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 neighbourhood.

Cover design:
Gustaf Kylberg, Hamid Sarve

Edited by:
Ewert Bengtsson, Vladimir Curic, Ingela Nyström, Robin Strand, Lena Wadelius, Erik Wernersson

Centre for Image Analysis, Uppsala, Sweden

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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 Wahlby, 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 Pinidiyarachchi at UU and Maria Axelsson at SLU. We were also happy to have one of our researcher, Carolina Wahlby, 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 prestigious 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.

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

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 Kärsnäs, 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 Nordén, 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 Wahlby, Docent, Researcher, PhD, (part time) UU
Catherine Östlund, Researcher, (part time) SLU

Master Thesis students:
  Erik Ahlberg, Christer Bergman, Anders Dänmark, 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  

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 Borjeffors  
   **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 Krötenheerd 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
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 MVW-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 Wahlby  
   **Assistant Supervisor:** Ewert Bengtsson  
   **Opponent:** Arvid Lundervold, Dept. of Biomedicine and Molecular Imaging Center, University of Bergen, Norway  
   **Committee:** Jos Buijs, Division of Biochemical Engineering, Mälardalen University; Lennart Björksten, 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, Hogskolan Halmstad; Magnus Borga, Dept. of Biomedical Engineering, Linköpings University, Markku Kataja, Dept. of Physics, University of Jyväskylä, Finland
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 Pas-  

sare, 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, Stock-  

holm 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 mathett-  

matically 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 mathe-  

matics. 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 thresh-  

   olds)*

   **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 applica-  

   tions 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  


5. Tomas Brandtberg, 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.](image)
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
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 Empirical 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 Wahlby, 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 Wahlby  
*Partners:* Anton K. Raap, Frans M. van de Rijke, Roos Jahangir Tafrechi, Dept. of Molecular Cell Biology, Leiden University Medical Center, The Netherlands; Visiopharm, Hørsholm, 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 mitochondrial 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 Wahlby  
*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 Wahlby  
*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 Wåhlby

*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 colocalization 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 Wåhlby  
*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.
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.


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 cell type 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 Wåhlby

*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 an Immunohistochemical 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, Hørsholm, 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](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
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 rep-
resents 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 visual-
ized 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 de-
veloped 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 segmen-
tation 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 particu-
larly 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
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.

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

![touch pad and joint drawings](image1)

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.

![TMV visualization](image2)

Visualization 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 Wåhlby, 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
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.
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.
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](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-

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Figure 18: Image examples from the synthetic dataset.
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 fluorescence 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 km². Wind and wave erosion has diminished the island in size to about 1.4 km² today. Like as for the Capelinhos, eruptions created more islands from the vents, Jnir 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 satellite 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 commercial 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
Inventia, 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.

![CBA publications 1997-2009](image)

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 Communications, 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

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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

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 $p(v)$ 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 Communications, 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

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


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


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 Wahlby, 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 Wahlby
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 \( \beta \text{/slow} \) (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)  
   (1) Lawrence Berkeley National Laboratory, Berkeley, CA
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
   Author: 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
   Author: Martin Ericsson, Anders Hast and Stefan Seipel
   Conference: 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 puts 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
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 methods for 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
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 our method to the problem of automatically detecting virus particle candidates 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 within a 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
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
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  

*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 for image partitioning, commonly used for interactive segmentation. Given an image where a subset of the image elements (seed-points) have been assigned user-defined labels, the IFT completes the labeling by computing minimal cost paths from all image elements to the seed-points. Each image element is then given the same label as the closest seed-point. In its original form, the IFT produces crisp segmentations, i.e., each image element is assigned the label of exactly one seed-point. Here, we propose a modified version of the IFT that computes region boundaries with sub-pixel precision by allowing mixed labels at region boundaries. We demonstrate that the proposed sub-pixel IFT allows properties of the segmented 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 $\mathbb{Z}^2$ and $\mathbb{Z}^3$ 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

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) Örebro University

Conference: 16th Scandinavian Conference Image Analysis, Oslo, Norway (SCIA’09), pp. 770–779

Abstract: For quantification of bone remodeling around implants, we combine information obtained by two modalities: 2D histological sections imaged in light microscope and 3D synchrotron radiation-based computed microtomography, SRµCT. In this paper, we present a method for segmenting SRµCT volumes. The impact of shading artifact at the implant interface is reduced by modeling the artifact. The segmentation is followed by quantitative analysis. To facilitate comparison with existing results, the quantification is performed on a registered 2D slice from the volume, which corresponds to a histological section from the same sample. The quantification involves measurements of bone area and bone-implant contact percentages. We compare the results obtained by the proposed method on the SRµCT data with manual measurements on the histological sections and discuss the 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) 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 theory-anchored 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 research, 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 interaction 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.

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 geographic 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 or
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 traditional 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 to the paper production, but its exact effects are not well understood. To correlate exact levels of lignin in wood fibers to their mechanical properties, lignin autofluorescence is imaged in wood fiber cross-sections. Highly lignified areas can be detected and related to the area of the whole cell wall. Presently these measurements are performed manually, which is tedious and expensive. In this paper a method is proposed to estimate the degree of lignification automatically. A multi-stage snake-based segmentation is applied on each cell separately. To make a preliminary evaluation we used an image which contained 17 complete cell cross-sections. This image was segmented both automatically and manually by an expert. There was a highly significant correlation between the two methods, although a systematic difference indicates a disagreement in the definition of 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: PanVirusShield 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 forskarstolen, 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
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
7.6 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 ´Curi´c
    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 SRµCT 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

   **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 illness 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 occasion 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 Čurić**  
   **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 Ćurčić**  
   **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
9. **Conference:** NSC 20-year Anniversary and SNIC Interaction 2009  
   **Ingela Nyström**  
   **Date:** 091013–14  
   **Address:** NSC, Linköping University  
   **Comment:** Discussions about SLU policy and management issues

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 current 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

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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 thorough 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:* eSENSE - 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:* Lantmännens 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 on 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 Moël**  
*Address:* Vattenfall, Älvkarleby
16. **Alex Olwal**  
*Address:* KTH, Stockholm  
*Host:* Ingrid Carlom  
*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 Carlom  
*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. **Aurélie 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 occasioned 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 Währby, Amin Allalou, Milan Gavrilovic, Cris Luengo**  
*Address:* Dako, Glostrup, Denmark  
*Date:* 090127–28  
*Topic:* ENLIGHT Meeting

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

4. **Ewert Bengtsson, Carolina Währby, Amin Allalou, Milan Gavrilovic, Cris Luengo**  
*Host:* Niels Foged  
*Address:* Visiopharm, Agers Alle 3, Hørsholm, 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 Wåhlby**  
   *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, Polackssbacken  
    *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, Bjørn 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, Norwegian 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 Mäkel, 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 Ugglå
   Address: Faculty of Veterinary Medicine and Animal Science, SLU, Ultuna
   Date: 091221
   Topic: Joint future research
   Comment: Ulf Magnusson, Leif Norrgren och Jan-Erik Hälgren also participated

48. Vladimir Ćurić
   Host: Nataša Sladoje
   Address: Faculty of Engineering, University of Novi Sad, Serbia
   Date: 091229
   Topic: Research collaboration
   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.


• Steering committee for Discrete Geometry for Computer Imagery (DGCI) conferences, 2000–
  *Comment:* DGCI 2009 took place in Montréal, 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 committee, 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 (IWCLA’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 committee 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

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