Centre for Image Analysis
Swedish University of Agricultural Sciences
Uppsala University

Annual Report

2012

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Annual Report 2012

Centre for Image Analysis

Centrum för bildanalys

Cover: Illustration of the project *Optical Character Recognition of Handwritten Texts* with figures from the publication Graphs Based Line Segmentation on Cluttered Handwritten Manuscripts by F. Wahlberg and A. Brun (Publication 6.2.18 in this report).

Top left: One spread from a medieval manuscript from the Uppsala University Library.
Right: Segmentation into text lines using vertical projection profiles of the binarized image.
Bottom left: Text line refinement.

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Fredrik Wahlberg, Gustaf Kylberg

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Centre for Image Analysis, Uppsala, Sweden

Contents

1 Introduction

The Centre for Image Analysis (CBA) carries out research and graduate education in computerized image analysis and perceptualization. Our work ranges from the pure theory to methods, algorithms and systems for applications primarily in biomedicine and forest industry.

1.1 General background

CBA is collaboration between Uppsala University (UU) and the Swedish University of Agricultural Sciences (SLU), which started in 1988. From an organizational point of view, 2011 and 2012 were transitional years for CBA, since we joined other organizations at the two universities. At UU, we belong to one of five divisions within the Dept. of Information Technology, the Division of Visual Information and Interaction (Vi2). At SLU, we belong to the Dept. of Forest Genetics and Plant Physiology in Umeå. How these organizational changes have been performed is outlined in Section 2. The re-organizations have not prevented us from continuing and expanding our research. We now foresee opportunities for collaborations among our new close colleagues at UU and SLU.

During 2012, a total of 35 persons were working at CBA: 17 researchers, 16 PhD students, one technical staff and one administrator. Additionally, 17 Master thesis students completed their thesis work with supervision from CBA. This does not mean, however, that we have had more than 50 full-time persons at CBA: many have split appointments, part time at CBA and part time elsewhere. Most of us at CBA also undertake some undergraduate teaching. Previously this has been organized by other divisions, but with the organizational changes our new division now handles undergraduate education.

We are pleased that Robin Strand and Ida-Maria Sintorn qualified as Docents at UU bringing the total number of CBA docents to twelve.

On average, three PhD dissertations are produced each year at CBA. Nevertheless, in 2012 there was no PhD exam. This is not unexpected since 2011 was “a year of harvest” with five PhD theses defended. We also expect a number of PhD these to be defended in 2013.

Image processing is highly inter- and multi-disciplinary, with foundations in mathematics, statistics, physics, signal processing and computer science, and with applications 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 domain experts. Our collaborators are found locally as well as nationally and internationally. For a complete list of our 45 national and 49 international collaborators see Section 5.6.

We received three grants in the 2012 call from the Swedish Research Council (*Vetenskapsrådet*). Anders Brun and his collaborators Mats Dahllöf from the Dept. of Linguistics and Philology and Lasse Mårtensson from the University of Gävle received a 13.7 MSEK Framework Grant. The project is entitled “Searching in Large Digitized Collections of Handwritten Text” and will enable a group of researchers to work on handwriting recognition for historical texts during the coming four years. The project is part of a larger strategic effort, supported by the Vice-Chancellor, also involving the Faculty of Languages, the Faculty of Science and Technology, and the Uppsala University Library. This represents a significant leap into the emerging field of digital humanities.

Carolina Wählby received a Project Research Grant for Junior Researchers for the project entitled “A flexible automated cell tracking system optimized on an application basis by user-controlled feedback”. The main goals of the project are to (i) make existing tracking algorithms available to the life sciences by reducing algorithmic insight required for parameter optimization, and (ii) validate developed tools on live cell experiments testing mechanistic hypotheses of molecular and cellular processes.

Ingrid Carlbom received a two-year Continuation Project Research Grant for the prostate cancer malignancy grading project. This new funding will allow the development of new classifiers from a combination of tissue morphology and immunohistochemical analysis that identify malignancy relative to long-term disease outcome. These classifiers could potentially improve upon the current Gleason grading system.

Ingela Nyström, our director, continues to coordinate the strategic research programme in the e-science field, eSSENCE. She retains her position on the board of the Swedish University Computer Network, SUNET.

Ewert Bengtsson has served as senior advisor on Information Technology at UU to the Vice-Chancellor since 1998. This role was terminated during 2012.

We are very active in international and national societies. Both Ewert Bengtsson and Gunilla Borgefors are elected members of the Royal Society of Sciences in Uppsala and the Royal Swedish Society of Engineering Sciences (IVA). In 2012, Ingela Nyström was elected member of Royal Society of Arts and Sciences of Uppsala. Gunilla Borgefors is Editor in Chief for the journal Pattern Recognition Letters and Cris Luengo is Area Editor for the same journal. Ingela Nyström was re-elected as Secretary of the International Association of Pattern Recognition, IAPR. Researchers at CBA also served on several other journal editorial boards, scientific organization boards, conference committees, and PhD dissertation committees. In addition, we took a very active part in reviewing grant applications and scientific papers submitted to conferences and journals. As part of our research networks we were hosting workshops in collaboration with SciLifeLab and hosted the 35th CERN School of Computing as well as arranged an AIMday Image.

In addition to the more common ways of spreading information about our activities and work, such as seminar series, publications, web-pages, etc., we have our "CBA TV". Short "trailers" on our projects and activities are presented on an LCD monitor facing the main entrance stairway where students and colleagues from other groups are passing by.

This annual report is also available on the CBA webpage, see `http://www.cb.uu.se/annual_report/AR2012.pdf`

1.2 Summary of research

The objective of CBA is to carry out research and education in computerized image analysis and perceptualization. We are pursuing this objective through a large number of research projects, ranging from fundamental mathematical methods development, to application-tailored development and testing, the latter mainly in biomedicine and forest industry. We are also developing new methods for perceptualization, combining computer graphics, haptics and image processing. Our research is organized in a large number of projects (54) of varying size, ranging in effort from a few person months to many person years. There is a lot of interaction between different researchers: generally 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 is of importance.

On the theoretical side, most of our work is based on discrete mathematics with fundamental work on sampling grids, fuzzy methods, skeletons, distance functions, and tessellations, in three and more dimensions.

Several projects deal with light microscopy, developing tools for modern quantitative biology and clinical cancer detection and grading. We are collaborating with local biologists and pathologists, research centers in the US and India, and a Danish company. We have close collaboration with the strategic project programme Science for Life Laboratory (SciLifeLab) through which a research platform in quantitative microscopy is formed.

We also work with electron microscopy (EM) images; one application is focused on finding viruses in EM images. Since the texture of the virus particles is an important feature in identification of the different virus types, this project has also led to basic research on texture analysis.

New techniques are creating 3D images on microscopic scales. We have been analyzing electron microscope tomography images of protein molecules for several years. More recently, we are also involved in optical projection tomography where we image zebrafish embryos. Another technique is X-ray microtomography; we are developing methods to use such images to study the internal structure of paper, wood fibre composites and bone, and bone-implant integration.

On a macroscopic scale we are working with interactive segmentation of 3D CT and MR images by use of haptics. We have developed a segmentation toolbox, WISH, which is publicly available. Applications of this toolbox are for facial surgery planning and measurements of CT wrist images.

Over the last several years we have expanded our activities in perceptualization under leadership of Guest 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 using a haptic glove. We have created a unique haptic gripper through which virtual objects can be grabbed and manipulated. This project has obvious synergy with the Human-Computer Interaction research performed within the Division Vi2.

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

An activity bridging research and education is the supervision of master thesis projects. This year we completed 17 such projects. In Section 3.2, we describe these theses.

1.3 How to contact CBA

CBA maintains a home page (`http://www.cb.uu.se/`) both in English and in Swedish. The main structure contains links to a brief presentation, staff, vacant positions (if any), etc. It also contains information on courses, seminars (note that our Monday 14:15 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.

In addition, all staff members have their own home page, which are linked to from the CBA "Staff" page. On these, you can usually find detailed course and project information, etc.

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

Visiting address: Lägerhyddsvägen 2
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2 Organization

From an organizational point of view, 2011 and 2012 were transitional years for CBA. From the start in 1988 until the end of 2010, CBA was an independent entity belonging equally to Uppsala University (UU) and Swedish University of Agricultural Sciences (SLU), but administered through UU. After decisions by the host universities this was changed. From 2011, the UU part of CBA became a division within the Dept. of Information Technology.

Within the IT Department, there was a review of the division structure, and on January 1, 2012, CBA together with the previous Division for Human-Computer Interaction formed the new Division for Visual Information and Interaction (Vi2). Ingela Nyström is head of Vi2 and also head of CBA. At SLU, the Dept. of Forest Genetics and Plant Physiology was appointed as host department where the SLU staff now is employed.

