: T. Barrera, D. Spångberg (1), Anders Hast and Ewert Bengtsson
   (1) Dept. of Materials Chemistry, UU
   Journal: Journal of Applied Mathematics 2(3), pp. 171–188
   Abstract: This paper presents fast implementations of the inverse square root and arcsine, both in double precision. In single precision it is often possible to use a small table and one ordinary Newton-Raphson iteration to compute elementary functions such as the square root. In double precision a substantially larger table is necessary to obtain the desired precision, or, if a smaller table is used, the additional Newton-Raphson iterations required to obtain the precision often requires the evaluation of other expensive elementary functions. Furthermore, large tables use a lot of the cash memory that should have been used for the application code. Obtaining the desired precision using a small table can instead be realised by using a higher order method than the second order Newton-Raphson method. A generalization of Newton's method to higher order is Householder's method, which unfortunately often results in very complicated expressions requiring many multiplications, additions, and even divisions. We show how a high-order method can be used, which only requires a few extra additions and multiplications for each degree of higher order. The method starts from the Taylor expansion of the difference of the value of the elementary function and a starting guess value for each iteration. If the Taylor series is truncated after the second term, ordinary Newton iterations

are obtained. In several cases it is possible to algebraically simplify the difference between the true value and the starting guess value. In those cases we show that it is advantageous to use the Taylor series to higher order to obtain the fast convergent method. Moreover, we will show how the coefficients of a Chebyshev polynomial can be fitted to give as little error as possible for the functions close to zero and in the same time reduce the terms in the Taylor expansion. In the paper we benchmark two example implementations of the method on the x86 64 architecture. The first is the inverse square root, where the actual table (to 12 bit precision) is provided by the processor hardware. The inverse square root is important in many application programs, including computer graphics, and explicit particle simulation codes, for instance the Monte Carlo and Molecular Dynamics methods of statistical mechanics.

3. **A Single Molecule Array for Digital Targeted Molecular Analyses**
   Authors: Jenny Göransson (1), Carolina Wählby, Magnus Isacsson (1), Mathias Howell (1), Jonas Javius (1) and Mats Nilsson (1)
   (1) Dept. of Genetics and Pathology, UU
   Journal: Nucleic Acids Research 37(1), electronic publication, published online 081125
   Abstract: We present a new random array format together with a decoding scheme for targeted multiplex digital molecular analyses. DNA samples are analyzed using multiplex sets of padlock or selector probes that create circular DNA molecules upon target recognition. The circularized DNA molecules are amplified through rolling-circle amplification (RCA) to generate amplified single molecules (ASMs). A random array is generated by immobilizing all ASMs on a microscopy glass slide. The ASMs are identified and counted through serial hybridizations of small sets of tag probes, according to a combinatorial decoding scheme. We show that random array format permits at least 10 iterations of hybridization, imaging and dehybridization, a process required for the combinatorial decoding scheme. We further investigated the quantitative dynamic range and precision of the random array format. Finally, as a demonstration, the decoding scheme was applied for multiplex quantitative analysis of genomic loci in samples having verified copy-number variations. Of 31 analyzed loci, all but one were correctly identified and responded according to the known copy-number variations. The decoding strategy is generic in that the target can be any biomolecule which has been encoded into a DNA circle via a molecular probing reaction.

4. **Image Analysis For Quantifying Microvessel Density in Renal Cell Carcinoma**
   Author: Hyun-Ju Choi
   Journal: Journal of Korea Society of Medical Informatics, 2(15), pp, 217–225
   Abstract: The most widely used method for quantifying new blood vessel growth in tumor angiogenesis is the determination of microvessel density, which is reported to be associated with tumor progression and metastasis, and a prognostic indicator of patient outcome. In this study, we propose a method for the determination of microvessel density by image analysis, to improve the accuracy and the objectivity of determination of the microvessel density. Four-micron-thick tissue sections of renal cell carcinoma samples were stained immunohistochemically for CD34. The regions with a high degree of vascularization were selected by an expert for digitization. Each image was digitized as a 24-bits/pixel image file with a resolution of 640×480 pixels. First, segmentation of the microvessels based on pixel classification using color features in hybrid color space was performed. After use of a correction process for microvessels with discontinuities and separation of touching microvessels, we counted the number of microvessels for the microvessel density measurement. The result was evaluated by comparison with manual quantification of the same images. The comparison revealed that our computerized microvessel quantification was highly correlated with manual counting by a pathologist. The results indicate that our method is better than the conventional computerized image analysis methods.

5. **Quantification of Colocalization and Cross-Talk Based on Spectral Angles**
   Authors: Milan Gavrilovic and Carolina Wählby
   Journal: Journal of Microscopy, 234(3), pp. 311-324
   Abstract: Common methods for quantification of colocalization in fluorescence microscopy typically require cross-talk free images or images where cross-talk has been eliminated by image processing, as they are based on intensity thresholding. Quantification of colocalization includes not only calculating a global measure of the degree of colocalization within an image, but also a classification of each image pixel as showing colocalized signals or not. In this paper, we present a novel, automated method for quantification of colocalization and classification of image pixels. The method, referred to as SpecDec, is based on an algorithm for spectral decomposition of multispectral data borrowed from the field of remote sensing. Pixels

are classified based on hue rather than intensity. The hue distribution is presented as a histogram created by a series of steps that compensate for the quantization noise always present in digital image data, and classification rules are thereafter based on the shape of the angle histogram. Detection of colocalized signals is thus only dependent on the hue, making it possible to classify also low-intensity objects, and decoupling image segmentation from detection of colocalization. Cross-talk will show up as shifts of the peaks of the histogram, and thus a shift of the classification rules, making the method essentially insensitive to cross-talk. The method can also be used to quantify and compensate for cross-talk, independent of the microscope hardware.

6. **Different Levels of 3D: An Evaluation of Visualized Discrete Spatiotemporal Data in Space-Time Cubes**
   Authors: Andreas Kjellin (1), Lars Pettersson, Stefan Seipel and Mats Lind (1)
   (1) Human-Computer Interaction, UU
   Journal: Information Visualization, electronic publication, published online 091106
   Abstract: New technologies and techniques allow novel kinds of visualizations and different types of 3D visualizations are constantly developed. We propose a categorization of 3D visualizations and, based on this categorization, evaluate two versions of a space-time cube that show discrete spatiotemporal data. The two visualization techniques used are a head-tracked stereoscopic visualization ('strong 3D') and a static monocular visualization ('weak 3D'). In terms of effectiveness and efficiency the weak 3D visualization is as good as the strong 3D and thus the need for advanced 3D visualizations in these kinds of tasks may not be necessary.

7. **Myonuclear Domain Size and Myosin Isoform Expression in Muscle Fibres from Mammals Representing a 100 000-Fold Difference in Body Size**
   Author: Jing-Xia Liu (1), Anna-Stina Höglund (1), Patrick Karlsson, Joakim Lindblad, Rizwan Qaisar (1), Sudhakar Aare (1), Ewert Bengsson and Lars Larsson (1)
   (1) Dept. of Neuroscience, UU
   Journal: Experimental Physiology, 94(1), pp. 117-129
   Abstract: This comparative study of myonuclear domain (MND) size in mammalian species representing a 100 000-fold difference in body mass, ranging from 25 g to 2500 kg, was undertaken to improve our understanding of myonuclear organization in skeletal muscle fibres. Myonuclear domain size was calculated from three-dimensional reconstructions in a total of 235 single muscle fibre segments at a fixed sarcomere length. Irrespective of species, the largest MND size was observed in muscle fibres expressing fast myosin heavy chain (MyHC) isoforms, but in the two smallest mammalian species studied (mouse and rat), MND size was not larger in the fast-twitch fibres expressing the IIA MyHC isofom than in the slow-twitch type I fibres. In the larger mammals, the type I fibres always had the smallest average MND size, but contrary to mouse and rat muscles, type IIA fibres had lower mitochondrial enzyme activities than type I fibres. Myonuclear domain size was highly dependent on body mass in the two muscle fibre types expressed in all species, i.e. types I and IIA. Myonuclear domain size increased in muscle fibres expressing both the β/slow (type I; r= 0.84, P ¡ 0.001) and the fast IIA MyHC isoform (r= 0.90; P ¡ 0.001). Thus, MND size scales with body size and is highly dependent on muscle fibre type, independent of species. However, myosin isoform expression is not the sole protein determining MND size, and other protein systems, such as mitochondrial proteins, may be equally or more important determinants of MND size.

8. **Neighborhood Sequences in the Diamond Grid: Algorithms with Two and Three Neighbors**
   Authors: Benedek Nagy (1) and Robin Strand
   (1) Faculty of Informatics, University of Debrecen, Debrecen, Hungary
   Journal: International Journal of Imaging Systems and Technology 19(29), pp. 146–157
   Abstract: In the digital image processing, digital distances are useful; distances based on neighborhood sequences are widely used. In this article, the diamond grid is considered, that is, the three-dimensional grid of carbon atoms in the diamond crystal. An algorithm to compute a shortest path defined by a neighborhood sequence between any two points in the diamond grid is presented. A formula to compute the distance based on neighborhood sequences with two neighborhood relations is given. The metric and nonmetric properties of some distances based on neighborhood sequences are also discussed. Finally, the constrained distance transformation is shown.

9. **Fully Automatic Heart Beat Rate Determination in Digital Video Recordings of Rat Embryos**
Authors: Muhammad Khalid Khan Niazi, Mats Nilsson (1), Bengt R Danielsson (1), Ewert Bengsson
(1) Div. of Toxicology, UU
Journal: Transactions on Mass-Data Analysis of Images and Signals 1(2), pp. 132–146
Abstract: Embryo cultures of rodents is an established technique for monitoring adverse effects of chemicals on embryonic development. The assessment involves determination of the heart rate of the embryo which is usually done visually, a technique which is tedious and error prone. We present a new method for fully automatic heart detection in digital videos of rat embryos. First it detects the heart location by using decimation free directional filter bank along with first absolute moment, and then it counts the number of heart beats for a predetermined period of time. Using this automated method many more embryos can be evaluated at reasonable cost.

10. **A Detailed Analysis of 3D Subcellular Signal Localization**
Authors: Amalka Pinidiyaarachchi, Agata Zieba (1), Amin Allalou, Katerina Pardali (1) and Carolina Wählby
(1) Dept. of Genetics and Pathology, UU
Journal: Cytometry part A, 75A(4), pp. 319–328
Abstract: Detection and localization of fluorescent signals in relation to other subcellular structures is an important task in various biological studies. Many methods for analysis of fluorescence microscopy image data are limited to 2D. As cells are in fact 3D structures, there is a growing need for robust methods for analysis of 3D data. This article presents an approach for detecting point-like fluorescent signals and analyzing their subnuclear position. Cell nuclei are delineated using marker-controlled (seeded) 3D watershed segmentation. User-defined object and background seeds are given as input, and gradient information defines merging and splitting criteria. Point-like signals are detected using a modified stable wave detector and localized in relation to the nuclear membrane using distance shells. The method was applied to a set of biological data studying the localization of Smad2-Smad4 protein complexes in relation to the nuclear membrane. Smad complexes appear as early as 1 min after stimulation while the highest signal concentration is observed 45 min after stimulation, followed by a concentration decrease. The robust 3D signal detection and concentration measures obtained using the proposed method agree with previous observations while also revealing new information regarding the complex formation.

11. **Performance of Principal Component Analysis and Independent Component Analysis with Respect to Signal Extraction from Noisy Positron Emission Tomography Data: a Study on Computer Simulated Images**
Authors: Pasha Razifar (1), Hamed Hamid Muhammed (2), Fredrik Engbrant, Per-Edvin Svensson, Johan Olsson, Ewert Bengtsson, Bengt Långström (3) and Mats Bergström (4)
(1) Uppsala Applied Science Laboratory, GE Healthcare
(2) School of Technology and Health, KTH
(3) Uppsala Imanet, GE Healthcare
(4) UU, Dept. of Pharmaceutical Biosciences
Journal: Open Neuroimaging Journal 1(3), pp. 1–16
Abstract: Multivariate image analysis tools are used for analyzing dynamic or multidimensional Positron Emission Tomography, PET data with the aim of noise reduction, dimension reduction and signal separation. Principal Component Analysis is one of the most commonly used multivariate image analysis tools, applied on dynamic PET data. Independent Component Analysis is another multivariate image analysis tool used to extract and separate signals. Because of the presence of high and variable noise levels and correlation in the different PET images which may confound the multivariate analysis, it is essential to explore and investigate different types of pre-normalization (transformation) methods that need to be applied, prior to application of these tools. In this study, we explored the performance of Principal Component Analysis (PCA) and Independent Component Analysis (ICA) to extract signals and reduce noise, thereby increasing the Signal to Noise Ratio (SNR) in a dynamic sequence of PET images, where the features of the noise are different compared with some other medical imaging techniques. Applications on computer simulated PET images were explored and compared. Application of PCA generated relatively similar results, with some minor differences, on the images with different noise characteristics. However, clear differences were seen with respect to the type of pre-normalization. ICA on images normalized using two types of normalization methods also seemed to perform relatively well but did not reach the improvement in SNR as PCA. Furthermore ICA seems to have a tendency under some conditions to shift over information from IC1 to other

independent components and to be more sensitive to the level of noise. PCA is a more stable technique than ICA and creates better results both qualitatively and quantitatively in the simulated PET images. PCA can extract the signals from the noise rather well and is not sensitive to type of noise, magnitude and correlation, when the input data are correctly handled by a proper pre-normalization. It is important to note that PCA as inherently a method to separate signal information into different components could still generate PC1 images with improved SNR as compared to mean images.