Since 2011, there is a three-year agreement between the Vice-Chancellors of the two universities, according to which CBA will continue as collaboration with joint activities administered by UU. The long term strategic planning of CBA will be handled by a joint council with two representatives from each university. All personnel will be employed at a department at one of the two universities, and everyday management of CBA will be the responsibility of the head of the division of the IT Department at UU to which CBA belongs.

The appointed members of the joint council *Centrumråd* are:

- Gunilla Borgefors, deputy chair, S-Faculty, SLU
- Elna-Marie Larsson, Faculty of Medicine, UU
- Cris Luengo, S-Faculty, SLU
- Ingela Nyström, chair, TN-Faculty, UU

One component of the close integration between image analysis research at the two universities is that the SLU Professor Gunilla Borgefors is a full-time Guest Professor in computerized image processing at UU, since February 1, 2012, with full financing from SLU.

The many organizational changes that have taken place have of course affected us all, to varying degrees. We hope that the new organization will allow us to continue our successful joint research and to develop new branches with new colleagues. As seen in this report, we have been able to keep up a high activity despite a turbulent period.

2.1 Finances

After the re-organization, where CBA at UU now is part of the Division of Visual Information and Interaction (Vi2) at the Dept. of Information Technology, the CBA economy is not separate. In fact, Vi2 has been formed to become integrated in activities as well as organization. Hence, we report how this is financed as a whole. The total expenditure for Vi2 was 38.2 million SEK for 2012. To cover this, 33% came from UU, 12% from SLU, 36% from external sources, and 20% from undergraduate education.

The largest cost in our budget is personnel, which is 55% of the total cost. Over the years, the number of people working at CBA has varied considerably. During 2012, about 35 people were working at CBA. About two thirds are employed by UU, the rest by SLU. Within the whole division Vi2, we counted more than 50 persons during the year (but not 50 full-time equivalents).

Even though CBA itself does not organize undergraduate education, Vi2 offers undergraduate education with several courses in Human-Computer Interaction themes. In addition, we have inherited the courses on Image Analysis, Computer Graphics, and Scientific Visualization previously organised by the Division of Scientific Computing and given by teachers from CBA. Most of us teach 10–20%, while some Senior Lecturers teach more. The economy in Table 1 below summarizes the overall economy for Vi2 in 2012. This summary is based on joining the two accounts from UU and SLU (and clearing internal transactions between the universities). The numbers are rounded to the nearest 1000 SEK. The same numbers for income and costs are also given as pie charts in Figure 1. Who finances each project can be ascertained in Section 5, where all projects are listed. Project grants that have been received but not used are directly balanced to next year, and are thus not included in the income–cost tables.

Table 1: Vi2 income and costs for 2012 in kSEK.

Income		**Costs**	
UU	12410	Personnel	21130
SLU	4371	Equipment	521
UU undergraduate education	7354	Operating exp.[4]	5140
Governmental grants[1]	5410	Rent	1938
Non-governmental grants[2]	3182	University overhead	9485
Contracts[3]	4477		
Financial netto	60		
Total income	**37264**	**Total cost**	**38214**

[1] The Swedish Research Council, SIDA, Formas
[2] Research foundations, EU
[3] Internal invoices from UU and compensations
[4] Including travel and conferences

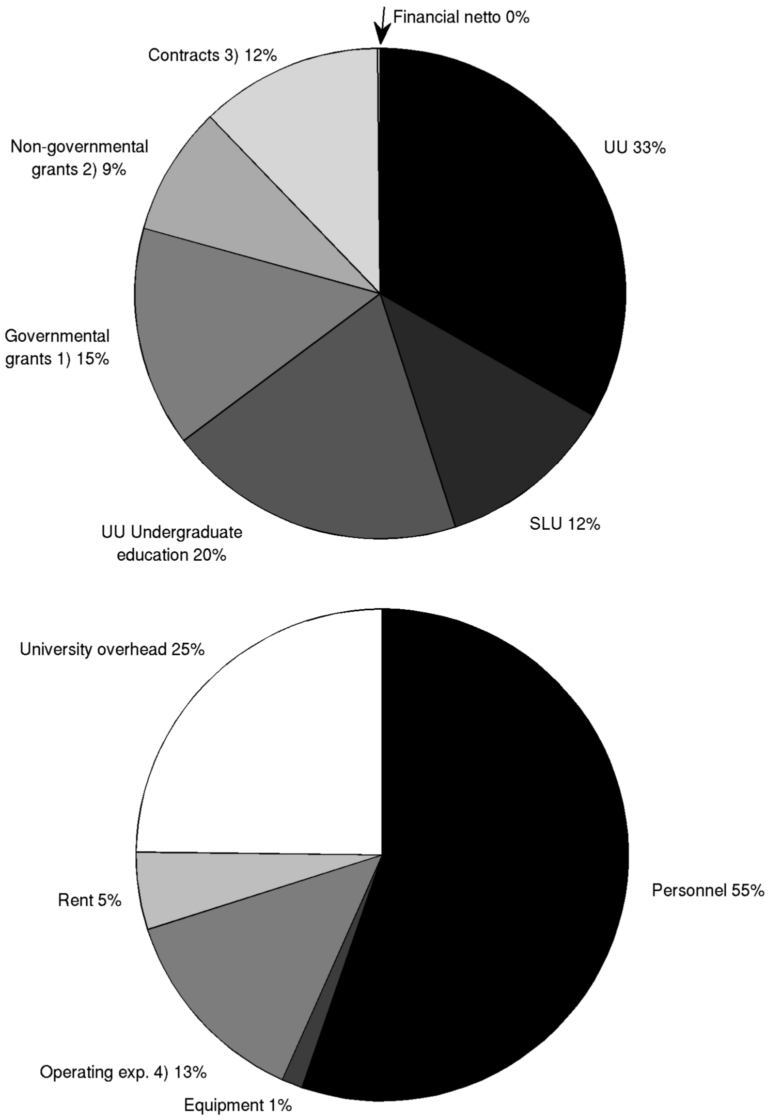


Figure 1: Vi2 income (top) and costs (below) for 2012.

2.2 Staff, CBA

Jimmy Azar, Graduate Student, UU
Ewert Bengtsson, Professor, PhD, UU
Gunilla Borgefors, Professor, PhD, SLU –120131, UU 120201–
Anders Brun, PhD, Researcher, SLU
Ingrid Carlbom, Professor, PhD, UU
Vladimir Curic, Graduate Student, UU
Olle Eriksson, PhD, Senior Lecturer, (part time) UU
Azadeh Fakhrzadeh, Graduate Student, SLU
Anders Hast, Docent, PhD, Lecturer 120116–, UU
Omer Ishaq, Graduate Student 120220–, UU
Gustaf Kylberg, Graduate Student, UU
Andreas Kårsnäs, Industrial Graduate Student, (part time) UU and Visiopharm, Hørsholm, Denmark
Elisabeth Linnér, Graduate Student, UU
Fei Liu, Graduate Student, University of Gävle
Cris Luengo, Docent, PhD, Researcher, SLU
Kristina Lidayova, Research Assistant 120411–120630, Graduate Student 120701–, UU
Patrik Malm, Graduate Student, UU
Filip Malmberg, PhD, Post Doc, UU
Issac Niwas, Researcher –120501, UU
Bo Nordin, PhD, Researcher/Senior Lecturer, (part time) UU
Lena Nordström, Administration
Fredrik Nysjö, Research Engineer, UU
Johan Nysjö, Graduate Student, UU
Ingela Nyström, Professor, PhD, Director, (part time) UU
Pontus Olsson, Graduate Student, UU
Alexandra Pacureanu, PhD, Post Doc 120201–, UU
Stefan Seipel, Professor, PhD, (part time) UU and University of Gävle
Bettina Selig, Graduate Student, SLU
Martin Simonsson, PhD, Post Doc, UU
Ida-Maria Sintorn, Docent 120903–, PhD, Researcher, SLU
Robin Strand, Docent 120126–, PhD, Researcher, UU
Lennart Svensson, Graduate Student, SLU
Erik Wernersson, Graduate Student, SLU
Fredrik Wahlberg, Research Assistant –120131, Graduate Student 120201–, UU
Carolina Wählby, Docent, PhD, Senior Lecturer, (part time) UU

Master Thesis students, located at CBA and that finished their projects in 2012
  Max Morén, Abdolrahim Kadkhodamohammadi, Jing Liu, Meng Liang, Zi-Quan Yu, Marine Astruc

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. 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) and mathematics. Listed in this section are the courses we have been involved in, as course organizers and/or teachers.

We offer a number of Master thesis projects (examensarbeten) each year; 17 were completed during 2012.

3.1 UU courses

1. **Computer Assisted Image Analysis I, 5hp**
   Anders Brun, Vladimir Curic, Azadeh Fakhrzadeh, Gustaf Kylberg, Cris Luengo, Bettina Selig, Erik Wernersson
   Period: 120101–0308
2. **Scientific Computing III, 5hp**
   Elisabeth Linnér
   Period: 120117–0314
3. **Computer Graphics, 10hp**
   Anders Hast, Gustaf Kylberg, Pontus Olsson
   Period: 120315–0525
4. **Cellular Imaging and Confocal Techniques, 3hp**
   Ida-Maria Sintorn, Carolina Wählby
   Period: 120524
5. **Programming, Bridging Course, 10hp**
   Olle Eriksson, Lennart Svensson
   Period: 120830–1220
6. **Scientific Visualization, 7.5hp**
   Anders Hast, Johan Nysjö
   Period: 120903–1024
7. **Bioimaging and Cell Analysis, 7.5hp**
   Anders Brun, Ida-Maria Sintorn, Robin Strand, Carolina Wählby
   Period: 120904–0928
8. **Analysis of Regression and Variance, 10hp**
   Jimmy Azar
   Period: 120904–1023
9. **Models and Methods for Precise Image Analysis, 3hp**
   Anders Brun, Gustaf Kylberg, Cris Luengo, Johan Nysjö, Alexandra Pacureanu, Ida-Maria Sintorn, Robin Strand, Erik Wernersson
   Period: 120911–1011
10. **Medical Informatics, 8hp**
    Ewert Bengtsson
    Period: 121204
11. **Scientific Visualization, 5hp**
    Stefan Seipel, Anders Hast
    Period: 120903–1105
12. **Computer Assisted Image Analysis II, 10hp**
    Anders Brun, Vladimir Curic, Azadeh Fakhrzadeh, Omer Ishaq, Cris Luengo, Ida-Maria Sintorn, Robin Strand, Carolina Wählby
    Period: 121031–1219

13. **Single Variable Calculus, 10hp**
    Vladimir Curic
    Period: 121101–1221

3.2 Master theses

1. **Comparison of Automated Feature Extraction Methods for Image Based Screening of Cancer Cells**
   Student: Michael Brennan
   Supervisor: Mats Gustafsson, Dept. of Medical Sciences
   Reviewer: Ewert Bengtsson
   Publisher: UPTEC F 11 068
   Abstract: Image based screening is an important tool used in research for development of drugs to fight cancer. Phase contrast video microscopy - a cheap and fast image screening technology - enables a rapid generation of large amounts of data, which requires a fast method for analysis of this data. As videos contain a lot of redundant information, the difficulty is to extract usable information in form of features from the videos, by compressing available information, or filter out redundant data. In this thesis, the problem is approached in an experimental fashion where three different methods have been devised and tested, to evaluate different ways to automatically extract features from phase contrast microscopy videos containing cultured cancer cells. The three methods considered are, in order: an adaptive linear filter, an on-line clustering algorithm, and an artificial neural network. The ambition is that outputs from these methods can create time-varying histograms of features that can be used in further mathematical modeling of cell dynamics. It is concluded that, while the results of the first method is not impressive and can be dismissed, the remaining two are more promising and are able to successfully extract features automatically and aggregate them into time-varying histograms.

2. **Efficient Volume Rendering on the Face Centered and Body Centered Cubic Grids**
   Student: Max Morén
   Supervisor: Elisabeth Linnér
   Reviewer: Robin Strand
   Publisher: UPTEC IT 12 013
   Abstract: In volumetric visualization, the body centered cubic grid (BCC) and its reciprocal, the face centered cubic grid (FCC), are despite their good sampling properties not well off regarding available rendering software and tools.

   Described in this thesis is the development of an extension for the volume rendering engine Voreen, implementing two recently presented GPU accelerated reconstruction algorithms for these grids, along with a simple nearest neighbor method. These reconstruction methods replace the trilinear reconstruction method used for data stored in a Cartesian cubic grid (CC). The goal is for the produced software to be useful for efficiently visualizing results from experiments with the BCC and FCC grids and thus help make such data easier to observe.

   The performance and rendering quality of the new raycasters is measured and compared to Voreen's existing Cartesian cubic ray caster. The experimental results show that the raycasters can render data in the BCC and FCC format at interactive frame rates while maintaining comparable visual quality.

3. **Counting Sertoli Cells in Thin Testicular Tissue**
   Student: Abdolrahim Kadkhodamohammadi
   Supervisor: Azadeh Fakhrzadeh
   Reviewer: Cris Luengo
   Publisher: UPTEC IT 12 017
   Abstract: This master thesis develops a novel system to model the tubular structure in thin sections of testicular tissue and count the Sertoli cells. A three-phase method is proposed to model the tubular structure in microscopic images of the tissue, the model is deployed to detect the cells. In the first phase, the germ-mass, which represents the inside layer of tubules, are detected. All cells are detected by radial symmetry transform and then the graph cut algorithm is used to separate the germ cells. Each region covered by a compact set of germ cells is considered as the germ-mass. In the second phase, all bright areas in the image are detected and used to adjust the germ-mass regions. In the last phase, all edges that are line-like

are identified and straight lines are fitted to the edges. The lines are later connected to compensate for the broken parts of the tubules' boundaries.

The closest cells to the germ-mass are chosen as the Sertoli cell candidates. The approximate boundary of tubules and the angle between the candidate cells are used to detect the Sertoli cells. Our experimental results show that our system is able to detect the tubule and the Sertoli cells with reasonable accuracy. If the method can not find enough edges to approximate the tubule's boundary, detecting Sertoli cells is complicated; the system can report those situations to the experts.

Since we use the symmetry attribute of the cells to detect them, the method is quite robust against noise, artifacts, and non-uniform illumination. The method is able to capture all tubules, even tubules that do not have any bright region in the middle (lumen). To the best of my knowledge, no one has proposed a method to model tubular structure without lumen. The border approximation method can work well even for tubules that are partially in the image. It should be mentioned that the proposed method could be applied to model any tubular structure with one or more cells types.

4. **Requirements and Needs for 3D Visualizations**
   Student: Henrik Jacobsson
   Supervisor: Kent Johansson, Scania AB, Södertälje
   Reviewer: Anders Hast
   Publisher: UPTEC IT 12 022
   Abstract: Product development within the automotive industry is progressing towards using more 3D models and less conventional 2D drawings. When development is done in a parallel cooperative way, demands for availability of relevant and current data are high. Engineering design in a 3D environment requires visualization that incorporates wide spread sharing and simple access, which after implementation would support demands for shorter lead times and reduced development costs.

   In this master thesis a focus to compile and present requirements for 3D visualizations, from different groups within Scania, has been at hand. These requirements will be featured in both text and with a graphical form conceptual.

   Moreover has the framing of questions within the area of information sharing been treated in respect to 3D visualizations and their impact on lead times for iterations for the product development process.

   Spreading of information could be made easier if more people would gain access to 3D visualizations. According to our results from conducted interviews would problems be detected earlier and in that way shorter lead times would be achieved.

   Knowledge, ideas and experience have been collected partly from interviews with employees at Scania (mostly R&D, but also from purchase, production and aftermarket), and partly from reference visits at Volvo Cars, White architects and SAAB Aeronautics. The reference visits have been a valuable source with their experience from implementing solutions for 3D visualizations.

   Conclusions that can be drawn from this master thesis are among others the importance of using one common and updated database. Furthermore it can be said that spreading and using 3D visualizations could imply shorter lead times.

5. **Implementation of a Semi-automatic Tool for Analysis of TEM Images of Kidney Samples**
   Student: Jing Liu
   Supervisor: Gustaf Kylberg
   Reviewer: Ida-Maria Sintorn
   Publisher: UPTEC IT 12 033
   Abstract: Glomerular disease is a cause for chronic kidney disease and it damages the function of the kidneys. One symptom of glomerular disease is proteinuria, which means that large amounts of protein are emerged in the urine. To be more objective,transmission electron microscopy (TEM) imaging of tissue biopsies of kidney are used when measuring proteinuria. Foot process effacement (FPE), which is defined as less than1 "slit" (gap)/micrometer at the glomerular basement membrane (GBM). Measuring FPE is one way to detect proteinuria using kidney TEM images, this technique is a time-consuming task and used to be measured manually by an expert.

   This master thesis project aims at developing a semi-automatic way to detect the FPE patients as well as a graphic user interface (GUI) to make the methods and results easily accessible for the user.

To compute the slits/micrometer for each image, the GBM needs to be segmented from the background. The proposed work flow combines various filters and mathematical morphology to obtain the outer contour of the GBM. The outer contour is then smoothed, and unwanted parts are removed based on distance information and angle differences between points on the contour. The length is then computed by weighted chain code counts. At last, an iterative algorithm is used to locate the positions of the ”slits” using both gradient and binary information of the original images.