12. **High Precision Boundary Length Estimation by Utilizing Gray-Level Information**
Authors: Natasa Sladoje (1) and Joakim Lindblad
(1) Faculty of Engineering, University of Novi Sad, Serbia
Journal: IEEE Transaction on Pattern Analysis and Machine Intelligence, 31(2)
Abstract: We present a novel method that provides an accurate and precise estimate of the length of the boundary (perimeter) of an object by taking into account gray levels on the boundary of the digitization of the same object. Assuming a model where pixel intensity is proportional to the coverage of a pixel, we show that the presented method provides error-free measurements of the length of straight boundary segments in the case of nonquantized pixel values. For a more realistic situation, where pixel values are quantized, we derive optimal estimates that minimize the maximal estimation error. We show that the estimate converges toward a correct value as the number of gray levels tends toward infinity. The method is easy to implement; we provide the complete pseudocode. Since the method utilizes only a small neighborhood, it is very easy to parallelize. We evaluate the estimator on a set of concave and convex shapes with known perimeters, digitized at increasing resolution. In addition, we provide an example of applicability of the method on real images, by suggesting appropriate preprocessing steps and presenting results of a comparison of the suggested method with other local approaches.

13. **Weighted Distances Based on Neighborhood Sequences for Point-Lattices**
Author: Robin Strand
Journal: Discrete Applied Mathematics 157(4), pp. 641–652
Abstract: A path-based distance is defined as the minimal cost-path between two points. One such distance function is the weighted distance based on a neighborhood sequence. It can be defined using any number of neighborhood relations and weights in conjunction with a neighborhood sequence. The neighborhood sequence restricts some steps in the path to a smaller neighborhood. We give formulas for computing the point-to-point distance and conditions for metricity for weighted distances based on neighborhood sequences with two neighborhood relations for the general case of point-lattices.

14. **Path-Based Distance Functions in n-Dimensional Generalizations of the Face- and Body-Centered Cubic Grids**
Authors: Robin Strand and Benedek Nagy (1)
(1) Faculty of Informatics, University of Debrecen, Debrecen, Hungary
Journal: Discrete Applied Mathematics 157(16), pp. 3386–3400
Abstract: Path-based distance functions are defined on n-dimensional generalizations of the face-centered cubic and body-centered cubic grids. The distance functions use both weights and neighborhood sequences. These distances share many properties with traditional path-based distance functions, such as the city-block distance, but are less rotational dependent. For the three-dimensional case, we introduce four different error functions which are used to find the optimal weights and neighborhood sequences that can be used to define the distance functions with low rotational dependency.

15. **Indication of an Interspecies "Spill-Over" Reaction in Common Swift Apus Apus**
Authors: Olle Tenow (1) and Torbjörn Fagerström and Cris Luengo
(1) SLU
Journal: Ornis Svecica, 19(4). pp. 233-236

16. **Visual Exploration of Three-Dimensional Gene Expression using Physical Views and Linked Abstract Views**
Authors: Gunther H Weber (1), Oliver Rübel (2), Min-Yu Huang (3), Angela H DePace (4), Charless C Fowlkes (5), Soile V E Keränen (1), Cris L Luengo Hendriks, Hans Hagen (2), David W Knowles (1), Jitendra Malik (6), Mark D Biggin (1) and Bernd Hamann (3)
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(6) Computer Science Division, University of California, Berkeley
Journal: IEEE/ACM Transactions on Computational Biology & Bioinformatics, 6(2), pp. 296–309
Abstract: During animal development, complex patterns of gene expression provide positional information within the embryo. To better understand the underlying gene regulatory networks, the Berkeley Drosophila Transcription Network Project (BDTNP) has developed methods that support quantitative computational analysis of three-dimensional (3D) gene expression in early Drosophila embryos at cellular resolution. We introduce PointCloudXplore (PCX), an interactive visualization tool that supports visual exploration of relationships between different genes' expression using a combination of established visualization techniques. Two aspects of gene expression are of particular interest: 1) gene expression patterns defined by the spatial locations of cells expressing a gene and 2) relationships between the expression levels of multiple genes. PCX provides users with two corresponding classes of data views: 1) Physical Views based on the spatial relationships of cells in the embryo and 2) Abstract Views that discard spatial information and plot expression levels of multiple genes with respect to each other. Cell Selectors highlight data associated with subsets of embryo cells within a View. Using linking, these selected cells can be viewed in multiple representations. We describe PCX as a 3D gene expression visualization tool and provide examples of how it has been used by BDTNP biologists to generate new hypotheses.

6.3 Refereed conference proceedings

1. **An Evaluation of Scale and Noise Sensitivity of Fibre Orientation Estimation in Volume Images**
Author: Maria Axelsson
Conference: 15th International Conference on Image Analysis and Processing, Salerno, Italy (ICIAP'09), pp. 975–984
Abstract: Fibre orientation influences many important properties of fibre-based materials, for example, strength and stiffness. Fibre orientation and the orientation anisotropy in paper and other wood fibre-based materials have previously been estimated using two-dimensional images. Recently, we presented a method for estimating the three-dimensional fibre orientation in volume images based on local orientation estimates. Here, we present an evaluation of the method with respect to scale and noise sensitivity. The evaluation is performed for both tubular and solid fibres. We also present a new method for automatic scale selection for solid fibres. The method is based on a segmentation of the fibres that also provides an estimate of the fibre dimension distribution in an image. The results show that the fibre orientation estimation performs well both in noisy images and at different scales. The presented results can be used as a guide to select appropriate parameters for the method when it is applied to real data. The applicability of the fibre orientation estimation to fibre-based materials with solid fibres is demonstrated for a volume image of a press felt acquired with X-ray microtomography.

2. **On Maximal Balls in Three Volume Grids**
Authors: Gunilla Borgefors and Robin Strand
Conference: 10th International Conference on Pattern Recognition and Information Processing, Minsk, Belarus (PRIP'09), pp, 31–36
Abstract: A volume image can be digitized in different grids, not only the cubic one. The fcc and bcc grids have many advantages, as they are more dense than the cubic one. The set of maximal balls in a shape in a volume image is a compact but complete description of the shape. The original set, identified by rules dependent on the metric used, can be further reduced, by observing that some balls are covered by groups of other balls. The set of maximal balls can, for example, be used for compression, manipulation and as anchor points for topologically correct medial representations.

3. **A Heterogeneous Cluster Framework for Computationally Heavy Visualization**
Authors: Martin Ericsson, Anders Hast and Stefan Seipel
Journal: International Conference Applied Computing, Rome, Italy (IADIS'09), vol. 2, pp. 337-339
Abstract: It is desirable to use different kinds of hardware for the same software project but it is in a lot

of cases not feasible due to the programming effort that it takes to get it running. We have developed a framework to gain more experience with dealing with several different computer architectures in the same project and to have a test suit for different applications. The hardware we used contains both homogeneous x86 multi-core processors as well as heterogeneous Cell Broadband Engine processors. We developed an example application in form of a distributed rendering system which demands a lot of computational power to test it. Also incorporated in this project is a stereoscopic display that put limits on resolution and frame rate of the system. From the lessons learned in this ongoing work we conclude that it is feasible to build and use heterogeneous resources for this kind of application even though it will take a bit of effort.

4. **Suppression of Autofluorescence based on Fuzzy Classification by Spectral Angles**
   Authors: Milan Gavrilovic and Carolina Wählby
   Conference: 12th International Conference on Medical Image Computing and Computer Assisted Intervention, London, UK (MICCAI'09)
   The workshop Optical Tissue Image analysis in Microscopy, Histopathology and Endoscopy (OPTIMHisE), pp. 135–146
   Abstract: Background fluorescence, also known as autofluorescence, and cross-talk are two problems in fluorescence microscopy that stem from similar phenomena. When biological specimens are imaged, the detected signal often contains contributions from fluorescence originating from sources other than the imaged fluorophore. This fluorescence could either come from the specimen itself (autofluorescence), or from fluorophores with partly overlapping emission spectra (cross-talk). In order to resolve spectral components at least two distinct wavelength intervals have to be imaged. This paper shows how autofluorescence can be presented statistically using a spectral angle histogram. Pixel classification by spectral angles was previously developed for detection and quantification of colocalization. Here we show how the spectral angle histogram can be employed to suppress autofluorescence. First, classical background subtraction (also referred to as linear unmixing) is presented in the form of a fuzzy classification by spectral angles. A modification of the fuzzy classification rules is also presented and we show that sigmoid membership functions lead to better suppression of background and amplification of true signals.

5. **Improved Textures for 3D Virtual Reconstruction and Visualization by a Modified Multiscale Texture Synthesis**
   Authors: Anders Hast, Martin Ericsson and T. Reiner (1)
   (1) University of Stuttgart, Germany
   Conference: 3rd International Workshop 3D Virtual Reconstruction and Visualization of Complex Architectures, Trento, Italy (3D-ARCH'09), electronic publication
   Abstract: When photos of walls are used in urban 3D visualizations they are often of limited quality due to the fact that it can be very hard, or even impossible, to take close up photos of the whole part of walls, especially for buildings with several floors. Thus walls will appear either pixelized or blurry when the viewer comes close to them. The latter if some kind of interpolation technique is being used to reduce the pixelization. In any case it his has a big impact on how the viewer perceives the 3D environment as it will look far from real. We present how a modified multiscale texture synthesis approach can be used to create highly detailed textures from photos with different levels of detail and scale. The novel idea is to switch colour space in order to improve both quality and speed. By using the HSV space it is possible to maintain colours, especially when the examplar image does not contain all colours present in the target image.

6. **Towards Automated TEM for Virus Diagnostics: Segmentation of Grid Squares and Detection of Regions of Interest**
   Authors: Gustaf Kylberg, Ida-Maria Sintorn and Gunilla Borgefors
   Conference: 16th Scandinavian Conference Image Analysis, Oslo, Norway (SCIA'09), pp. 169–178
   Abstract: When searching for viruses in an electron microscope the sample grid constitutes an enormous search area. Here, we present methodsfor automating the image acquisition process for an automatic virus-diagnostic application. The methods constitute a multi resolution approach where we first identify the grid squares and rate individual grid squares based on content in a grid overview image and then detect regions of interest in higher resolution images of good grid squares. Our methods are designed to mimic the actions of a virus TEM expert manually navigating the microscope and they are also compared to the expert's performance. Integrating the proposed methods with the microscope would reduce the search area by more than 99.99% and it would also remove the need for an expert to perform the virus search by the microscope.

7. **Local Intensity and PCA Based Detection of Virus Particle Candidates in Transmission Electron Microscopy Images**
   Authors: Gustaf Kylberg, Ida-Maria Sintorn, Mats Uppström (1) and Martin Ryner (2)
   (1) Vironova AB, Stockholm
   (2) Dept. of Medicine, Centre for Molecular Medicine, Karolinska Institutet, Stockholm; Dept. of Mathematics and NADA, Royal Institute of Technology, Stockholm
   Conference: 6th International Symposium on Image and Signal Processing and Analysis, Salzburg, Austria (ISPA'09), pp. 426–431
   Abstract: We present a general method using local intensity information and PCA to detect objects characterized only by that they differ from their surroundings. We apply ourmethod to the problem of automatically detecting virus particlecandidates in transmission electron microscopy images. Viruses have very different shapes and sizes, many species are spherical whereas others are highly pleomorphic. To detect any kind of virus particles in electron microscopy images it is therefore necessary to use a method not restricted to detection of a specific shape. The method proposed here uses only one input parameter, the approximate virus thickness, which is a conserved feature withina virus species. It is capable to detect virus particles of very varying shapes. Results on images with highly textured background of several different virus species are presented.

8. **Improved Quantification of Bone Remodelling by Utilizing Fuzzy Based Segmentation**
   Authors: Joakim Lindblad, Natasa Sladoje (1), Vladimir Ćurić, Hamid Sarve, Carina B Johansson (2) and Gunilla Borgefors
   (1) Faculty of Engineering, University of Novi Sad, Serbia
   (2) Örebro University
   Conference: 16th Scandinavian Conference Image Analysis, Oslo, Norway (SCIA'09), pp. 750–759
   Abstract: We present a novel fuzzy theory based method for the segmentation of images required in histomorphometrical investigations of bone implant integration. The suggested method combines discriminant analysis classification controlled by an introduced uncertainty measure, and fuzzy connectedness segmentation method, so that the former is used for automatic seeding of the later. A thorough evaluation of the proposed segmentation method is performed. Comparison with previously published automatically obtained measurements, as well as with manually obtained ones, is presented. The proposed method improves the segmentation and, consequently, the accuracy of the automatic measurements, while keeping advantages with respect to the manual ones, by being fast, repeatable, and objective.

9. **On Set Distances and Their Application to Image Registration**
   Authors: Joakim Lindblad, Vladimir Ćurić and Natasa Sladoje
   Conference: 6th International Symposium on Image and Signal Processing and Analysis, Salzburg, Austria (ISPA'09), pp. 449-454
   Abstract: In this paper we study set distances that are used in image processing. We propose a generalization of Sum of minimal distances and show that its special cases include a metric by Symmetric difference. The Hausdorff metric and the Chamfer matching distances are also closely related with the presented framework. In addition, we define the Complement set distance of a given distance. We evaluate the observed distance with respect to applicability to image object registration. We perform comparative evaluations with respect to noise sensitivity, as well as with respect to rigid body transformations. We conclude that the family of Generalized sum of minimal distances has many desirable properties for this application.

10. **Closing Curves with Riemannian Dilation: Application to Segmentation in Automated Cervical Cancer Screening**
    Authors: Patrik Malm and Anders Brun
    Conference: 5th International Symposium on Visual Computing, Las Vegas, NV (ISVC'09), part II, pp. 337–346
    Abstract: In this paper, we describe a nuclei segmentation algorithm for Pap smears that uses anisotropic dilation for curve closing. Edge detection methods often return broken edges that need to be closed to achieve a proper segmentation. Our method performs dilation using Riemannian distance maps that are derived from the local structure tensor field in the image. We show that our curve closing improve the segmentation along weak edges and significantly increases the overall performance of segmentation. This is validated in a thorough study on realistic synthetic cell images from our Pap smear simulator. The algorithm is also demonstrated on bright-field microscope images of real Pap smears from cervical cancer screening.

11. **Binarization of Phase Contrast Volume Images of Fibrous Materials: A Case Study**
Authors: Filip Malmberg, Catherine Östlund and Gunilla Borgefors
Conference: 4th International Conference on Computer Vision Theory and Applications, Lisboa, Portugal (VISAPP'09), pp. 148–153
Abstract: In this paper, we present a method for segmenting phase contrast volume images of fibrous materials into fibre and background. The method is based on graph cut segmentation, and is tested on high resolution X-ray microtomography volume images of wood fibres in paper an composites. The new method produces better results than a standard method based on edge-preserving smoothing and hysteresis thresholding. The most important improvement is that the proposed method handles thick and collapsed fibres more accurately than previous methods.

12. **Sub-pixel Segmentation with the Image Foresting Transform**
Authors: Filip Malmberg, Joakim Lindblad and Ingela Nyström
Conference: 13th International Workshop on Combinatorial Image Analysis, Playa del Carmen, Mexico (IWCIA'09), pp. 201–211
Abstract: The Image Foresting Transform (IFT) is a framework forimage partitioning, commonly used for interactive segmentation. Givenan image where a subset of the image elements (seed-points) have beenassigned user-defined labels, the IFT completes the labeling by computingminimal cost paths from all image elements to the seed-points. Eachimage element is then given the same label as the closest seed-point. Inits original form, the IFT produces crisp segmentations, i.e., each imageelement is assigned the label of exactly one seed-point. Here, we proposea modified version of the IFT that computes region boundaries withsub-pixel precision by allowing mixed labels at region boundaries. Wedemonstrate that the proposed sub-pixel IFT allows properties of thesegmented object to be measured with higher precision.

13. **Neighborhood Sequences in the Diamond Grid - Algorithms with Four Neighbors**
Authors: Benedek Nagy (1) and Robin Strand
(1) Faculty of Informatics, University of Debrecen, Debrecen, Hungary
Conference: 13th International Workshop on Combinatorial Image Analysis, Playa del Carmen, Mexico (IWCIA'09), theoretical track, pp. 109–121
Abstract: In digital image processing digital distances are useful; distances based on neighborhood sequences are widely used. In this paper the diamond grid is considered, that is the three-dimensional grid of Carbon atoms in the diamond crystal. This grid can be described by four coordinate values using axes of the directions of atomic bonds. In this way the sum of the coordinate values can be either zero or one. An algorithm to compute a shortest path defined by a neighborhood sequence between any two points in the diamond grid is presented. The metric and non-metric properties of some distances based on neighborhood sequences are also discussed. The constrained distance transformation and digital balls obtained by some distance functions are presented.

14. **Neighborhood Sequences on nD Hexagonal/Face-Centered-Cubic Grids**
Authors: Benedek Nagy (1) and Robin Strand
(1) Faculty of Informatics, University of Debrecen, Debrecen, Hungary
Conference: 13th International Workshop on Combinatorial Image Analysis, Playa del Carmen, Mexico (IWCIA'09), theoretical track, pp. 96–108
Abstract: The two-dimensional hexagonal grid and the three-dimensional face-centered cubic grid can be described by intersecting Z^3 and Z^4 with a (hyper)plane. Corresponding grids in higher dimensions (nD) are examined. In this paper, we define distance functions based on neighborhood sequences on these, higher dimensional generalizations of the hexagonal grid. An algorithm to produce a shortest path based on neighborhood sequences between any two gridpoints is presented. A formula to compute distance and condition of metricity are presented for neighborhood sequences using two types of neighbors. Distance transform as an application of these distances is also shown.

15. **An Automatic Method for Counting Annual Rings in Noisy Sawmill Images**
Author: Kristin Norell
Conference: 15th International Conference on Image Analysis and Processing, Salerno, Italy (ICIAP'09), pp. 307–316
Abstract: The annual ring pattern of a log end face is related to the quality of the wood. We propose a method for computing the number of annual rings on a log end face depicted in sawmill production. The method is based on the grey-weighted polar distance transform and registration of detected rings from two

different directions. The method is developed and evaluated on noisy images captured in on-line sawmill production at a Swedish sawmill during 2008, using an industrial colour camera. We have also evaluated the method using synthetic data with different ring widths, ring eccentricity, and noise levels.

16. **Creating Synthetic Log End Face Images**
Author: Kristin Norell
Conference: 6th International Symposium on Image and Signal Processing and Analysis, Salzburg, Austria (ISPA'09), pp. 353–358
Abstract: In this paper we present the design and creation of synthetic images of log end faces. The images are constructed to resemble images of Scots pine taken in on-line sawmill production. Wood features such as knots, heartwood, and annual rings, as well as the sawing procedure, storage, and imaging, including camera position, are simulated. A dataset of 100 images is provided, together with code for generating new synthetic data.

17. **Segmentation and Visualization of 3D Medical Images through Haptic Rendering**
Authors: Ingela Nyström, Filip Malmberg, Erik Vidholm, Ewert Bengtsson
Conference: 10th International Conference on Pattern Recognition and Information Processing, Minsk, Belarus (PRIP'09), pp. 43–48
Abstract: High-dimensional and high-resolution image data is increasingly produced by modern medical imaging equipment. As a consequence, the need for efficient interactive tools for segmentation and visualization of these medical images is also increasing. Existing software include state-of-the-art algorithms, but in most cases the interaction part is limited to 2D mouse/keyboard, despite the tasks being highly 3D oriented. This project involves interactive medical image visualization and segmentation, where true 3D interaction is obtained with stereo graphics and haptic feedback. Well-known image segmentation algorithms, e.g., fast marching, fuzzy connectedness, deformable models, and live-wire, have been implemented in a framework allowing the user to interact with the algorithms and the volumetric data in an efficient manner. The data is visualized via multi-planar reformatting, surface rendering, and hardware-accelerated volume rendering. We present a case study where liver segmentation is performed in CT images with high accuracy and precision.

18. **Quantification of Bone Remodeling in SR µCT Images of Implants**
Authors: Hamid Sarve, Joakim Lindblad and Carina B. Johansson (1)
(1) Örebro University
Conference: 16th Scandinavian Conference Image Analysis, Oslo, Norway (SCIA'09), pp. 770–779
Abstract: For quantification of bone remodeling around implants, wecombine information obtained by two modalities: 2D histological sectionsimaged in light microscope and 3D synchrotron radiation-based computedmicrotomography, SRµCT. In this paper, we present a methodfor segmenting SµCT volumes. The impact of shading artifact at theimplant interface is reduced by modeling the artifact. The segmentationis followed by quantitative analysis. To facilitate comparison with existingresults, the quantification is performed on a registered 2D slicefrom the volume, which corresponds to a histological section from thesame sample. The quantification involves measurements of bone areaand bone-implant contact percentages.We compare the results obtained by the proposed method on the SµCTdata with manual measurements on the histological sections and discussthe advantages of including SRµCT data in the analysis.

19. **Designing Efficient Visualizations for Applications in the Paper and Pulp Industry**
Authors: Stefan Seipel and Ann-Kristin Forsberg (1)
(1) Dept. of Mathematics, Natural- and Computer Science, Gävle University
Conference: International Conference Applied Computing, Rome, Italy (IADIS'09), vol. 1, pp. 403–410
Abstract: 2D and 3D visualization has become a rapidly growing area of research during the past years. For a long time advanced graphical techniques where mainly used within the scientific community, however, their potential benefits are now increasingly recognized also for industrial applications. The visualization community is meanwhile following a theoryanchored and evaluation based approach paving the way for the design of perceptually efficient visualizations. In this paper we describe the development, evaluation and deployment of efficient visualizations to support process operators in the paper and pulp process industry. We first identify and describe the data analysis task of the real working situation at hand. Starting from existing theory in the field of visualization and vision esearch, we then describe the process of designing perceptually motivated new visualizations for the specific task of the operators. The result is a new deviation color scale that we apply to 2D color map and 3D height-field representations. We then describe

an experiment to formally evaluate the efficiency of these visualizations for the visual detection of thermal overheating of rotary kilns. The results of this study showed that our new differential color scale lead to significantly reduced detection times when compared with traditional color coding schemes. Also, when conventional color scales are used for the visualization of absolute temperature levels, the inclusion of the 3D cues in the visualization for the visual encoding of the rate of change contributes to faster detection of temperature increases.

20. **On the Applicability of Direct and Indirect Input in Table-Top and Vertical Displays**
Authors: Stefan Seipel and Ann-Kristin Forsberg (1)
(1) Dept. of Mathematics, Natural- and Computer Science, Gävle University
Conference: International Conference Applied Computing, Rome, Italy (IADIS'09), vol. 2, pp. 8–11
Abstract: Recent developments in display and interaction technologies afford new IT based applications e.g. for use cases with several collaborating users. Table-top display environments are among those techniques that are expected to boost the development of an entire range of new computer applications. While technological development has advanced rapidly, little research has been done to evaluate the applicability of such techniques for general interaction. In this paper we present latest results of a study on the efficiency of direct interaction and indirect nteraction with a table-top display and we compare it with indirect input on a conventional vertical display. The results show that users made significantly shorter cursor movements in the table-top interface than in the conventional vertical interface. In regard to time, task performance for direct, pen-based input on a table-top interface was even superior to conventional, mouse based interaction on a vertical display. Users performance was worst for mouse based interaction in the table-top condition despite shorter travel distances. The results of our work give some interesting criteria for the development of applicable systems. That is to say, contrary to earlier research we find that the use of a table-top display yields to more efficient interaction than a comparable vertical display as long as direct input is used.

21. **Prediction of Ventilation Paths in Urban Environments using Digitized Maps**
Authors: Stefan Seipel and Julia Åhlén (1)
(1) Dept. of Computer Science, Gävle University
Conference: International Conference Applied Computing, Rome, Italy (IADIS'09), vol. 2, pp. 217–221
Abstract: Urban populations and the density of settlements constantly become higher. This leads to higher energy consumption and generally to deterioration of life comfort. Study of urban heat and cool islands is of great importance for social community planners and building engineers. Ventilation paths are defined by turbulent mass, momentum and energy transport conditions and can thus be modeled. This area is usually studied by measurements of the conditions and air flows in laboratory environments. This paper presents a method for the prediction of free ventilation paths in a small city using digital imagery. A digitized map created from a eographic data base is used as input. Image analysis is performed in order to create an optimal edge image. A modified Hough transform is applied. Points of interest are defined and surroundings are calculated. These points are inputs to a parameter space. As a result a free wind passage is predicted based on the position of the observer. Prediction is done by calculation of possible straight lines in a parameter space. Finally, the method is verified by comparison with position vectors from the same space in the image and the best fitted path is chosen.

22. **A collaborative visualization environment for natural interaction with architectural content**
Authors: Stefan Seipel and Ann-Kristin Forsberg (1)
(1) Dept. of Mathematics, Natural- and Computer Science, Gävle University
Conference: 3rd International Workshop 3D Virtual Reconstruction and Visualization of Complex Architectures, Trento, Italy (3D-ARCH'09), electronic publication
Abstract: Interactive exploration and assessment of architectural design studies or reconstructions of historical built environments have for centuries been based on physical models from wood, plaster or cardboard. With the development of powerful 3D graphics functionality on personal computers, digital models of complex architecture (constructed or digitized) can be visualized and be explored interactively by means of advanced 3D computer displays. Virtual Reality based experiences can be used efficiently to provide detail views by means of virtual architectural walkthroughs as well as facilitate contextual views by adopting a birds-eye metaphor upon the data. One of the drawbacks of many 3D architectural presentations is that a correct 3D perspective is presented for a virtual camera with one predefined central perspective projection. In consequence only one if any of several observers benefits from a spatially correct view of the virtual scenery. In addition, for 3D presentations on vertical computer screens, natural interaction between two ore

more collaborating users is hampered as direct face-to-face communication is distracted. In this paper we present results of our most recent development and ongoing work towards a more usable tabletop display system for two collaborating users and we present its application in the visualization of public buildings and historic environments. What renders our display environment specific is a combination of several features that make it feasible for everyday use: The technical design of our system allows for a compact form factor allowing the system to be used in everyday office situations. The system is capable of providing a dynamic stereoscopic 3D view for one moving observer, or alternatively monoscopic dynamic 3D views for two independently moving observers. This visualization environment is based on rear-projection and it incorporates an optical film into the screen which allows for high-resolution multi-point interaction at pixel accuracy using several optical digital pens that communicate wireless with the computer. In this paper we present the technical design of the system as well as its use in the visual assessment of building structures and presentation of pre-historical architecture. The main and most novel contributions of this paper are the results of an experimental study that investigated performance differences between natural pen-based direct interaction versus tradition mouse-based interaction in this new visualization environment.

23. **Segmentation of Highly Lignified Zones in Wood Fiber Cross-Sections**
Authors: Bettina Selig, Cris L. Luengo Hendriks, Stig Bardage (1) and Gunilla Borgefors
(1) Dept. of Forest Products, SLU
Conference: 16th Scandinavian Conference Image Analysis, Oslo, Norway (SCIA'09), pp. 369–378
Abstract: Lignification of wood fibers has important consequences tothe paper production, but its exact effects are not well understood. Tocorrelate exact levels of lignin in wood fibers to their mechanical properties, lignin autofluorescence is imaged in wood fiber cross-sections. Highlylignified areas can be detected and related to the area of the whole cellwall. Presently these measurements are performed manually, which is te-dious and expensive. In this paper a method is proposed to estimate thedegree of lignification automatically. A multi-stage snake-based segmen-tation is applied on each cell separately. To make a preliminary evaluationwe used an image which contained 17 complete cell cross-sections. Thisimage was segmented both automatically and manually by an expert.There was a highly significant correlation between the two methods, al-though a systematic difference indicates a disagreement in the definitionof the edges between the expert and the algorithm.