If necessary, the result from length measurement and ”slits” counting can be manually corrected by the user. A tool for manual measurement is also provided as an option. In this case, the user can add anchor points on the outer contour of the GBM and then the length is automatically measured and ”slit” locations are detected. For very difficult images, the users can also mark all ”slits” locations by hand.

To evaluate the performance and the accuracy, data from five patients are tested,for each patient six images are available. The images are 2048 by 2048 gray-scale indexed 8 bit images and the scale is 0.008 micrometer/pixel. The one FPE patient in the dataset is successfully distinguished.

6. **Automatic Identification and Cropping of Rectangular Objects in Digital Images**
   Student: Tomas Toss
   Supervisor: Henrik Johansson, National Library of Sweden, Stockholm
   Reviewer: Anders Brun
   Publisher: UPTEC IT 12 040
   Abstract: Today, digital images are commonly used to preserve and present analogue media. To minimize the need for digital storage space, it is important that the object covers as large part of the image as possible. This paper presents a robust methodology, based on common edge and line detection techniques, to automatically identify rectangular objects in digital images. The methodology is tailored to identify posters, photographs and books digitized at the National Library of Sweden (the KB). The methodology has been implemented as a part of DocCrop, a computer program written in Java to automatically identify and crop documents in digital images. With the aid of the developed tool, the KB hopes to decrease the time and manual labour required to crop their digital images.

   Three multi-paged documents digitized at the KB have been used to evaluate the tool's performance. Each document features different characteristics. The overall identification results, as well as an in-depth analysis of the different methodology stages, are presented in this paper. In average, the developed software identified 98% of the digitized document pages successfully. The software's identification success rate never went below 95% for any of the three documents. The robustness and execution speed of the methodology suggests that the methodology can be a compelling alternative to the manual identification used at the KB today.

7. **3D Co-occurrence Matrix Based Texture Analysis Applied to Cervical Cancer Screening**
   Student: Meng Liang
   Supervisor: Patrik Malm
   Reviewer: Ewert Bengtsson
   Publisher: UPTEC IT 12 041
   Abstract: Cervical cancer is the second most common cancer in women worldwide, approximately 471,000 new cases are diagnosed each year. In 2005, there were about 500,000 cases of cervical cancer and 260,000 cases caused death in worldwide. Cervical cancer starts as a precancerous condition, however the changes of precancerous are hardly detected by the naked eyes, special test such as Papanicolaou test are used to spot the conditions. These are time consuming to inspect visually. In the last 50 years there have been many projects to develop automated computer image analysis system for screening.

   One of the most important changes in a cell when it becomes precancerous is a change in chromatin texture. The field of nuclear texture analysis gives information about the spatial arrangement of pixel gray levels in a digitized microscopic nuclei image. A well known method for quantifying textures in digital images is the gray level co-occurrence matrix(GLCM). This method tries to quantify specific pairwise gray level occurrence at specific relative positions. In this project, firstly we have developed and tested three image normalization methods : gradient based intensity normalization, histogram equalization and standardizing normal random variables; secondly we have developed 2D gray level co-occurrence matrix calculation and 3D gray level co-occurrence matrix calculation, thirdly compared Haralick features with adaptive feature vectors from class distance and class difference matrices (adaptive texture feature) based on the 2D gray level co-occurrence matrix; compared the Haralick features with adaptive feature based on the 3D gray level co-occurrence matrix. Our result shows that neither of the 3D results yields a significant improvement from 2D results.

8. **Adaptive Binarization of 17th Century Printed Text**
   Student: Carl Carenwall
   Supervisor: Fredrik Wahlberg
   Reviewer: Anders Brun
   Publisher: UPTEC IT 12 055
   Abstract: This work focused on implementing and evaluating an adaptive water flow model for binarization of historical documents, as presented by Valizadeh and Ehsanollah in an article published in early 2012.

   While the original method sought an optimal result for all kinds of degraded documents, both on hand written and printed, the work presented here only needed to be concerned with printed documents. This was due to being focused on specific documents scanned by the Uppsala university library.

   The method itself consists of several steps, including a couple that uses other methods for binarization to achieve a good result.

   While the implementation appears to have been largely successful in replicating the results of the original method, it is very possible that some minor tweaking could result in further improvements. To replicate the results, however, a new parameter had to be inserted in the method. Regardless if this was because of some mistake, or if the sample data used by Valizadeh and Ehsanollah simply differs from the one used here, this may be worth looking more at. In the end of this report are comparisons with a couple of common and state-of-the-art methods for binarization, and this method appear to perform favourably in most cases.

9. **Stitching of X-ray Images**
   Student: Krishna Paudel
   Supervisor: Felix Rutscher, Protec GmbH & Co, Oberstenfeld, Germany
   Reviewer: Cris Luengo
   Publisher: UPTEC IT 12 057
   Abstract: Image processing and analysis algorithms are widely used in medical systems to analyze medical images to help diagnose the disease of a patient. This thesis covers one of the demanding problems of a medical system: Stitching of X-ray Images. The flat panel of an X-ray system cannot cover all part of a body, so image stitching is incorporated in the medical system to combine two or more X-ray images and get a single high resolution image. The output of this thesis work is to develop a real-time and user interactive stitching application which works for all X-ray images with different intensity and orientation.

   The stitching of X-ray images is carried out by employing two basic steps: registration and blending. The classical registration methods search for all the pixels to get the best registration. These methods are slow and cannot perform well for high resolution X-ray images. The feature based registration methods are faster and always gives the best registration. This thesis evaluates three popular feature based registration methods: HARRIS, SIFT and SURF. The exhaustive nearest neighborhood method has been modified to get faster matching of key points.

   The overlapping areas of the composite image are blended to remove the seams and discontinuities. This thesis evaluates some faster blending techniques and incorporates an advanced blending method using blending masks to blend complexly aligned images.

10. **Online Learning of Multi-class Support Vector Machines**
    Student: Xuan Tuan Trinh
    Supervisor: Christian Igel, the Image Group, University of Copenhagen, Denmark
    Reviewer: Robin Strand
    Publisher: UPTEC IT 12 061
    Abstract: Support Vector Machines (SVMs) are state-of-the-art learning algorithms for classification problems due to their strong theoretical foundation and their good performance in practice. However, their extension from two-class to multi-class classification problems is not straightforward. While some approaches solve a series of binary problems, other, theoretically more appealing methods, solve one single optimization problem. Training SVMs amounts to solving a convex quadratic optimization problem. But even with a carefully tailored quadratic program solver, training all-in-one multi-class SVMs takes a long time for large scale datasets. We first consider the problem of training the multi-class SVM proposed by Lee, Lin and Wahba (LLW), which is the first Fisher consistent multi-class SVM that has been proposed in the literature,

and has recently been shown to exhibit good generalization performance on benchmark problems. Inspired by previous work on online optimization of binary and multi-class SVMs, a fast approximative online solver for the LLW SVM is derived. It makes use of recent developments for efficiently solving all-in-one multi-class SVMs without bias. In particular, it uses working sets of size two instead of following the paradigm of sequential minimal optimization. After successful implementation of the online LLW SVM solver, it is extended to also support the popular multi-class SVM formulation by Crammer and Singer. This is done using a recently established unified framework for a larger class of all-in-one multi-class SVMs. This makes it very easy in the future to adapt the novel online solver to even more formulations of multi-class SVMs. The results suggest that online solvers may provide for a robust and well-performing way of obtaining an approximative solution to the full problem, such that it constitutes a good trade-off between optimization time and reaching a sufficiently high dual value.

11. **Seed Surface Measurements From Multiple Views: Using Image Analysis**
    Student: Prabhu Mani
    Supervisor: Jaan Luup, Maxx Automation AB, Uppsala
    Reviewer: Cris Luengo
    Publisher: UPTEC IT 12 071
    Abstract: Analyzing the properties of seed helps in determining the quality of seeds. Seeds like wheat, barley, rye, oats and triticale are considered for the quality analysis. It is important that in a sample of seeds (for instance wheat) there should be no adulteration. To find the quality of seeds, samples have to be examined to find the percentage of damaged seeds and foreign seeds among good seeds. To accomplish this task each seed should to be examined manually to identify if a seed is good, which is a time consuming task. A machine is built to automate this task. It is capable of separating seeds individually and makes it slide one after the other quickly. The sliding seeds images are captured by a camera for analysis. The setup uses mirrors in such a way that image has 3 different views of a seed covering the entire surface of a seed.

    From this new type of seed images, image processing techniques are developed to identify different properties of a seed like, height, width etc. A mathematical 3-D model for a seed is developed and each seed image is converted to this model to estimate the volume of the seed. From the volume data seeds weight is estimated. Also different forms of seed damages such as broken seeds, husk damages are analyzed and estimated. However in finding husk damage, a general solution for all the seeds could not be devised as distinct features of husk and seed is not common in all the seeds. But different approaches for finding few common patterns of husk damages are discussed. All the implementations are discussed in detail and the test results of implementations are compared with manually calculated data.