24. **Pixel Coverage Segmentation for Improved Feature Estimation**
Authors: Natasa Sladoje (1) and Joakim Lindblad
(1) Faculty of Engineering, University of Novi Sad, Serbia
Conference: 15th International Conference on Image Analysis and Processing, Salerno, Italy (ICIAP'09), pp. 923–938
Abstract: By utilizing intensity information available in images, partial coverage of pixels at object borders can be estimated. Such information can, in turn, provide more precise feature estimates. We present a pixel coverage segmentation method which assigns pixel values corresponding to the area of a pixel that is covered by the imaged object(s). Starting from any suitable crisp segmentation, we extract a one-pixel thin 4-connected boundary between the observed image components where a local linear mixture model is used for estimating fractional pixel coverage values. We evaluate the presented segmentation method, as well as its usefulness for subsequent precise feature estimation, on synthetic test objects with increasing levels of noise added. We conclude that for reasonable noise levels the presented method outperforms the achievable results of a perfect crisp segmentation. Finally, we illustrate the application of the suggested method on a real histological colour image.

25. **Recovering Affine Deformations of Fuzzy Shapes**
Authors: Attila Tenacs (1), Csaba Domokos (1), Natasa Sladoje (2), Joakim Lindblad and Zoltan Kato (1)
(1) Dept. of Image Processing and Computer Graphics, University of Szeged, Hungary
(2) Faculty of Engineering, University of Novi Sad, Serbia
Conference: 16th Scandinavian Conference Image Analysis, Oslo, Norway (SCIA'09), pp. 735-744
Abstract: Fuzzy sets and fuzzy techniques are attracting increasing attention nowadays in the field of image processing and analysis. It has been shown that the information preserved by using fuzzy representation based on area coverage may be successfully utilized to improve precision and accuracy of several shape descriptors; geometric moments of a shape are among them. We propose to extend an existing binary shape matching method to take advantage of fuzzy object representation. The result of a synthetic test show that fuzzy representation yields smaller registration errors in average. A segmentation method is also presented

to generate fuzzy segmentations of real images. The applicability of the proposed methods is demonstrated on real X-ray images of hip replacement implants.

26. **Generating synthetic µCT images of wood fibre materials**
Authors: Erik Wernersson, Cris L. Luengo Hendriks and Anders Brun
Conference: 6th International Symposium on Image and Signal Processing and Analysis, Salzburg, Austria (ISPA'09)
Abstract: X-ray Computerized Tomography at micrometer resolution (µCT) is an important tool for understanding the properties of wood fibre materials such as paper, carton and wood fibre composites. While many image analysis methods have been developed for µCT images in wood science, the evaluation of these methods if often not thorough enough because of the lack of a dataset with ground truth. This paper describes the generation of synthetic µCT volumes of wood fibre materials. Fibres with a high degree of morphological variations are modeled and densely packed into a volume of the material. Using a simulation of the µCT image acquisition process, realistic synthetic images are obtained. This simulation uses noise characterized from a set of µCT images. The synthetic images have a known ground truth, and can therefore be used when evaluating image analysis methods.

27. **Segmentation of Wood Fibres in 3D CT Images Using Graph Cuts**
Authors: Erik Wernersson, Anders Brun and Cris L. Luengo Hendriks
Conference: 15th International Conference on Image Analysis and Processing, Salerno, Italy (ICIAP'09)
Abstract: To completely segment all individual wood fibres in volume images of fibrous materials presents a challenging problem but is important in understanding the micro mechanical properties of composite materials. This paper presents a filter that identifies and closes pores in wood fibre walls, simplifying the shape of the fibres. After this filter, a novel segmentation method based on graph cuts identifies individual fibres. The methods are validated on a realistic synthetic fibre data set and then applied on µCT images of wood fibre composites.

6.4 Non-refereed conferences and workshops

1. **Signal Detection in 3D by StableWave Signal Verification**
Authors: Amin Allalou and Carolina Wählby
Conference: Swedish Symposium on Image Analysis, Halmstad (SSBA'09)

2. **Dimensionality Reduction for Colour Based Pixel Classification**
Authors: Milan Gavrilovic, Carolina Wählby and Joakim Lindblad and Ewert Bengtsson
Conference: Swedish Symposium on Image Analysis, Halmstad (SSBA'09)

3. **Spectral Angle Histogram: a Novel Image Analysis Tool for Quantification of Colocalization and Cross-talk**
Authors: Milan Gavrilovic, Carolina Wählby and Joakim Lindblad and Ewert Bengtsson
Conference: 9th International ELMI Meeting on Advanced Light Microscopy

4. **Detecting Virus-like Particles Using Transmission Electron Microscopy**
Authors: Gustaf Kylberg and Ida-Maria Sintorn
Conference: Swedish Symposium on Image Analysis, Halmstad (SSBA'09)

5. **Curve Closing by Gradient Weighted Distance Transformation Applied in Automated Cervical Cancer Screening**
Authors: Patrik Malm and Anders Brun
Conference: Swedish Symposium on Image Analysis, Halmstad (SSBA'09)

6. **Interactive Segmentation with Relaxed Image Foresting Transforms**
Authors: Filip Malmberg and Ingela Nyström
Conference: Swedish Symposium on Image Analysis, Halmstad (SSBA'09)

7. **Measuring Distribution of Lignin in Wood Fibre Cross-Sections**
   Authors: Bettina Selig, Cris L. Luengo Hendriks and Gunilla Borgefors
   Conference: Swedish Symposium on Image Analysis, Halmstad (SSBA'09)

8. **Closing Pores and Segmenting Individual Fibres in 3D Images of Wood Fibre Composites using Curvature Information and Graph Cuts**
   Authors: Erik Wernersson, Anders Brun and Cris L Luengo Hendriks
   Conference: Swedish Symposium on Image Analysis, Halmstad (SSBA'09)

6.5 Other publications

See also Section 3.3 for Master theses finished during 2009.

1. **CBA Annual Report 2008**
   Editors: Ewert Bengtsson, Kristin Norell, Erik Wernersson, Ingela Nyström, Robin Strand, Lena Wadelius
   Publisher: Centre for Image Analysis, 76 pages

2. **Läkarens känsel hjälper datorn**
   Authors: Erik Vidholm, Filip Malmberg, Ingela Nyström
   Publisher: Forskning & Framsteg, 1

7 Activities

Apart from the activities reported in previous Sections, we also spend much time and effort on outside contacts. These contacts are aimed at colleagues in academia, at industries based on image analysis or need of it, and at society in general. We participate in conferences; give and organize seminars; receive visitors and make visits, both for long and short stays; and participate in many different committees, both international and national. In the following Section, we have listed these activities for the year 2009. 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. Still, the lists are quite extensive.

This year CBA personnel received two awards: Robin Strand was awarded with Benzelius award from the Royal Society of Sciences in Uppsala and Erik Wernersson received the best paper award at an international conference, ISPA'09.

Professor Stefan Seipel has served as Vice-chair of the Swedish Society for Computer Graphics (SIGRAD). Professor Ewert Bengtsson continued to serve as advisor to the Rector of UU on information technology and also as Chair of the UU IT-council, together with many other related appointments. Professor Gunilla Borgefors is one of three Area Editors for the Journal "Pattern Recognition Letters". To give some figures: We held as many as 20 seminars outside CBA, most in the Uppsala area, but also in Denmark, Croatia, South Korea, India and Sri Lanka. We had eight invited seminars at CBA, from Spain, and Sweden. In addition, we held 35 seminars in our "Monday seminar series", of which six were Master Thesis presentations. We gave eight special invited talks, six oral and three poster presentations at international fully reviewed conferences, and ten other oral conference presentations. We had one long-term visitor from Serbia and one from South Korea. In addition, Joakim Linblad has spent several longer visits at the Faculty of Engineering, University of Novi Sad, Serbia. We have also received a large number of national and international short-term visitors at many different occasions and have often visited others ourselves.

Finally, we have listed 29 international and 47 national "committees" of the most varying types in which we have served.

7.1 Awards

1. *Title:* Benzelius award from the Royal Society of Sciences
   Name: Robin Strand
   Date: 090901
   Comment: Strand was awarded the Benzelius prize from the Royal Society of Sciences in Uppsala

2. *Title:* Best paper award at the 6th International Symposium on Image and Signal Processing and Analysis, Salzburg, Austria
   Name: Erik Wernersson, Cris Luengo, Anders Brun
   Date: 090916
   Comment: The title of the paper is *Generating synthetic micro-CT images of wood fibre materials*

7.2 Organised conferences and workshops

1. **CBA 20 Year Anniversary Celebration**
   Organisers: CBA staff
   Address: Centre for Image Analysis, Uppsala
   Date: 090203, 090205
   Attendees: On 090203: Colleagues and cooperation partners at Polacksbacken.

On 090205: Invited VIP:s that have had special importance for CBA over the years.
Comment: The research at CBA was presented in the 3D visualization lab.

2. **One day workshop at Second Workshop on UnConventional High Performance Computing, (UCHPC'09)**
Organisers: Anders Hast
Address: Ischia, Italy
Date: 090518–21

3. **Special Session on Digital Shape Analysis: Theory and Application at 6th International Symposium on Image and Signal Processing and Analysis (ISPA'09)**
Organisers: Joakim Lindblad and Natasa Sladoje
Address: University of Salzburg, Austria, Department of Computer Sciences
Date: 090916–18

7.3 Seminars held outside CBA

1. **Amin Allalou**
Date: 090128
Address: Dako Produktionsvej 42 Glostrup, Denmark
Title: 3D Signal Detection
Comment: Project meeting for the ENLIGHT project

2. **Milan Gavrilovic**
Date: 090128
Address: Dako Produktionsvej 42 Glostrup, Denmark
Title: Spectral Angle Based Classification in Fluorescence Microscopy
Comment: Project meeting for the ENLIGHT project

3. **Ingrid Carlbom**
Date: 090210
Address: KTH, Stockholm
Title: Challenges in Multi-Disciplinary Multi-Media Research

4. **Kristin Norell**
Date: 090212
Address: Rundvik sawmill, Rundvik
Title: Image Analysis of Saw Logs – Pith Position and Annual Ring Density
Comment: The seminar was part of a one day presentation of the company A-sort and their prototype. The seminar was held in Swedish

5. **Gunilla Borgefors**
Date: 090304
Address: Polacksbacken, UU
Title: The Mathematician That Became a Journalist
Comment: In the "Mathematics without borders" series for undergraduate students. The lecture was given in Swedish

6. **Ida-Maria Sintorn**
Date: 090305
Address: MSB - Swedish Civil Contingencies Agency, Kungsgatan 53, Stockholm
Title: PanViruShield Project Report

7. **Gunilla Borgefors**
Date: 090325
Address: IT-department, UU
Title: Tessellating the Plane

8. **Ingela Nyström**
Date: 090526
Address: 3DIS4U

Title: Stereo Rendering – An Exercise in Applied Mathematics to Present Scientific Data
Comment: In the seminar series of the Centre for Interdisciplinary Mathematics

9. **Joakim Lindblad**
   Date: 090528
   Address: Faculty of Electrical Engineering and Computing, University of Zagreb, Croatia
   Title: Pixel Coverage Segmentation for Improved Feature Estimation
   Comment: Seminar at the Image Processing Group, Zagreb

10. **Stina Svensson**
    Date: 090728
    Address: Naturvetenskapliga forskarskolan, Karlskrona, Sweden
    Title: Undersök världen med hjälp av digitala bilder
    Comment: Lecture given at the Science research school in Karlskoga for upper secondary school pupils from all over the country. It is organised every summer by PhD students from Swedish Universities

11. **Kristin Norell**
    Date: 090902
    Address: Arlanda Hotellby
    Title: Att räkna till 20 – svårigheter och möjligheter
    Comment: Norell was invited speaker at this themeday for the association "Föreningen Svenska Sågverksmän". About 50 participants from Swedish sawmill industry. The seminar was given in Swedish

12. **Ewert Bengtsson**
    Date: 090917
    Address: EBC, UU
    Title: ERC Young Investigators Grant Application Hints
    Comment: Bengtsson presented advice to young researchers planning to file applications to the European Research Council, based on his experience as grant application evaluator

13. **Stefan Seipel**
    Date: 091020
    Address: Rotary Club, Lokal Avdelning Gävle
    Title: Visualisering – Begränsningar och Möjligheter
    Comment: Inbjuden populärvetenskaplig presentation om visualiseringens framtid

14. **Ewert Bengtsson**
    Date: 091023
    Address: Villa Aske, Bro, conference hotel
    Title: The New Program on IT and Current IT Challenges at UU
    Comment: Part of the Uppsala University Deans Meeting

15. **Gustaf Kylberg, Ida-Maria Sintorn**
    Date: 091113
    Address: Swedish Defence Materiel Administration, Stockholm
    Title: Oral Project Report, PanViruShield

16. **Ewert Bengtsson**
    Date: 091124
    Address: Inje University, GimHae, South Korea
    Title: Biomedical Image Analysis in Many Dimensions
    Comment: About 25 researchers from Inje University attended the 60 minute presentation

17. **Ewert Bengtsson**
    Date: 091125
    Address: Inje University Paik Hospital, Busan, South Korea
    Title: Biomedical Image Analysis in Many Dimensions
    Comment: About 15 medical researchers from the hospital attended the 60 minute presentation

18. **Ewert Bengtsson**
Date: 091209
Address: CDAC-T, Thiruvananthapuram, India
Title: Biomedical Image Analysis in Many Dimensions
Comment: The research group that we will cooperate with in the Cerviscan project attended the overview presentation about our current research in biomedical image analysis

19. **Ewert Bengtsson**
Date: 091214
Address: University of Peradeniya, Kandy, Sri Lanka
Title: Biomedical Image Analysis in Many Dimensions
Comment: About 80 researchers and computer science students attended the 60 minute presentation

20. **Milan Gavrilovic**
Date: 091216
Address: Biomedical and X-Ray Physics Group, Dept. of Applied Physics, The Royal Institute of Technology (KTH), Stockholm
Title: Spectral Image Analysis in Fluorescence Microscopy: Quantification of Colocalization by Spectral Angles