12. **Stabilization of Handheld Firearms Using Image Analysis**
    Student: Alexander Lindstedt
    Supervisor: Göran Backlund, Combitech, Linköping
    Reviewer: Cris Luengo
    Publisher: UPTEC F 12 010
    Abstract: When firing a handheld weapon, the shooter tries to aim at the point where he wants the bullet to hit. However, due to imperfections in the human body, this can be quite hard. The weapon moves relative to the target and the shooter has to use precise timing to fire the shot exactly when the weapon points to the intended target position. This can be very hard, especially when shooting at long range using a magnifying rifle scope.

    In this thesis, a solution to this problem using image analysis is described and tested. Using a digital video camera and software, the system helps the shooter to fire at the appropriate time. The system is designed to operate in real-time conditions on a PC.

    The tests carried out have shown that the solution is promising and helps to achieve better accuracy. However it needs to be optimized to run smoothly on a smaller scale embedded system.

13. **Implementing the Circularly Polarized Light Method for Determining Wall Thickness of Cellulosic Fibres**
    Student: Marcus Edvinsson
    Supervisor: Thomas Storsjö
    Reviewer: Cris Luengo
    Publisher: UPTEC F 12 014
    Abstract: The wall thickness of pulp fibers plays a major role in the paper industry, but it is currently not possible to measure this property without manual laboratory work. In 2007, researcher Ho Fan Jang patented a technique to automatically measure fiber wall thickness, combining the unique optical properties of pulp fibers with image analysis. In short, the method creates images through the use of an optical system resulting in color values which demonstrate the retardation of a particular wave length instead of the intensity. A device based on this patent has since been developed by Eurocon Analyzer. This thesis investigates the software aspects of this technique, using sample images generated by the Eurocon Analyzer prototype.

    The software developed in this thesis has been subdivided into three groups for independent consideration. First being the problem of solving wall thickness for colors in the images. Secondly, the image analysis process of identifying fibers and good points for measuring them. Lastly, it is investigated how statistical analysis can be applied to improve results and derive other useful properties such as fiber coarseness.

    With the use of this technique there are several problems which need to be overcome. One such problem is that it may be difficult to disambiguate the colors produced by fibers of different thickness. This complication may be reduced by using image analysis and statistical analysis. Another challenge can be that theoretical values often differ greatly from the observed values which makes the computational aspect of the method problematic. The results of this thesis show that the effects of these problems can be greatly reduced and that the method offers promising results.

    The results clearly distinguish between and show the expected characteristics of different pulp samples, but more qualitative reference measurements are needed in order to draw conclusions on the correctness of the results.

14. **Fibre Network Generation and Analysis: Method for simulation of inhomogeneous static fibre networks**
    Student: Abdellah Mesquine
    Supervisor: Tomas Nyberg, Dept. of Engineering Sciences
    Reviewer: Anders Brun
    Publisher: UPTEC F 12016
    Abstract: In paper optics, advanced modeling of the interaction of light with complex structures are required for optimization of the optical properties of paper. Monte Carlo simulation routines have been developed in an Open Source project, PaperOpt, in order to simulate light scattering in paper. The goal of the project is to make the tool more modular and extensible so that researchers within the paper optics field can make their own contributions to the model. This thesis is a part of Open PaperOpt project and its goal is to generate paper structures that resemble real paper sheets. This Master's thesis describes the design and implementation of a model for generation of virtual fiber networks with controlled fiber distribution within the papersheet. A C++ written program that generates a fiber network according to a fibermass distribution table has been developed. A qualitative and quantitative comparison between simulated paper structures and real paper obtained from beta-scan measurements is also described.

15. **Interactive Visualization of Financial Data: Development of a Visual Data Mining Tool**
    Student: Joakim Saltin
    Supervisor: Patrik Johansson, SkySparc, Stockholm
    Reviewer: Filip Malmberg
    Publisher: UPTEC F 12 023
    Abstract: In this project, a prototype visual data mining tool was developed, allowing users to interactively investigate large multi-dimensional datasets visually (using 2D visualization techniques) using so called drill-down, roll-up and slicing operations. The project included all steps of the development, from writing specifications and designing the program to implementing and evaluating it.

    Using ideas from data warehousing, custom methods for storing pre-computed aggregations of data (commonly referred to as materialized views) and retrieving data from these were developed and implemented in order to achieve higher performance on large datasets. View materialization enables the program to easily fetch or calculate a view using other views, something which can yield significant performance gains if view sizes are much smaller than the underlying raw dataset. The choice of which views to materialize was done in an automated manner using a well-known algorithm - the greedy algorithm for view materialization - which selects the fraction of all possible views that is likely (but not guaranteed) to yield the best performance gain. The use of materialized views was shown to have good potential to increase performance for large datasets, with an average speedup (compared to on-the-fly queries) between 20 and 70 for a test dataset containing 500 000 rows.

The end result was a program combining flexibility with good performance, which was also reflected by good scores in a user-acceptance test, with participants from the company where this project was carried out.

16. **Eigen-birds: Exploring Avian Morphospace with Image Analytic Tools**
Student: Mikael Thuné
Supervisor: Anders Brun; Jochen Wolf, Dept. of Ecology and Genetics
Reviewer: Ida-Maria Sintorn
Publisher: UPTEC F 12024
Abstract: The plumage colour and patterns of birds have interested biologists for a long time. Why are some bird species all black while others have a multitude of colours? Does it have anything to do with sexual selection, predator avoidance or social signalling? Many questions such as these have been asked and as many hypotheses about the functional role of the plumage have been formed. The problem, however, has been to prove any of these. To test these hypotheses you need to analyse the bird plumages and today such analyses are still rather subjective. Meaning the results could vary depending on the individual performing the analysis. Another problem that stems from this subjectiveness is that it is difficult to make quantitative measurements of the plumage colours. Quantitative measurements would be very useful since they could be related to other statistical data like speciation rates, sexual selection and ecological data. This thesis aims to assist biologists with the analysis and measurement of bird plumages by developing a MATLAB toolbox for this purpose. The result is a well structured and user friendly toolbox that contains functions for segmenting, resizing, filtering and warping, all used to prepare the images for analysis. It also contains functions for the actual analysis such as basic statistical measurements, principal component analysis and eigenvector projection.

17. **Detection of Free-lying Epithelial Cells by Low Resolution Image Analysis of Cell Samples – The First Step in an Automated System for Early Detection of Cervical Cancer**
Student: Marine Astruc
Supervisor: Patrik Malm
Reviewer: Ewert Bengtsson
Publisher: Ecole Centrale Nantes, France
Abstract: Automated cervical cancer screening systems require high resolution analysis of a large number of epithelial cells, involving complex algorithms, mainly analysing the shape and texture of cell nuclei. This can be a very time consuming process. An initial selection of relevant fields-of-view in low resolution images could limit the number of fields to be further analysed at a high resolution. In particular, the detection of cell clusters is of interest for nuclei segmentation improvement, and for diagnostic purpose, malignant and endometrial cells being more prone to stick together in clusters than other cells. In this study, methods aiming at evaluating the quality of fields-of-view in bright field microscope images of cervical cells are proposed. The approach consists in the construction of neighbourhood graphs using the nuclei as the set of vertices. Transformations are then applied on such graphs in order to highlight the main structures in the image. The methods result in the delineation of regions with varying cell density and the identification of cell clusters. Clustering methods are evaluated using a dataset of manually delineated clusters and compared to a related work.

18. **Stochastic Watershed: A Comparison of Different Seeding Methods**
Students: Kenneth Gustavsson, Karl Bengtsson Bernander
Supervisor: Bettina Selig
Reviewer: Martin Sjödin, Dept. of Engineering Sciences, UU
Publisher: UPTEC TVE 12024
Abstract: We study modifications to the novel stochastic watershed method for segmentation of digital images. This is a stochastic version of the original watershed method which is repeatedly realized in order to create a probability density function for the segmentation. The study is primarily done on synthetic images with both same-sized regions and differently sized regions, and at the end we apply our methods on two endothelial cell images of the human cornea. We find that, for same-sized regions, the seeds should be placed in a spaced grid instead of a random uniform distribution in order to yield a more accurate segmentation. When images with differently sized regions are being segmented, the seeds should be placed dependent on the gradient, and by also adding uniform or gaussian noise to the image in every iteration a satisfactory result is obtained.
Comment: Bachelor thesis

4 Graduate education

At the end of 2012, we were main supervisors for 16 PhD students, eleven at UU and four at SLU.

4.1 Graduate courses

1. **Research Methodology for Image Analysis, 4hp**
   Gunilla Borgefors
   Period: 120401–0630
   Description: The goal is to give new PhD students useful knowledge about how to become good and published researchers in image processing and applications thereof. The first part is a series of lectures on general themes. The second part is a series of seminars on scientific journals held by the participants.
   Comment: A guest lecture was given by Ulrika Haak from the Ångström library.