7.4 Special invited speakers

1. *Conference:* The fourth Scientific-Technical Meeting InterRegioSci 2009, AP Vojvodina
Joakim Lindblad
Date: 090421
Address: Government, Autonomous Province of Vojvodina, Novi Sad, Serbia
Title: Segmentation and Precise Feature Estimation in Fuzzy Digital Images
Comment: InterRegioSci is the annual conference by the Government of AP Vojvodina, Serbia, with presentations scientific works originating from research projects that are co financed by the Provincial Secretariat for Science and Technological Development

2. *Conference:* 10th Int. Conference on Pattern Recognition and Information Processing (PRIP'09)
Gunilla Borgefors
Date: 090519–21
Address: Belarusian State University, Minsk, Belarus
Title: Maximal Balls in Three Volume Grids
Comment: Borgefors was also Session Chair

3. *Conference:* 10th International Conference on Pattern Recognition and Information Processing (PRIP'09)
Ingela Nyström
Date: 090519–21
Address: Belarusian State University, Minsk, Belarus
Title: Segmentation and Visualization of 3D Medical Images
Comment: Nyström was also Session Chair

4. *Conference:* Summer School on Foundations of Information Technologies (FIT'09)
Joakim Lindblad
Date: 090614–27
Address: Faculty of Technical Sciences, University of Novi Sad, Serbia
Title: New Objective Analysis Techniques for Quantification of Tissue Regeneration Around Medical Devices
Comment: The FIT Summer School is supported by the TEMPUS Programme through the Project Doctoral School towards European Knowledge Society – DEUKS

5. *Conference:* Summer School on Image Processing 2009 (SSIP'09)
Joakim Lindblad
Date: 090702–11
Address: Department of Computer Graphics and Image Processing, Faculty of Informatics, University of Debrecen, Hungary

Title: Pixel Coverage Segmentation for Improved Feature Estimation
Comment: SSIP is organized annually for graduate and PhD students interested in image processing

6. *Conference:* Bio-IT World Conference & Expo 2009
Ingela Nyström
Date: 091005–08
Address: Exhibition Grounds, Hannover, Germany
Title: Sweden at the Forefront: The Buildup of Computational Power and Large-Scale Storage for Gene-Sequence Data
Comment: Representing UPPMAX and Uppsala University

7. *Conference:* Visualization seminar
Stina Svensson
Date: 091020
Address: Swedish Embassy, Tokyo, Japan
Title: ProViz – Interactive Visualization of in situ 3D Protein Images
Comment: Part of a journey to Tokyo organized by Invest in Sweden Agency and the Knowledge Foundation (through the Visualization Program)

8. *Conference:* DICTA 2009
Ewert Bengtsson
Date: 091130–1203
Address: Medina Hotel, Melbourne, Australia
Title: Biomedical Image Analysis in Many Dimensions
Comment: One of four key-note speakers at this National Australian conference

7.5 Seminars at CBA with invited guest lecturers

1. **Olof Dahlqvist Leinhard**
Address: Center for Medical Image Science and Visualization (CMIV), Linköping University Hospital
Date: 090209
Title: Abdominal Quantitative MRI and Applications in Clinical Research

2. **Bo Malmberg**
Address: Dept. of Human Geography, Stockholm University
Date: 090316
Title: Human Geography – A Link Between Image Analysis and the Social Sciences?

3. **Susana Mata**
Address: Universidad Rey Juan Carlos, Madrid, Spain
Date: 090513
Title: Multiresolution Representation of 3D Objects using Distance Information

4. **Karl Krissian**
Address: Grupo de Imagen, Tecnología Médica y Televisión Dept. of Signal and Communications University of Las Palmas of Gran Canaria, Spain
Date: 090518
Title: Presentation and Demonstration of the AMILab Software for Image Processing and Visualization

5. **Alex Olwal**
Address: School of Computer Science and Communication, The Royal Institute of Technology (KTH), Stockholm
Date: 090525
Title: Unobtrusive Augmentation of Physical Environments: Seamless Empowerments of the Senses

6. **Stefan Gustavsson**
Address: Visual Information Technology and Applications (VITA) group, Dept. of Science and Technology, Linköping University, Campus Norrköping
Date: 090601
Title: Image Based Lighting in complex scenes – a 5D problem

7. **Olle Gällmo**
   Address: Dept. of Information Technology, UU
   Date: 091207
   Title: A Brief Introduction to Natural Computation

7.6 Seminars at CBA

Seminars by seniors, PhD students and Master thesis students at CBA.
Some of these seminars were held in Swedish.

1. **Ewert Bengtsson**
   Date: 090112
   Title: Visions for IT – Checking the Crystal Ball Trying to Understand Where the IT Development is Taking our Universities

2. **Kristin Norell**
   Date: 090119
   Title: Spatially-Variant Mathematical Morphology on Binary Images

3. **Fredrik Engbrant**
   Date: 090126
   Title: Signal Extraction and Separation in Dynamic PET Studies using Masked Volume Wise Principal Component Analysis (MVW-PCA) in List Mode
   Comment: Master thesis presentation

4. **Bettina Selig and Gustaf Kylberg**
   Date: 090202
   Title: I Know What You Did Last Summer

5. **Hamid Sarve**
   Date: 090216
   Title: Color Image Processing in FPGA

6. **Amalka Pinidiyaarachchi**
   Date: 090223
   Title: Digital Image Analysis of Cells – Application in 2D, 3D and Time
   Comment: Rehearsal before the public defence of the thesis

7. **Johan Olsson and Per-Edvin Svensson**
   Date: 090302
   Title: Automated Method for Generation of Input Function in PET Studies using MVW-PC Images, and Characterization and Reduction of Noise in PET Data using MVW-PCA
   Comment: Master thesis presentation

8. **Anders Brun**
   Date: 090309
   Title: Creativity for Researchers

9. **Lennart Svensson**
   Date: 090323
   Title: The ProViz Project

10. **Amin Allalou**
    Date: 090330
    Title: 3DSWD and Improved Signal Detection by Combining Detection and Verification

11. **David Forslund**
    Date: 090403
    Title: Realtime Scene Analysis in Infrared Images
    Comment: Master thesis presentation

12. **Filip Malmberg**
    Date: 090406
    Title: Linear Interpolation with the Image Foresting Transform

13. **Ida-Maria Sintorn**
    Date: 090420
    Title: Gradient Magnitude Based Intensity Normalization for Comparisons within and Across Cellular Imaging Experiments

14. **Ingrid Carlbom and Gerald Pettersson**
    Date: 090427
    Title: Uppsala University Support for Innovation and Commercialization
    Comment: UU Innovation

15. **Christer Bergman**
    Date: 090504
    Title: Low Cost Real-time Gaze Tracker Using a Web Camera
    Comment: Master thesis presentation

16. **Gunilla Borgefors**
    Date: 090511
    Title: Mathematics in the News(?)

17. **Cris Luengo**
    Date: 090824
    Title: Constrained Path Openings and Closings

18. **Gunilla Borgefors**
    Date: 090831
    Title: Tessellations and Their Use in Architecture

19. **Catherine Östlund**
    Date: 090907
    Title: Taking the Fingerprint of a Press Felt

20. **Vladimir Ćurić**
    Date: 090914
    Title: On Set Distances and Their Application in Image Processing

21. **Gunilla Borgefors**
    Date: 090921
    Title: Highlights from 9th International Symposium on Mathematical Morphology (ISMM 2009)

22. **Patrik Malm**
    Date: 090928
    Title: Closing Curves with Riemannian Dilation

23. **Robin Strand**
    Date: 091002
    Title: Introduction to Image Analysis and Processing.
    Comment: Strand gave a lecture on the course *Labelling chemistry and compound development* given at Dept. of Oncology, Radiology and Clinical Immunology, UU

24. **Joakim Lindblad**
    Date: 091005
    Title: Pixel Coverage Segmentation for Improved Feature Estimation

25. **Yang Wenlan**
    Date: 091009
    Title: Image Analysis for Marker-less Facial Tracking
    Comment: Master thesis presentation

26. **Anders Hast**
Date: 081012
Title: Improved Textures for 3D Virtual Reconstruction and Visualization by a Modified Multiscale Texture Synthesis Approach

27. **Khalid Niazi and Bettina Selig**
Date: 091019
Title: Image Registration using Particle Swarm Optimization

28. **Erik Wernersson**
Date: 091026
Title: Generating Synthetic micro-CT Images of Wood Fibre Materials

29. **Stefan Seipel**
Date: 091102
Title: A Model for Curvature Based Local Illumination

30. **Ewert Bengtsson**
Date: 091109
Title: Biomedical Image Analysis in Many Dimensions

31. **Nils Lenngren**
Date: 091110
Title: k-Uniform Tilings by Regular Polygons
Comment: Master thesis presentation

32. **Milan Gavrilovic**
Date: 091116
Title: Colour Based Pixel Classification by Reducing RGB Colour Space to Solid Angle Histogram

33. **Ingela Nyström**
Date: 091123
Title: UPPMAX Builds Computational Power and Large-Scale Storage for Gene-Sequence Data: Welcome to Submit Image Data Also

34. **Kristin Norell**
Date: 091130
Title: Creating Synthetic Log end Face Images

35. **Magnus Gedda**
Date: 091214
Title: Algorithms for Grey-Weighted Distance Transforms

7.7 Conference participation

7.7.1 Oral presentations – refereed conferences

1. *Conference:* 9th International Conference on Applied Mathematics (APLIMAT'09)
Anders Hast
Date: 090203–06
Address: Faculty of Mechanical Engineering, Slovak Technical Univerzity, Bratislava, Slovakia
Title: Vectorized table driven algorithms for double precision elementary functions using Taylor expansions

2. *Conference:* International Joint Conference on Computer Vision, Imaging and Computer Graphics Theory and Applications (VISIGRAPP'09)
Filip Malmberg
Date: 090205–08
Address: Lisboa, Portugal
Title: Binarization of Phase Contrast Volume Images of Fibrous Materials – A Case Study

3. *Conference:* 3D Virtual Reconstruction and Visualization of Complex Architectures (3D-ARCH'2009)
   Anders Hast
   Date: 090225–28
   Address: Trento, Italy
   Title: Improved Textures for 3D Virtual Reconstruction and Visualization by a Modified Multiscale Texture Synthesis Approach

4. *Conference:* 16th Scandinavian Conference on Image Analysis (SCIA'09)
   Gustaf Kylberg
   Date: 090615–18
   Address: Oslo, Norway
   Title: Towards Automated TEM for Virus Diagnostics: Segmentation of Grid Squares and Detection of Regions of Interest

5. *Conference:* 15th International Conference on Image Analysis and Processing (ICIAP'09)
   Erik Wernersson
   Date: 090909–11
   Address: Vietri sul Mare, Salerno, Italy
   Title: Segmentation of Wood Fibres in 3D CT Images Using Graph Cuts

6. *Conference:* 6th International Symposium on Image and Signal Processing and Analysis (ISPA'09)
   Vladimir Ćurić
   Date: 090916–18
   Address: Department of Computer Sciences, University of Salzburg, Salzburg, Austria
   Title: On Set Distances and Their Application to Image Registration

7. *Conference:* 6th International Symposium on Image and Signal Processing and Analysis (ISPA'09)
   Kristin Norell
   Date: 090916–18
   Address: Department of Computer Sciences, University of Salzburg, Salzburg, Austria
   Title: Creating Synthetic Log End Face Images
   Comment: The paper was presented at the Special Session on Wood Science and Technology

8. *Conference:* 6th International Symposium on Image and Signal Processing and Analysis (ISPA'09)
   Erik Wernersson
   Date: 090916–18
   Address: Department of Computer Sciences, University of Salzburg, Salzburg, Austria
   Title: Generating Synthetic & CT Images of Wood Fibre Materials

9. *Conference:* 6th International Symposium on Image and Signal Processing and Analysis (ISPA'09)
   Gustaf Kylberg
   Date: 090916–18
   Address: Department of Computer Sciences, University of Salzburg, Salzburg, Austria
   Title: Local Intensity and PCA Based Detection of Virus Particle Candidates in Transmission Electron Microscopy Images

10. *Conference:* 13th International Workshop on Combinatorial Image Analysis (IWCIA'09)
    Filip Malmberg
    Date: 091124–27
    Address: Playa del Carmen, Mexico
    Title: Sub-pixel Segmentation with the Image Foresting Transform

11. *Conference:* 6th International Symposium on Visual Computing (ISVC'09)
    Patrik Malm
    Date: 091130–1202
    Address: Las Vegas, USA
    Title: Closing Curves with Riemannian Dilation: Application to Segmentation in Automated Cervical Cancer Screening

7.7.2 Poster presentations – refereed conferences

1. *Conference:* 3D Virtual Reconstruction and Visualization of Complex Architectures (3D-ARCH'2009)
   Stefan Seipel
   Date: 090225–28
   Address: Trento, Italy
   Title: A Collaborative Visualization Environment for Natural Interaction with Architectural Content

2. *Conference:* 16th Scandinavian Conference on Image Analysis (SCIA'09)
   Bettina Selig
   Date: 090615–18
   Address: Oslo, Norway
   Title: Segmentation of Highly Lignified Zones in Wood Fiber Cross-Sections

3. *Conference:* 16th Scandinavian Conference on Image Analysis (SCIA'09)
   Hamid Sarve
   Date: 090615–18
   Address: Oslo, Norway
   Title: Quantification of Bone Remodeling in SRuCT Images of Implants

4. *Conference:* 16th Scandinavian Conference on Image Analysis (SCIA'09)
   Joakim Lindblad
   Date: 090615–18
   Address: Oslo, Norway
   Title: Improved Quantification of Bone Remodelling by Utilizing Fuzzy Based Segmentation
   Comment: Also co-presenting: "Recovering affine deformations of fuzzy shapes" and "Quantification of Bone Remodeling in SRμCT Images of Implants"

5. *Conference:* 15th International Conference on Image Analysis and Processing (ICIAP'09)
   Joakim Lindblad
   Date: 090909–11
   Address: Vietri sul Mare, Salerno, Italy
   Title: Pixel Coverage Segmentation for Improved Feature Estimation