2. **Image Processing Using Graphs, 5hp**
   Filip Malmberg
   Alexandre Falcao, Erik Wernersson
   Period: 120403–0601
   Description: Graduate course in graph based image processing.

3. **Models and Methods for Precise Image Analysis, 3hp**
   Cris Luengo Hendriks, Robin Strand, Erik Wernersson, Ida-Maria Sintorn, Gustaf Kylberg, Anders Brun, Alexandra Pacureanu, Johan Nysjö
   Period: 120911–1011
   Description: Graduate course organized by visiting researchers Nataša Sladoje and Joakim Lindblad.

4. **Quantitative Microscopy, 10hp**
   Carolina Wählby
   Ewert Bengtsson, Cris Luengo, Alexandra Pacureanu, Ida-Maria Sintorn
   External invited lecturers: Anders Ahlander, BioVis, UU, Anna Asplund, IGP, UU, Åsa Kassman Rudolphpi, Dept. Eng. Science, UU, Göran Månsson, CLICK facility, KI, Dirk Pacholsky, BioVis, IGP, UU, Daniel Rönnlund, Exp. Biomolecular Physics, KTH, Alan Sabirsh, AstraZeneca
   Period: 121009–1212
   Description: This postgraduate in Quantitative Microscopy was organized at the Dept. of Information Technology, Division of Visual Information and Interaction, during October – December 2012. Different kinds of microscopy are becoming more and more common as tools for research in science and medicine. Very often, the analysis of microscopy data is limited to visual inspection, but with knowledge about the information content, quantitative measurements can be extracted from the data, increasing the value of any scientific experiment. The aim of the course was to provide knowledge about different sample preparation and microscopy imaging techniques, and give a wide perspective on what kinds of information that can be extracted from microscopy image data, and how this can be approached using digital image processing. Apart from theoretical lectures on different microscopy techniques and image analysis, the course also contained a practical project with the aim to give the participants a better understanding of the workflow from sample preparation to quantitative measurements for a specific research application defined based on their own research interests. The projects were realized through a multidisciplinary practical project carried out collaboratively between students specialized in digital image processing, and students from the application areas. The projects included all steps from sample preparation (where the student from the application area acted as the expert, teaching the others), via microscopy, to digital image processing and quantification (where the student from digital image processing acted as an expert, teaching the others). Projects were presented orally in the form of a mini-conference, and printed as part of the internal report series of the Centre for Image Analysis.
   Comment: credits: 5+ 1-5 (optional size of project)

5. **Classical & Modern Papers**
   PhD students at CBA
   Period: During the whole year
   Description: Presentation of a classical or modern paper.

4.2 Docent degrees

1. *Title:* Avståndsfunktioner som ett Verktyg i Datoriserad Bildbehandling
   Distance Transforms as a Tool in Computerized Image Processing
   Robin Strand
   Date: 120126
   Abstract: För att bestämma avståndet mellan två bildelement, pixlar, i en bild behövs en avståndsfunktion. I den här föreläsningen presenteras en typ av avståndsfunktion och några av dess egenskaper. Avståndsfunktionen är grånivåviktad, vilket innebär att grånivåvärden i bilden definierar avståndet. I föreläsningen förklaras hur avståndsfunktionen kan approximeras för att möjliggöra att den beräknas effektivt. Dessutom jämförs avståndsfunktionen med andra grånivåviktade avståndsfunktioner.

   Segmentering, vilket innebär att man särskiljer objekt från bakgrund, av bilder är ett viktigt steg i många bildanalysprojekt. Helt automatiska segmenteringsmetoder av bilder är inte tillräckligt pålitliga för många tillämpningar. Därför används ofta interaktiv segmentering, där segmenteringsprocessen styrs av en användare. I föreläsningen presenteras exempel på hur grånivåviktade avståndsfunktioner kan användas för interaktiv segmentering.
   Comment: The lecture was given in Swedish.

2. *Title:* Texturmått för Identifiering av Virus i Elektronmikroskopbilder
   Texture Measures for Identification of Virus in Electron Microscopy Images
   Ida-Maria Sintorn
   Date: 120903
   Abstract: Textur är ett begrepp inom bildanalys som används för att beskriva mönster eller struktur på avbildade ytor och objekt. Texturmär således mått som beräknas för att kunna särskilja eller känna igen olika typer av ytor eller objekt. Att visuellt analysera och identifiera virus med hjälp av elektronmikroskop är en beprövad och etablerad teknik. Ett utmanande problem är att automatiskt och expertoberoende kunna identifiera virus i elektronmikroskopbilder, vilket vore av stor nytta vid akuta sjukdomsutbrott och för svårdiagnostiserade virustyper. I den här föreläsningen kommer jag beskriva några väletablerade och nya texturmått samt visa hur de kan användas för att känna igen olika virustyper i bilder från ett transmissionselektronmikroskop.
   Comment: The lecture was given in Swedish.

Docent degrees from CBA

1. Lennart Thurfjell, 1999
2. Ingela Nyström, 2002
3. Lucia Ballerini, 2006
4. Stina Svensson, 2007
5. Tomas Brandtberg, 2008
6. Hans Frimmel, 2008
7. Carolina Wählby, 2009
8. Anders Hast, 2010
9. Pasha Razifar, 2010
10. Cris Luengo, 2011
11. Robin Strand, 2012
12. Ida-Maria Sintorn, 2012

5 Research

CBA is conducting a wide range of projects ranging from theoretical image analysis research to translational applications. In addition, there is an increased focus on scientific visualization and haptics-enabled systems. By pursuing both theoretical and applied research, we endeavor to make the best contribution to our field. In line with the stated goal for CBA, we give priority to applications in the fields of biomedicine and forest industry.

In this Section, we list the 54 research projects that were active during 2012. Some are large projects that have been active for a long time, while others are smaller and short-lived. We started 14 new projects this year, while 17 were completed.

Most of the projects are carried out in close cooperation with researchers from other universities and from other research areas. In Section 5.6, we list both the national and the international groups with which we have had active cooperation in 2012.

5.1 3D analysis and visualization

1. **Whole Hand Haptics with True 3D Displays**
   Ingrid Carlbom, Ewert Bengtsson, Filip Malmberg, Ingela Nyström, Stefan Seipel, Pontus Olsson, Fredrik Nysjö
   Partners: Stefan Johansson (Division of Microsystems Technology, Uppsala University and Teknovest AB); Jonny Gustafsson and Lars Mattson, Industrial Metrology and Optics Group, KTH; Jan-Michaél Hirsch, Dept. of Surgical Sciences, Oral & Maxillofacial Surgery, at UU and Consultant at Dept. of Plastic- and Maxillofacial Surgery, UU Hospital; Håkan Lanshammar and Kjartan Halvorsen, Dept. of Information Technology, UU; Roland Johansson, Dept. of Neurophysiology, Umeå University; PiezoMotors AB; SenseGraphics AB
   Funding: Knowledge Foundation (KK Stiftelsen) 5250000 SEK
   Period: 090810–120810
   Abstract: *Hardware Developments.* In the last eight months of this project, we built generations three and four of the haptics hardware. In the third generation, the force sensor was replaced with a sensor using force sensitive ink printed on a flexible polymer carrier (Figure 2). The force sensor was placed close to the fingertip to reduce the effects from mechanical friction and elastic deformation. To reduce play in the joints and plastic deformation of the more critical mechanical details, some parts were redesigned in steel and aluminum. The evaluation of the third generation clearly indicates that the desired haptic perception could be reached with this solution, with most artifacts attributable to the flexible force sensor. This was later verified in the fourth and last version where a high quality strain gauge force sensor replaced the force sensitive ink on the polymer carrier. In this last design (Figure 2) the resilience between end-effector and force cell is negligible and most previously observed artifacts are remedied.

   The two main remaining issues with the glove are audible noise and speed. The motor used in the glove prototypes is a standard component for high precision movements and the maximum speed does not allow for very fast finger movements. A new ultrasonic motor, developed for this project (Figure 3), was evaluated and tested experimentally. The motor was designed to operate in the inaudible ultrasonic frequency and the maximum speed was experimentally verified to be 160 mm/s at no load. This force level in combination with the high speed makes it well suited for linear direct drive (no leverage) of a glove joint.

   In summary, the prototype admittance-type haptic glove with a compact integrated piezoelectric motor can produce both accurate force-displacement responses of non-linear elastic material stiffness and a fast and stable response to an applied load.

Software Developments. Stiffness, the relationship between load and deflection, is of interest in haptic rendering because it is a mechanical property that we use to distinguish one object from another, and to guide us how an object should be handled. While an ideal spring obeys a linear relationship between load and deflection, many load-deflection curves of real objects are non-linear. To test the proposed glove's ability to render stiffness, we loaded the controller with a series of load-deflection curves with measurements from real, physical objects, and measured how closely the glove can follow these curves by measuring the actual position of the index finger thimble while applying a series of known loads. We generated the sampled load/deflection values during compression of several balls using a Minimat 2000 compression and tensile testing machine (Figure 4). In addition, for two of the sampled materials we also measured how fast the thimble reaches the target deflections corresponding to a defined load applied at the thimble (Figure 4).

We showed that the glove can realistically display load-deflection curves obtained from physical samples, and how linear compliance compensation in the control loop can further improve the accuracy. The dynamic response after a load is applied to the thimble is a fast and stable transition to the new target position without overshoot or oscillation.

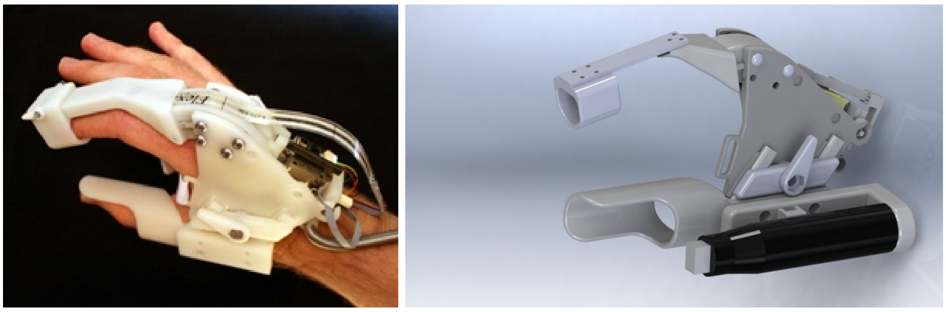


Figure 2: (Left) Third generation glove. (Right) A CAD model of fourth generation exoskeleton.

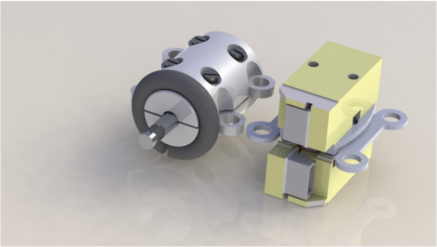


Figure 3: The new US motor (left) next to the twin LEGS motor (right) used in the glove prototypes.

Snap-to-fit. Virtual assembly of complex objects has application in domains ranging from surgery planning to archaeology. In these domains the objective is to plan the restoration of skeletal anatomy or archaeological artifacts and to achieve an optimal reconstruction without causing further damage. Haptics can improve an assembly task by giving feedback when objects collide, but precise fitting of fractured objects guided by delicate haptic cues similar to those present in the physical world requires haptic display transparency beyond the performance of today's systems. We developed a haptic alignment tool that combines a 6 Degrees-of-Freedom (DOF) attraction force with traditional 6 DOF contact forces to pull a virtual object towards a local stable fit with a fixed object. Hierarchical data structures and pre-computation combine to achieve haptic rates for fractured surfaces with over 5000 points. We demonstrated the use of our system on applications from both cranio-maxillofacial surgery and archaeology. (See Project 2.)

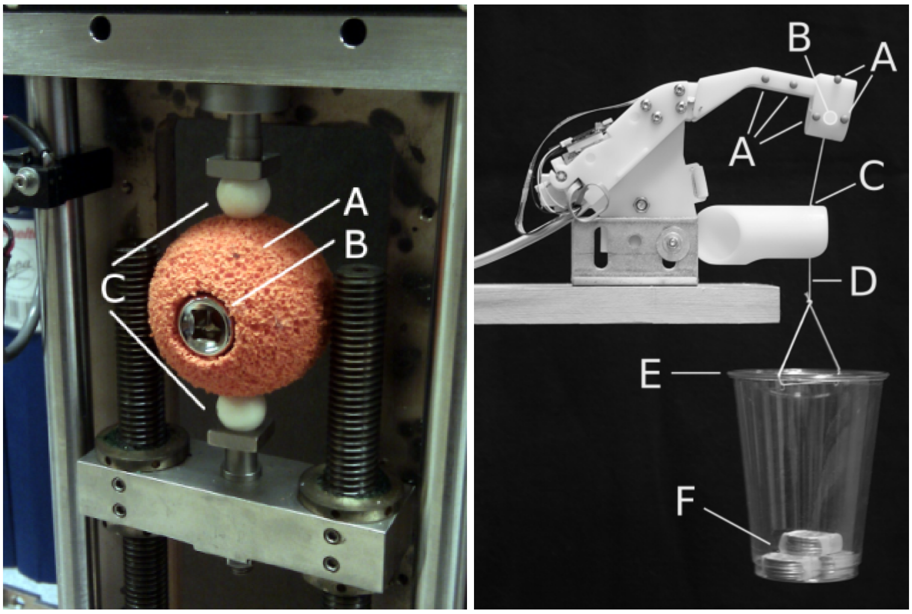


Figure 4: (Left) The load-deflection curve of a physical sample (A), with an inserted metal cylinder (B), is measured in the compression test machine. The sample is compressed between two spherical contact points (C).
(Right) Haptic glove during static and dynamic stiffness experiments. The reference point (B) is tracked with the markers (A). A force is applied at the thimble in the direction of a hole in the thumb-tube (C) via the string (D). The cup (E) holds weights (F).

2. **Haptics-Assisted Cranio-Maxillofacial Surgery Planning**
   Ingrid Carlbom, Pontus Olsson, Fredrik Nysjö
   Partner: Jan-Michaél Hirsch, Dept. of Surgical Sciences, Oral & Maxillofacial Surgery, at UU and Consultant at Dept. of Plastic- and Maxillofacial Surgery, UU Hospital
   Funding: See Project 1, Whole Hand Haptics with True 3D Display
   Period: 090810–120810
   Abstract: Cranio-maxillofacial surgery to restore normal skeletal anatomy in patients with serious trauma to the face can be very complex and time consuming. But it is generally accepted that careful pre-operative planning will lead to a better outcome with a higher degree of function and reduced morbidity and also reduced time in the operating room. However, today's surgery planning systems are primitive, relying mostly on the user's ability to plan complex tasks using a two-dimensional graphical interface.

   We developed a system for planning the restoration of skeletal anatomy in facial trauma patients which combines stereo visualization with six degrees-of-freedom, high-fidelity haptic feedback to enable analysis, planning, and preoperative testing of alternative solutions for restoring bone fragments to their proper positions in a virtual model derived from patient-specific CT data. The stereo display gives the surgeon accurate visual spatial perception and the haptics system guides the surgeon by providing intuitive contact forces when bone fragments are in contact as well as six degrees-of-freedom attraction forces (Snap-to-fit) that can be used to find precise bone fragment alignment.

   A senior surgeon with no prior experience of the system received 45 minutes of training on the system. Following that he completed a virtual reconstruction in 22 minutes of a complex mandible fracture with a reduced and well adapted result.

3. **Improved Interactive Medical Image Analysis through Haptic Display Methods**
Filip Malmberg, Ingela Nyström, Ewert Bengtsson, Stefan Seipel
Funding: 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 described further in projects 7 and 8.

   A software package for interactive visualization and segmentation developed within this project has been released under an open-source license. The package, called WISH, is available for download at `http://www.cb.uu.se/research/haptics`.

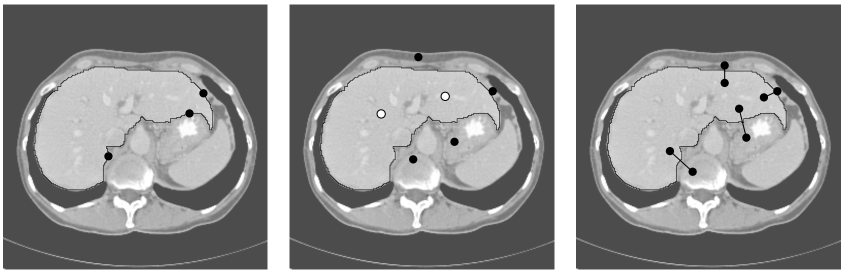
4. **Improved Methods for Interactive Graph-Based Segmentation**
Filip Malmberg, Ingela Nyström, Ewert Bengtsson
Funding: TN-faculty, UU
Period: 0901–
Abstract: Image segmentation, the process of identifying and separating relevant objects and structures in an image, is a fundamental problem in image 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.

   Interactive segmentation methods use human expert knowledge as additional input, thereby making the segmentation problem more tractable. A successful semi-automatic method minimizes the required user interaction time, while maintaining tight user control to guarantee the correctness of the result. The input from the user is typically given in one of two forms:

   - *Boundary constraints*
     The user is asked to provide pieces of the desired segmentation boundary.
   - *Regional constraints*
     The user is asked to provide a partial labeling of the image elements (e.g., marking a small number of image elements as “object” or “background”).