6. *Conference:* 15th International Conference on Image Analysis and Processing (ICIAP'09)
   Kristin Norell
   Date: 090909–11
   Address: Vietri sul Mare, Salerno, Italy
   Title: An automatic method for counting annual rings in noisy sawmill images

7. *Conference:* 12th International Conference on Medical Image Computing and Computer Assisted Intervention (MICCAI'09)
   Milan Gavrilovic
   Date: 090920–23
   Address: Imperial College London, UK
   Title: Suppression of Autofluorescence based on Fuzzy Classification by Spectral Angles

8. *Conference:* 7th Eurographics Italian Chapter Conference 2009
   Anders Hast
   Date: 091104–07
   Address: Verona, Italy
   Title: Texture Synthesis

9. *Conference:* International Conference Applied Computing (IADIS'09)
   Anders Hast
   Date: 091119–21
   Address: Rome, Italy
   Title: A Heterogeneous Cluster Framework for Computationally Heavy Visualization

7.7.3 Oral presentations

1. *Conference:* Swiss-Swedish R& T Workshop on Image Processing, Visualization & Modeling
   Ingrid Carlbom
   Date: 090309–10
   Address: Artorg Center, Bern, Switzerland
   Title: Centre for Image Analysis
   Comment: Workshop to stimulate Swiss-Swedish collaborative Research
2. *Conference:* Swedish Symposium on Image Analysis, Halmstad (SSBA'09)
   Erik Wernersson
   Date: 090318–20
   Address: Halmstad
   Title: Closing Pores and Segmenting Individual Fibres in 3D Images of Wood Fibre Composites Using Curvature Information and Graph Cuts
3. *Conference:* Swedish Symposium on Image Analysis, Halmstad (SSBA'09)
   Gustaf Kylberg
   Date: 090318–20
   Address: Halmstad
   Title: Detecting Virus-like Particles Using Transmission Electron Microscopy
4. *Conference:* Swedish Symposium on Image Analysis, Halmstad (SSBA'09)
   Filip Malmberg
   Date: 090318–20
   Address: Halmstad
   Title: Interactive Segmentation with Relaxed Image Foresting Transform
5. *Conference:* Swedish Symposium on Image Analysis, Halmstad (SSBA'09)
   Patrik Malm
   Date: 090318–20
   Address: Halmstad
   Title: Curve Closing by Gradient Weighted Distance Transformation Applied in Automated Cervical Cancer Screening
6. *Conference:* Swedish Symposium on Image Analysis, Halmstad (SSBA'09)
   Milan Gavrilovic
   Date: 090318–20
   Address: Halmstad
   Title: Dimensionality Reduction for Colour Based Pixel Classification
7. *Conference:* Swedish Symposium on Image Analysis, Halmstad (SSBA'09)
   Amin Allalou
   Date: 090318–20
   Address: Halmstad
   Title: Signal Detection in 3D by Stable Wave Signal Verification
   Comment: Due to illnes Allalou could not attend the conference
8. *Conference:* Swedish Symposium on Image Analysis, Halmstad (SSBA'09)
   Bettina Selig
   Date: 090319–20
   Address: Halmstad
   Title: Measuring Distribution of Lignin in Wood Fibre Cross-Sections
9. *Conference:* Round Table, Akademiska Sjukhuset
   Ingrid Carlbom
   Date: 091019
   Address: Uppsala
   Title: Whole hand Haptics with True 3D Displays
   Comment: Round table arranged on the occation of the visit by Professor Hans-Florian Zeilhofer from Basel, Switzerland

7.7.4 Poster presentations

1. *Conference:* 9th European Light Microscopy Initiative (ELMI) meeting on Advanced Light Microscopy
   Milan Gavrilovic
   Date: 090609–12
   Address: Glasgow Caledonian University, Scotland, UK
   Title: Spectral Angle Histogram: a Novel Image Analysis Tool for Quantification of Colocalization and Cross-talk

7.7.5 Attended conferences

1. *Conference:* PhD student day, Swedish Symposium on Image Analysis, Halmstad (SSBA'09)
   Maria Axelsson, Milan Gavrilovic, Gustaf Kylberg, Patrik Malm, Filip Malmberg, Khalid Niazi, Kristin Norell, Hamid Sarve, Bettina Selig, Lennart Svensson, Erik Wernersson
   Date: 090318
   Address: School of Information Science, Computer and Electrical Engineering, Halmstad University

2. *Conference:* Swedish Symposium on Image Analysis, Halmstad (SSBA'09)
   Ewert Bengtsson, Gunilla Borgefors, Maria Axelsson, Ingrid Carlbom, Cris Luengo, Khalid Niazi, Kristin Norell, Ingela Nyström, Hamid Sarve, Ida-Maria Sintorn, Robin Strand, Lennart Svensson
   Date: 090319–20
   Address: School of Information Science, Computer and Electrical Engineering, Halmstad University
   Comment: Nyström and Sintorn were on the Board at the SSBA annual meeting

3. *Conference:* Eurographics 2009
   Stefan Seipel
   Date: 090330–0403
   Address: Technical University, Munich, Germany

4. *Conference:* 16th Scandinavian Conference on Image Analysis (SCIA'09)
   Ewert Bengtsson, Gunilla Borgefors, Patrik Malm
   Date: 090614–18
   Address: Oslo, Norway

5. *Conference:* 36th International COnference and Exhibition on Computer Graphics and Interactive Techniques, (SIGGRAPH'09)
   Ingrid Carlbom
   Date: 090803–07
   Address: New Orleans, LA, USA

6. *Conference:* 9th International Conference on Mathematical Morphology (ISMM'09)
   Gunilla Borgefors
   Date: 090825–27
   Address: Groningen, The Netherlands
   Comment: Borgefors was session chair

7. *Conference:* 12th International Conference on Medical Image Computing and Computer Assisted Intervention (MICCAI'09)
   Milan Gavrilovic
   Date: 090920–23
   Address: Imperial College London, UK

8. *Conference:* Mini-Conference on Digital Geometry
   Gunilla Borgefors, Robin Strand, Vladimir Ćurić
   Date: 090924
   Address: Ångström laboratory, Uppsala
   Comment: The symposium was held the day before the dissertation of Hanna Uscka-Wehlou. The speakers were the opponent and committee members

9. *Conference:* View
   Anders Hast
   Date: 091104–07
   Address: Conference center Torino Incontra, Turin, Italy

10. *Conference:* International Conference Applied Computing (IADIS'09)
    Stefan Seipel
    Date: 091119–21
    Address: Rome, Italy
    Comment: Stefan Seipel was chairing three conference sessions

7.7.6 Other conferences

In this Section, we list attended non-image processing conferences.

1. *Conference:* ENLIGHT
   Ewert Bengtsson, Carolina Wählby, Cris Luengo, Milan Gavrilovic, Amin Allalou
   Date: 090127–28
   Address: Dako AB, Copenhagen, Denmark

2. *Conference:* VINNOVA and MSB Workshop: Future R& D areas related to security and crisis management
   Ida-Maria Sintorn
   Date: 090305
   Address: KonferensHuset, Stockholm

3. *Conference:* Visionskonferens
   Ingrid Carlbom, Stina Svensson
   Date: 090311
   Address: The Swedish Exhibition and Congress Centre, Göteborg
   Comment: Conference in conjunction with Visual Forum 2009 organized by the Visualization program (the Knowledge Foundation and others)

4. *Conference:* Visual Forum 2009
   Ingrid Carlbom, Stina Svensson, Anders Hast
   Date: 090312
   Address: Göteborg

5. *Conference:* IT department at UU 10 years
   Ewert Bengtsson
   Date: 090326
   Address: ITC Uppsala
   Comment: Attended the 10th anniversary celebration for the IT department

6. *Conference:* Deans meeting UU
   Ewert Bengtsson
   Date: 090331–0401
   Address: Fagerudd Conference Centre
   Comment: Semiannual discussions about UU policy issues

7. *Conference:* The fourth Scientific-Technical Meeting InterRegioSci 2009, AP Vojvodina
   Vladimir Ćurić
   Date: 090421
   Address: Government, Autonomous Province of Vojvodina, Novi Sad, Serbia
   Comment: InterRegioSci is the annual conference by the Government of AP Vojvodina, Serbia, with presentations scientific works originating from research projects that are co financed by the Provincial Secretariat for Science and Technological Development

8. *Conference:* SLU prefect meeting
   Ewert Bengtsson
   Date: 090422

Address: Krusenberg Manor
Comment: Discussions about SLU policy and management issues

9. *Conference:* NSC 20-year Anniversary and SNIC Interaction 2009
Ingela Nyström
Date: 091013–14
Address: NSC, Linköping University
Comment: Representing UPPMAX

10. *Conference:* Interdisciplinary round table on trauma and tumor surgery
Ewert Bengtsson, Ingrid Carlbom
Date: 091019
Address: Uppsala University Hospital and Uppsala University Medical Faculty, Dept of Surgical Sciences
Comment: The conference was arranged for the visit of professor Hans-Florian Zeilhofer from Basel, Switzerland. Ingrid Carlbom made a presentation

11. *Conference:* 2nd Nordic Confocal & Fluorescence Meeting
Milan Gavrilovic
Date: 091021
Address: Leica for Science meeting in Sigtuna

12. *Conference:* The Royal Technology Forum
Ewert Bengtsson
Date: 091022
Address: IVA Conference Centre, Stockholm
Comment: The forum presented and discussed the findings of the research strategy project for which Bengtsson was part of the reference group

13. *Conference:* IVA Högtidssammankomst
Ewert Bengtsson
Date: 091023
Address: Stockholm Concert Hall
Comment: The annual conference by the Royal Swedish Academy of Engineering Sciences with presentations about cutrrent developments in engineering in Sweden

14. *Conference:* The SLU rectors meeting for prefects
Ewert Bengtsson
Date: 091103–04
Address: Krusenberg Manor
Comment: Discussions about SLU policy and management issues including findings from the KON evaluation

15. *Conference:* UU information department seminar on social media
Ewert Bengtsson
Date: 091105
Address: Department of Law seminar room, UU
Comment: Presentation and discussion about how the new social media influences university work

16. *Conference:* Swedish Bioimaging Network Inauguration Meeting
Ewert Bengtsson
Date: 091110
Address: Alba Nova, KTH, Stockholm
Comment: Information about the European Research Infrastructure Initiative and how it potentially applies to Biomedical Imaging in Sweden and how we should respond to that

17. *Conference:* GÉANT Launch Event
Ingela Nyström
Date: 091201–02
Address: Museum of Modern Art, Stockholm
Comment: Being a board member of SUNET, Nyström was representing Uppsala University at this launch of the future Internet

7.8 Visiting scientists (staying at least 2 weeks)

1. **Hyun-Ju Choi**
   Address: School of Medicine, Pusan National University, Republic of Korea
   Host: Ewert Bengtsson
   Date: 090101–1231
   Comment: Research cooperation

2. **Nataša Sladoje**
   Address: Faculty of Engineering, University of Novi Sad, Serbia
   Host: Joakim Lindblad
   Date: 090205–20
   Comment: Research cooperation

7.9 Other visitors

1. **Carina B Johansson**
   Address: Örebro University
   Host: Hamid Sarve, Joakim Lindblad
   Date: 090205
   Topic: Project discussions

2. **Olof Dahlqvist Leinhard**
   Address: Dept. of Medical and Health Sciences, Linköping University
   Host: Ingela Nyström, Filip Malmberg
   Date: 090209
   Topic: Discussion on joint interests of interactive segmentation of medical images

3. **Tuomas Turpeinen, Arttu Miettinen**
   Address: Department of Physics, University of Jyväskylä, Finland
   Host: Cris Luengo, Anders Brun, Erik Wernersson
   Date: 090218
   Topic: WoodFibre3D collaboration

4. **WoodFibre3D meeting**
   Address: KTH, Stockholm; RisøDTU, Denmark; JYU, Finland; PFI, Norway; NTNU, Norway; SINTEF, Norway; and Research Council of Norway.
   Host: Cris Luengo
   Date: 090219
   Number of visitors: 9
   Topic: WoodFibre3D meeting
   Comment: Full day meeting with all the partners in the project

5. **IT programme pupils**
   Address: John Bauergymnasiet, Uppsala
   Host: Ingela Nyström, Martin Ericsson
   Date: 090225
   Number of visitors: 60
   Topic: 3DIS4U: Stereo Rendering for Research and Fun
   Comment: The first year pupils were presented what can be accomplished after a thourough mathematics and IT education

6. **Saed Mousavi**
   Address: Swedish Defence Research Agency, Grindsjön
   Host: Gunilla Borgefors
   Date: 090227
   Topic: Discussion on joint Master thesis on metal deformation

7. **Håkan Lindström, Ingela Vretblad**
   Address: A-sort, Uppsala
   Host: Kristin Norell
   Date: 090303
   Topic: Discussions on possible cooperation

8. **UPPMAX board and others**
   Address: Various Departments at UU, Lund University, and Umeå University.
   Host: Ingela Nyström
   Date: 090310
   Number of visitors: 14
   Topic: eSSENCE - An eScience Collaboration
   Comment: The meeting was one of the steps to write a joint application from the universities of Uppsala, Lund, and Umeå for the strategic area of eScience

9. **Lennart Dencker, Mats Nilsson**
   Address: Department of Pharmaceutical Biosciences, UU
   Host: Ewert Bengtsson, Khalid Niazi
   Date: 090403
   Topic: Joint application to VR
   Comment: The meeting led to an application which was granted

10. **Pernilla Björk**
    Address: Uppsala University Central Administration
    Host: Ewert Bengtsson
    Date: 090417
    Topic: How IT is used in University information and communication and about CBA as a joint university unit
    Comment: The visitor moved from being responsible for the central information at SLU to the same position at UU

11. **Kristofer Gamstedt and Fabrice Mangiapane**
    Address: KTH, Stockholm
    Host: Cris Luengo, Anders Brun, Erik Wernersson
    Date: 090421
    Topic: Woodfibre3D collaboration

12. **CG Pettersson**
    Address: Lantmännen Lantbruk, Grain Department, Business development, Enköping
    Host: Ewert Bengtsson, Robin Strand
    Date: 090507
    Topic: Discussing if image analysis can be used for grain quality control

13. **Alan Sabirsh**
    Address: Molecular Pharmacology, CNS& Pain, AstraZeneca, Södertälje
    Host: Ewert Bengtsson, Robin Strand
    Date: 090511
    Topic: Possible cooperation om biomedical image analysis

14. **Karl Krissian**
    Address: GIMET (Grupo de Imagen, Tecnología Médica y Televisión), Departamento de Señales y Comunicaciones, Pabellón B, Edificio Telecomunicaciones Laboratorio 203, Universidad de Las Palmas de Gran Canaria, Campus de Tafira, 35017 Las Palmas, Spain
    Host: Anders Brun
    Date: 090513–23
    Topic: Image analysis and distance transforms
    Comment: Brun was working with Krissian at Harvard (Boston) during his PhD work

15. **Mattias Moëll**
    Address: Vattenfall, Älvkarleby

Host: Gunilla Borgefors
Date: 090514
Topic: Tropical forest survey from above

16. **Alex Olwal**
Address: KTH, Stockholm
Host: Ingrid Carlbom
Date: 090525
Topic: To explore common research interests

17. **Ulf Skoglund**
Address: Karolinska Institute, Stockholm
Host: Lennart Svensson
Date: 090528
Topic: Annual ProViz meeting

18. **Stefan Gustavson**
Address: Visual Information Technology and Applications (VITA) group, Dept. of Science and Technology, Linköping University, Campus Norrköping
Host: Robin Strand
Date: 090601
Topic: Collaboration with Robin Strand

19. **Steven Feiner**
Address: Columbia University, New York, USA
Host: Ingrid Carlbom
Date: 090602
Topic: Perceptualization

20. **James Terkeurst, Bengt Rinde**
Address: Institute of digital innovation, University of Teeside, UK and Uppsala City Council
Host: Ewert Bengtsson
Date: 090610
Topic: Possible links between Uppsala and Middlesbrough region in high tech developments

21. **Lars Roepstorff, Anna Byström**
Address: Dept. of Equin Studies, SLU, Uppsala
Host: Gunilla Borgefors, Anders Brun
Date: 090624
Topic: Image analysis for saddle pressure and foot deformation measurements

22. **Susanne Sjöberg**
Address: SLU, Umeå
Host: Gunilla Borgefors
Date: 090910
Topic: CBA in general
Comment: Sjöberg is the new communicator at S-fak

23. **Pasha Razifar**
Address: GE Healthcare, Uppsala
Host: Ewert Bengtsson
Date: 090917
Topic: Cooperation on PET image analysis

24. **Mats Nilsson, Bill Webster**
Address: BMC, UU & Anatomy & Histology, School of Medical Sciences University of Sydney, Australia
Host: Khalid Niazi
Date: 090928
Topic: Counting of heart beats from rat embryos during arrhythmia

25. **Urban Josefsson, John Worley**
Address: Museum Gustavianum, UU
Host: Ewert Bengtsson
Date: 090929
Topic: Inventory of old research equipment at CBA

26. **Örjan Smedby**
Address: Center for Medical Image Science and Visualization (CMIV), Linköping University
Host: Cris Luengo, Joakim Lindblad
Date: 091009
Topic: Possible collaboration on 3D trabecular bone images

27. **Björn Holmberg, Mats Ekman, Kjartan Halvorsen**
Address: SAAB Systems, Järfälla
Host: Cris Luengo, Ewert Bengtsson
Date: 091009
Topic: Possible master thesis project

28. **Susanne Hoefner**
Address: Department of Physics and Astronomy, UU
Host: Ewert Bengtsson
Date: 091015
Comment: Ewert Bengtsson serves as mentor of Dr Hoefner, this was the first of several meetings

29. **Aurelie Laloeuf**
Address: Karolinska Institute, Stockholm
Host: Lennart Svensson
Date: 091103
Topic: Collaboration discussions

30. **Carla Puglia**
Address: Office of Faculty of Science and Technology, UU
Host: Ewert Bengtsson, Ingela Nyström
Date: 091103
Topic: Visualization in the planned Energy House and Planetarium
Comment: Discussed possible CBA participation

31. **Anders Tegeman**
Address: Hofors
Host: Ewert Bengtsson
Date: 091106
Topic: Discussion of light microscopy findings in blood samples
Comment: One of several visits of Anders Tegeman

32. **Tony Barrera, Christer Kiselman**
Address: Uppsala
Host: Ewert Bengtsson
Date: 091109
Topic: Multi-complex numbers
Comment: Part of ongoing discussions with Tony Barrera about mathematical and computer graphics concepts, this time the focus was on the concept of multi-complex numbers

33. **Björn Holmberg and Daniel Skog**
Address: SAAB Systems, Järfälla
Host: Cris Luengo
Date: 091202
Topic: Daniel's MSc project at CBA with SAAB
Comment: Daniel will start at CBA on the 20th of January

34. **Johan Forsgren**
Address: Nanotechnology and functional materials, UU
Host: Ida-Maria Sintorn
Date: 091210
Topic: Potential collaboration about analysis of bone regrowth around implants

35. **Kristofer Gamstedt and Bjørn Steinar Tanem**
Address: KTH, Stockholm and SINTEF, Trondheim, Norway
Host: Cris Luengo, Anders Brun, Erik Wernersson, Gunilla Borgefors
Date: 091216
Topic: Woodfibre3D collaboration
Comment: Discussed future directions of our project

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

1. **Joakim Lindblad**
Host: Nataša Sladoje, Silvia Ghilezan
Address: Faculty of Engineering, University of Novi Sad, Serbia
Topic: Joint research project
Comment: Several longer visits were made during the year.

7.11 Short visits to other research groups and meetings outside CBA

Note: Meetings occassioned by permanent appointments are listed in section 7.12

1. **Anders Hast**
Address: AlbaNova University Center, Stockholm
Date: 090115
Topic: Swedish LOFAR Science interest meeting

2. **Ewert Bengtsson, Carolina Wählby, Amin Allalou, Milan Gavrilovic, Cris Luengo**
Address: Dako, Glostrup, Denmark
Date: 090127–28
Topic: ENLIGHT Meeting

3. **Ewert Bengtsson, Carolina Wählby, Amin Allalou, Milan Gavrilovic, Cris Luengo**
Host: Niels T. Foged
Address: Visiopharm, Hørsholm, Denmark
Date: 090128–29
Topic: ProDiagnose collaboration

4. **Ewert Bengtsson, Carolina Wählby, Amin Allalou, Milan Gavrilovic, Cris Luengo**
Host: Niels Foged
Address: Visiopharm, Agers Alle 3, Hörsholm, Denmark
Date: 090129
Topic: Cooperation in and beyond ENLIGHT

5. **Ida-Maria Sintorn**
Host: Ali Mirazimi, Kjell-Olof Hedlund
Address: Swedish Institute for Infectious Disease Control (SMI), Nobels väg 18, Stockholm, Sweden
Date: 090206
Topic: PanViruShield project meeting

6. **Cris Luengo**
Host: David Sumpter
Address: Ångströmlaboratoriet, UU
Date: 090220
Topic: Discuss possible collaboration on animal behaviour

7. **Anders Brun, Erik Wernersson**
   Host: Marco Stampanoni
   Address: Paul Scherrer Institut, Villigen, Switzerland
   Date: 090223–25
   Topic: TOMCAT imaging for Woodfibre3D project

8. **Ewert Bengtsson, Carolina Wählby**
   Host: Mikael Sebesta
   Address: The meeting took place at a hotel in Halmstad
   Date: 090318
   Topic: Possible collaboration on image analysis of holographic microscopy images
   Comment: Our host was from Phase Holographic Imaging AB, Lund

9. **Robin Strand**
   Host: Anders Ahnesjö
   Address: Uppsala Science Park
   Date: 090403
   Topic: Possible collaboration

10. **Robin Strand**
    Host: Per Jannesten
    Address: MIC, Polacksbacken
    Date: 090407
    Topic: Possible collaboration

11. **Cris Luengo**
    Host: Angela DePace
    Address: Harvard Medical School, Boston, Massachusetts
    Date: 090413–16
    Topic: Ongoing BDTNP collaboration
    Comment: Visited Angela's new lab, instructed her people in the tools we developed for the BDTNP, discussed possible applications and new collaborations

12. **Anders Hast**
    Host: CINECA
    Address: CINECA, Supercomputer Center in Italy
    Date: 090415
    Topic: Research and collaboration visit
    Comment: Discussing future collaboration

13. **Bettina Selig**
    Address: Hannover, Germany
    Date: 090419–25
    Topic: RoboCup German Open 2009
    Comment: Participating in Rescue League (See Teaching: Projekt IT)

14. **Khalid Niazi, Ingela Nyström**
    Host: Prof. Albert Alm
    Address: Department of Ophthalmology, UU Hospital
    Date: 090423
    Topic: Retinal Image Registration
    Comment: Discussion about the project and we received a retinal images database

15. **Hamid Sarve, Joakim Lindblad**
    Host: Carina B. Johansson
    Address: Department of Clinical Medicine, Örebro University, Örebro, Sweden
    Date: 090504
    Topic: Project discussions and imaging

16. **Robin Strand**
Host: Niels T. Foged, Visiopharm
Address: Visiopharm A/S, Hørsholm, Denmark
Date: 090506
Topic: Job interview
Comment: Job interview for recruiting a PhD student in a project together with Visiopharm

17. **Lennart Svensson**
Host: Stina Svensson
Address: Karolinska Institute, Stockholm
Date: 090507
Topic: Introducing the ProViz demonstrator

18. **Anders Brun, Cris Luengo, Gunilla Borgefors**
Host: SINTEF, Björn Tanem
Address: SINTEF/NTNU, 7491 Trondheim, Norway
Date: 090510
Topic: WoodWisdom meeting Trondheim

19. **Ewert Bengtsson**
Host: Siamak Ayani
Address: OculusAI Technologies AB, Teknikringen 33, Stockholm
Date: 090512
Topic: Information about image analysis activities and possible cooperation ideas

20. **Joakim Lindblad**
Host: Sven Loncarić
Address: Image Processing Group, Faculty of Electrical Engineering and Computing, University of Zagreb, Croatia
Date: 090525–29
Topic: Research visit

21. **Cris Luengo, Erik Wernersson**
Host: Marco Stampanoni
Address: Paul Scherrer Institut, Villigen, Switzerland
Date: 090525–26
Topic: TOMCAT imaging for Woodfibre3D project

22. **Gunilla Borgefors, Anders Brun, Cris Luengo**
Host: Bjørn Tanem
Address: SINTEF, Norweigian University of Science and Technology, Trondheim, Norway
Date: 090610
Topic: Wood Fibre 3D meeting
Comment: Meeting with all participants in the project. Progress reports and future plans

23. **Anders Brun**
Host: Hans Rullgård
Address: Matematiska institutionen, Stockholms universitet, Stockholm
Date: 090611
Topic: Generalized Hough transforms
Comment: Work on the GHT

24. **Ingela Nyström**
Host: Karl Tombre
Address: INRIA, Nancy, France
Date: 090715–16
Topic: IAPR Executive Committee Meeting

25. **Lennart Svensson**
Host: Stina Svensson

Address: Karolinska Institute, Stockholm
Date: 090826
Topic: Research collaboration within the ProViz project

26. **Ewert Bengtsson**
Host: Hendrik Mäkeler, Harald Nilsson
Address: The Uppsala University Coin Cabinet
Date: 090828
Topic: Start of master thesis project
Comment: Introducing our new German Master Thesis Student Jens Hedrich

27. **Filip Malmberg**
Host: Olof Dahlqvist Leinhard
Address: CMIV, Linköping
Date: 090908
Topic: Liver Segmentation Project

28. **Robin Strand**
Host: Joel Kullberg
Address: Department of Oncology, Radiology and Clinical Immunology, Radiology
Date: 090910
Topic: Possible collaboration

29. **Lennart Svensson**
Host: Aurelie Laloeuf
Address: Karolinska Institute
Date: 090911
Topic: Research collaboration within the ProViz project

30. **Gunilla Borgefors, Hamid Sarve**
Host: Magnus Jacobsson
Address: Astra Tech, Mölndal
Date: 090917
Topic: Co-operation on visualisation of bone implants in the KK-founded project
Comment: Carina Johansson from Örebro University was also present

31. **Kristin Norell**
Host: Lars Björklund
Address: Timber measurement council, VMU, Uppsala Science Park
Date: 090924
Topic: Log quality measurements
Comment: Discussions on timber quality measurements. Christina Lundgren and Jacob Edlund, VMU and Udo Sauter, Forest Research Institute Baden-Württemberg, Freiburg, Germany also attended the meeting

32. **Kristin Norell, Anders Brun, Anders Dånmark**
Host: Mats Nylinder
Address: Dept. of forest products, SLU, Uppsala
Date: 090924
Topic: Master thesis discussions
Comment: Discussions about Anders Dånmark's master thesis project

33. **Cris Luengo**
Host: Joanna Hornatowska
Address: Innventia, Stockholm
Date: 091001
Topic: Taking images for Woodfibre3D project
Comment: Joanna advised on a method to image the same wood fibres before and after wetting, and let me use her microscope to take a collection of images

34. **Stina Svensson, Lennart Svensson**
Address: KTH Royal Institute of Technology
Date: 091007
Topic: Showing the ProViz demonstrator

35. **Ewert Bengtsson**
Host: Bengt Långström
Address: Imanet PET Centre Uppsala
Date: 091012
Topic: Swedish Bioimaging Infrastructure
Comment: Discussion about Swedish and Uppsala Initiatives in the new European Infrastructure Initiative for Biomedical Imaging

36. **Kristin Norell**
Host: Bo Ryrvall
Address: SAWCO, Nyköping
Date: 091020
Topic: Log quality measurements
Comment: Meeting with several people at SAWCO and Lars Björklund, VMU, to discuss image analysis of logs

37. **Gunilla Borgefors, Anders Brun, Cris Luengo, Erik Wernerson**
Host: Kristofer Gamstedt
Address: School of Chemical Science and Engineering, KTH, Stockholm
Date: 091106
Topic: WoodFibre 3D
Comment: Project meeting. Members from Denmark, Finland and Norway also participated

38. **Bettina Selig**
Host: Stig Bardage
Address: SLU, Uppsala
Date: 091118–19
Topic: Imaging compression wood sections

39. **Ewert Bengtsson, Ingrid Carlbom**
Host: Anders Ahlen
Address: Signals and Systems, Ångström Laboratory
Date: 091118
Topic: Wavelet based sound analysis in 2D
Comment: Johan Gustafsson and Ulf Hammarqvist are two students interested in doing a project. We discussed ideas and possible cooperation in relation to that

40. **Ewert Bengtsson**
Host: Heug-Kook Choi
Address: Inje University, GimHae, South Korea
Date: 091123–26
Topic: Collaboration on biomedical microscopy
Comment: Start up meeting within a joint cooperation grant

41. **Ewert Bengtsson**
Host: Andrew Mehnert, Craig Engstrom
Address: Department of Information Technology and Electrical Engineering, University of Queensland, Brisbane, Australia
Date: 091203–04
Topic: Collaboration on biomedical image analysis
Comment: Discussions about continued cooperation, visit to labs

42. **Patrik Malm, Ewert Bengtsson**
Host: CDAC
Address: Thiruvananthapuram, India

Date: 091207–12
Topic: CerviScan Project Meeting
Comment: Startup meeting

43. **Ida-Maria Sintorn**
Host: Ali Mirazimi, Kjell-Olof Hedlund
Address: Swedish Institute for Infectious Disease Control (SMI), Nobels väg 18, Stockholm, Sweden
Date: 091208
Topic: PanViruShield project meeting

44. **Gunilla Borgefors**
Host: Fredrik Walter, Tomas Brandtberg
Address: Dianthus AB, Boden
Date: 091211
Topic: Alumni contact
Comment: Walter and Brandtberg are former PhDs from CBA, that now leads this IT company of forestry applications

45. **Ewert Bengtsson, Patrik Malm**
Host: K. Sujathan
Address: Regional Cancer Centre, Thiruvananthapuram, Kerala, India
Date: 091211
Topic: Planning PAP-screening research cooperation
Comment: Discussed application for permission to obtain samples from RCC to CBA

46. **Ewert Bengtsson**
Host: Amalka Pinidiyaarachchi
Address: Faculty of Science and Technology, University of Peradeniya
Date: 091214–15
Topic: Visit to follow up on PhD student period at CBA
Comment: Discussions about current research at Peradeniya and possible continued collaboration

47. **Ewert Bengtsson, Gunilla Borgefors**
Host: Arvid Uggla
Address: Faculty of Veterinary Medicine and Animal Science, SLU, Ultuna
Date: 091221
Topic: Joint future research
Comment: Ulf Magnusson, Leif Norrgren och Jan-Erik Hällgren also participated

48. **Vladimir Ćurić**
Host: Nataša Sladoje
Address: Faculty of Engineering, University of Novi Sad, Serbia
Date: 091229
Topic: Research colaboration
Comment: Joakim Lindblad also participated

7.12 Committees

Ewert Bengtsson
International:

- Editorial board member of the journal Machine Graphics & Vision, 1994–
  Comment: Published by Polish Academy of Sciences
- Editorial board member of the journal Computer Methods and Programs in Biomedicine, 1995–
  Comment: Published by Elsevier
- Senior member of the Institute of Electrical and Electronics Engineers (IEEE) 2004–
  Comment: Member since 1974
- Member of the International Society for Optical Engineering (SPIE)
- Member of Eurographics, the European Association for Computer Graphics, 1998–
- Member of the International Society for Analytical Cytology (ISAC), 2000–
- On the EU Project ENLIGHT Program Management Board, 0608–0907
- Scientific review committee for the Innovation and Technology Commission of Hong Kong Special Administrative Region Government, 090409–28
  Comment: Written review of research proposals
- Member of the European Research Council Advanced Grants Panel (ERC) 2008–
  Comment: During 2009 this appointment only involved reviewing applications

National:

- Member of the Royal Swedish Academy of Engineering Sciences, Section VII: Basic and Interdisciplinary Engineering Sciences. 200610–
  Comment: (5 meetings)
- Vice Chair of Section VII of the Royal Swedish Academy of Engineering Sciences, 091119 –
- Member of the Royal Society of Sciences in Uppsala (Kungliga Vetenskapssocieteten), 1998–
  Comment: Elected member of the oldest scientific society in Sweden. (3 meetings)
- Chair of Uppsala University IT Council, 2008–
  Comment: The IT Council is responsible for coordinating all aspects of IT usage and development at UU. The board has about 15 members. 4 meetings and additionally 4 preparatory and follow up 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.
- Member of the Board of UpGIS, the net for Geographical Information Systems at UU, 1999–
  Comment: (5 meetings.)
- Member of the UU student cooperation group, 2000–
  Comment: A group where the leadership of the university and the student unions meets to discuss matters of common interest. (3 meetings)
- Member of the scientific board of Hillevi Fries Research Scholarship Foundation.
  Comment: A Swedish foundation that accepts applications and gives out research grants for urology research. The board has three members. (1 meeting)
- Expert evaluator for grant applications to the Swedish Foundation for International Cooperation in Research and Higher Education, STINT
- On the cooperation group for units supporting IT in learning at UU 2007–
  Comment: (3 meetings)
- On the reference group for Open Access Publications at UU 2008–
  Comment: (4 meetings)

- Non-voting member of the UU Library Board 2007–
  Comment: (6 meetings)
- On the Department Head Council of Polacksbacken, "Prefektrådet"
  Comment: (2 meetings)
- On a planning group for an application to the Wallenberg Foundation on IT in learning together with Stanford University.
  Comment: (6 meetings)
- Auditor for Swedish Society for Image Analysis (SSBA), 2004–
- Member of the Reference group for IVA project on research strategies, 090120–1022
  Comment: A temporary committee of the Swedish Academy of Engineering Sciences. (4 meetings)
- Chair of the Evaluation Panel for grant applications to the Swedish Research Council (VR): Natural and Engineering Sciences-Biomedical Engineering, 090512–1110
  Comment: Four full day meetings, about two weeks of full time work reading applications, more than 200 emails

Gunilla Borgefors
International:

- Fellow of the Institute of Electrical and Electronics Engineers, Inc. (IEEE), 2007–
  Comment: Senior member since 1998
- IEEE Computer Society Fellows Evaluation Committee, 2008–
- Fellow of the International Association for Pattern Recognition (IAPR), 1998–
- Member of the Advisory Committee of the International Association for Pattern Recognition (IAPR), 2008–2010
- Area editor of the journal Pattern Recognition Letters, 2004–
  Comment: On the editorial Board since 1998. Published by Elsevier.
- Editorial Board member of the journal Image Processing and Communications, 1994–
  Comment: Published by the Institute of Telecommunications, Bydgoszcz, Poland.
- Editorial Board member of the journal Pattern Recognition and Image Analysis: Advances in Mathematical Theory and Applications, 1993–
  Comment: Published by Interperiodica Publishing in cooperation with the "Cybernetics" Scientific Council, Russian Academy of Sciences.
- Editorial Board of the book series Computational Imaging and Vision, published by Springer, 2003–
- Steering committee for Discrete Geometry for Computer Imagery (DGCI) conferences, 2000–
  Comment: DGCI 2009 took place in Motréal, Canada, September 2009
- Programme committee for 9th International Symposium on Mathematical Morphology (ISMM'09), Groningen, The Netherlands, 090101–0830
- Programme committee for 10th Int. Conference on Pattern Recognition and Information Processing (PRIP'09), Minsk Belarus, 090101–0530
- Programme committee for 13th International Conference on Computer Analysis of Images and Patterns (CAIP'09), Münster, Germany, 090301–0930

National:

- Royal Society of Sciences in Uppsala (Kungliga Vetenskapssocieteten), Member No. 19, 2000–
  Comment: Elected member of the oldest scientific society in Sweden (founded 1710), (4 meetings.)
- Swedish Parliamentarians and Scientists, 1987–
  Comment: Members are elected. Only one scientist per field admitted.
- Nomination Committee, Swedish Society for Automated Image Analysis (SSBA)

- Vice chair of Appointments board, Faculty of Forest Sciences, SLU, 199907–
  Comment: (13 meetings.)
- The Prize and Reward committee of the Faculty of Forest Sciences, SLU, 2006–
  Comment: (1 meeting)
- Deputy member of the Docent committee, Faculty of Forest Sciences, SLU, 2007–
- Celsius-Linné committe, TN-faculty, UU, 200705–
  Comment: The committee selects the speakers for the annual Celsius and Linné lectures
- Member of the Board of UpGIS, the net for Geographical Information Systems at UU, 199904–
  Comment: Representing TN-faculty, UU
- Recruitment committee for a professor in Mathematical Statistics, SLU Umeå, 090801–0930
  Comment: (1 meeting)
- Deputy Elector for the Natural and Engineering Sciences Board of the Swedish Research Council (VR), 091001–1231
- Dissertation committee of of Miriam von Tiedemann, Dept. of Clinical Neuroscience, Karolinska Institutet, Stockholm, 090403
  Comment: Title: Image Processing Methods to Study the Living Hearing Organ
- Dissertation committee of Dereje Teferi Lemma, Dept. of Signals and Systems, Chalmers, Halmstad, 090612
  Comment: Title: Recognition and Evaluation by Video Synthesis Methods and Symmetry Features
- Dissertation Committee of Ola Nilsson, Dept. of Science and Technology, Campus Norrköping, Linköping University, 091119
  Comment: Title: Level-set Methods and Geodesic Distance Functions

Ingrid Carlbom
International:

- Co-Chair of the Editorial Board of Graphical Models, 090101–1231

National:

- Chair of the board of FMB, Forskarskolan i Matematik och Berkningsvetenskap, 090101–1231
- Contributor for e-Science Strategic Research Committee, 090101–1231
  Comment: Contributed material on UU Innovation for research proposal and also edited the English
- KK Stiftelsen's review committee for Light and Heavy Projects in Visualization, 090305–0527

Joakim Lindblad
International:

- Program Committee for the 15th International Conference on Discrete Geometry for Computer Imagery (DGCI'09), Motréal, Canada, Sept. 2009, 090101–1002
- Reviewing and Program Committee for the 13th International Workshop on Combinatorial Image Analysis (IWCIA'09), Mexico, November 2009, 090101–1127

Cris Luengo
National:

- Dissertation committee of Amalka Pinidiyaarachchi, CBA, UU, 090227
  Comment: Title: Digital Image Analysis of Cells: Applications in 2D, 3D and Time

Ingela Nyström
International:

- Member of the Executive Committee, International Association for Pattern Recognition (IAPR)
  - 2nd Vice President 2008–2010

- Governing Board Member, International Association for Pattern Recognition (IAPR), 2002–
- International member of PhD tribunal of Susana Mata, Universidad Rey Juan Carlos, Madrid, Spain, 090602
  Comment: Title: Multi-resolution Representations of 3D Objects based on Tolerance and Errors
- Programme committe for Second Workshop on UnConventional High Performance Computing (UCHPC'09), Ischia, Italy, 090101–0517

National:

- Board Member of Swedish Society for Automated Image Analysis (SSBA), 2000–
  Comment: President 2002–2006
- Board Member of the Swedish University computer NETwork (SUNET), 2008–
- Board Member of the Linnaeus Centre for Bioinformatics (LCB), 2009–
- Dissertation committee of Amalka Pinidiyaarachchi, Centre for Image Analysis, UU, 090227
  Comment: Title: Digital Image Analysis of Cells: Applications in 2D, 3D and Time
- Dissertation committee of Thomas Larsson, School of Innovation, Design and Engineering, Mälardalen University, Västerås, 090305
  Comment: Title: Adaptive Bounding Volume Hierarchies for Efficient Collision Queries
- Dissertation committee of Henrik Johansson, Dept. of Information Technology, UU, 090424
  Comment: Title: Autonomic Management of Partitioners for SAMR Grid Hierarchies
- Dissertation committee of Peter Holdfeldt, Dept. of Signals and Systems, Chalmers University of Technology, Göteborg, 090515
  Comment: Title: Dynamic Programming for Ultrasound Image Analysis of Atherosclerosis
- Dissertation committee of Ola Spjuth, Dept. of Pharmaceutical Biosciences, UU, 091127
  Comment: Title: Bioclipse: Integration of Data and Software in the Life Sciences
- Dissertation committee of Andreas Sigfridsson, Dept. of Biomedical Engineering and Dept. of Medical and Health Sciences, Linköping University, 091218
  Comment: Title: Multidimensional MRI of Myocardial Dynamics

Stefan Seipel
National:

- Board Member of the SIGRAD organisation, Svenska föreningen för grafisk databehandling, 2004–
- Member of the scientific program committee for the national annual computer graphics conference SIGRAD2009, held in Göteborg

Ida-Maria Sintorn
National:

- Board member of Swedish Society for Automated Image Analysis (SSBA), 2008–
- Member of the Evaluation Panel for grant applications to the Swedish Governmental Agencies for Innovation Systems, programme Innovations for Future Health: Diagnostic

Robin Strand
International:

- Program committee for 13th International Workshop on Combinatorial Image Analysis (IWCIA'09), Mexico, 090101–1127

Carolina Wählby
International:

- Opponent at dissertation of Antti Lehmussola, Dept. of Signal Processing, Tampere University of Technology, Tampere, Finland, 091210
  Comment: Title: Image Processing for Systems Biology