   In a recent publication, we showed that these two types of input can be seen as special cases of what we refer to as *generalized hard constraints*. This concept is illustrated in Figure 5. An important consequence of this result is that it facilitates the development of general-purpose methods for interactive segmentation, that are not restricted to a particular paradigm for user input.

   In 2012, results from this project were presented at the International Conference on Pattern Recognition (ICPR) in Tsukuba, Japan.



(a) (b) (c)

Figure 5: Interactive segmentation of the liver in a slice from a CT volume image, using three different interaction paradigms. (a) Segmentation using boundary constraints. The black dots indicate graph edges that must be included in the segmentation boundary. (b) Segmentation using regional constraints. Black and white dots indicate background and object seeds, respectively. (c) Segmentation using generalized constraints. Each constraint is displayed as two black dots connected by a line.

5. **Interactive Segmentation and Analysis of Medical Images**
   Filip Malmberg, Robin Strand, Ingela Nyström, Ewert Bengtsson
   Partners: Joel Kullberg, Håkan Ahlström, Dept. of Radiology, Oncology and Radiation Science, UU
   Funding: TN-faculty, UU
   Period: 1106–
   Abstract: Three-dimensional imaging technique such as computed tomography (CT) and magnetic resonance imaging (MRI) are now routinely used in medicine. This has led to an ever increasing flow of high-resolution, high-dimensional, image data that needs to be qualitatively and quantitatively analyzed. Typically, this analysis requires accurate segmentation of the image.

   At CBA, we have been developing powerful new methods for interactive image segmentation (see Project 4). In this project, We seek to employ these methods for segmentation of medical images, in collaboration with the Department of Radiology, Oncology and Radiation Science (ROS) at the Uppsala University Hospital.

   During 2012, a new software for interactive segmentation called *Smartpaint* was developed within this project, see Figure 6. We used this software to participate in a MICCAI challenge on prostate segmentation (PROMISE12), and made 3rd place.

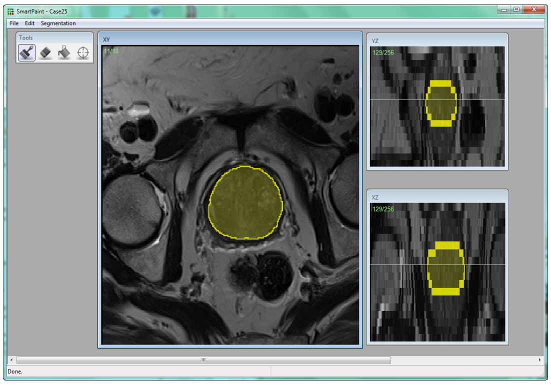


Figure 6: Screenshot from the *Smartpaint* software for interactive segmentation of volume images, developed at CBA. A radiologist segments the prostate in a MR image by interactively “painting” the segmentation using a brush tool.

6. **ProViz – Interactive Visualization of 3D Protein Images**

Lennart Svensson, Ida-Maria Sintorn, Johan Nysjö, Ingela Nyström, Anders Brun, Gunilla Borgefors

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: Electron tomography is the only microscopy technique that allows 3-D imaging of biological samples at nano-meter resolution. It thus enables studies of both the dynamics of proteins and individual macromolecular structures in tissue. However, the electron tomography images have a low signal-to-noise ratio, which make image analysis methods an important tool in interpreting the images. The ProViz project aims at developing visualization and analysis methods in this area.

During 2012 we performed an investigation of GPU implementation techniques for registration in these images. The results of this were presented at the International Joint Conference on Computer Vision, Imaging and Computer Graphics Theory and Applications, VISIGRAPP 2012. With a specialized implementation in CUDA we achieved speed increases by an order of a magnitude compared to a parallel CPU implementation. During the year we have also investigated a new way of creating registration templates for finding proteins in these images (Figure 7), as well as continued to work on the ProViz software package, which will make the methods developed in the project easily accessible for other researchers.

(a) PDB structure (b) PDB template (c) New template

Figure 7: Traditionally, templates for searching for proteins in electron tomograms are created from an atomic resolution structure derived using crystallography. An atomic resolution structure of the antibody IgG is shown to the left and the corresponding nano-meter template in the middle. However, this only represents one conformation (shape variant) of the protein. By automatic alignment and averaging of protein examples from electron tomography, we can derive a new template, shown to the right, that better represents the shape variation of a protein molecule.

7. **Orbit Segmentation for Cranio-Maxillofacial Surgery Planning**
Filip Malmberg, Ewert Bengtsson, Ingela Nyström, Johan Nysjö
Partners: Jan Michael Hirsch, Elias Messo, Babett Williger, Andreas Thor, Dept. of Surgical Sciences, UU Hospital
Funding: TN-faculty, UU; NovaMedTech
Period: 0912–
Abstract: A central problem in cranio-maxillofacial (CMF) surgery is to restore the normal anatomy of the skeleton after defects, i.e., malformations, tumors and trauma to the face. This is particularly difficult when a fracture causes vital anatomical structures such as the bone segments to be displaced significantly from their proper position, when bone segments are missing, or when a bone segment is located in such a position that any attempt to restore it into its original position 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, see Figure 8.

During 2012, we have been investigating two additional applications for the system: volumetric measurements of the upper airway space in cone-beam CT (CBCT) images; and volumetric measurements of the maxillary sinuses in CT images.

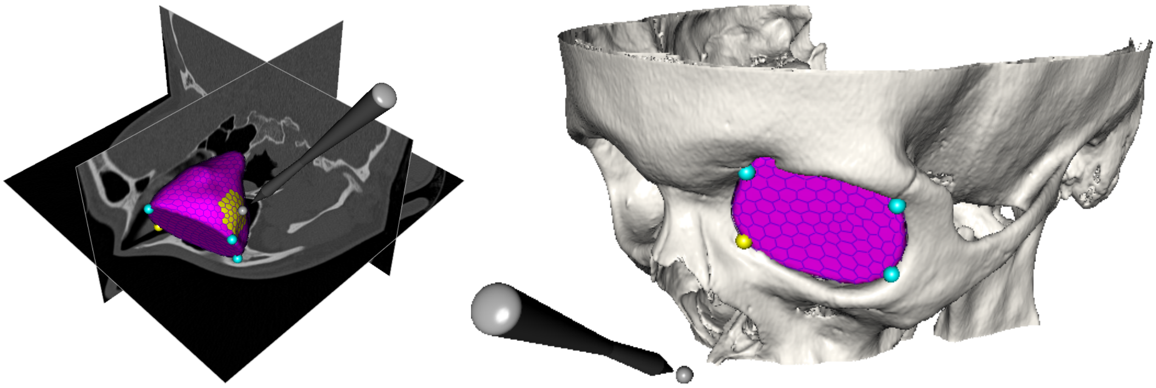


Figure 8: (Left) Segmentation of the orbit in a CT image using a deformable model. (Right) Final segmentation of the orbit, visualized with the skull surface.

8. **Haptic-Enabled 3D Angle Measurements in CT Wrist Images**
Filip Malmberg, Johan Nysjö, Ingela Nyström, Ida-Maria Sintorn
Partners: Albert Christersson, Dept. of Orthopedics, UU Hospital
Funding: TN-faculty, UU
Period: 1111–
Abstract: To be able to decide the correct treatment of a fracture, for example, whether a fracture needs to be operated on or not, it is important to assess the details about the fracture. One of the most important factors is the fracture displacement, particularly the angulation of the fracture. When a fracture is located close to a joint, for example, in the wrist, which is the most common location for fractures in the human being, the angulation of the joint line in relation to the long axis of the long bone needs to be measured. Since the surface of the joint line in the wrist is highly irregular, and since it is difficult to take X-rays of the wrist in exactly the same projections from time to time, conventional X-ray is not an optimal method for this purpose. In most clinical cases, the conventional X-ray is satisfactory for making a correct decision about the treatment, but when comparing two different methods of treatment, for example, two different operation techniques, the accuracy of the angulation of the fractures before and after the treatment has to be higher.

In this project, we are developing a system for measuring these angles in 3D computed tomography (CT) images of the wrist. Our proposed system is semi-automatic; the user is required to guide the system by indicating the approximate position and orientation of various parts of the radius bone. This information is subsequently used as input to an automatic algorithm that makes precise angle measurements. To facilitate user interaction in 3D, we use a system that supports 3D input, stereo graphics, and haptic feedback.

A RANSAC-based method for estimating the long axis of the radius bone was presented at the International Conference on Computer Vision and Graphics (ICCVG 2012). We are currently developing methods and software for measuring the orientation of the joint surface of the radius. Some preliminary results of this work are shown in Figure 9.

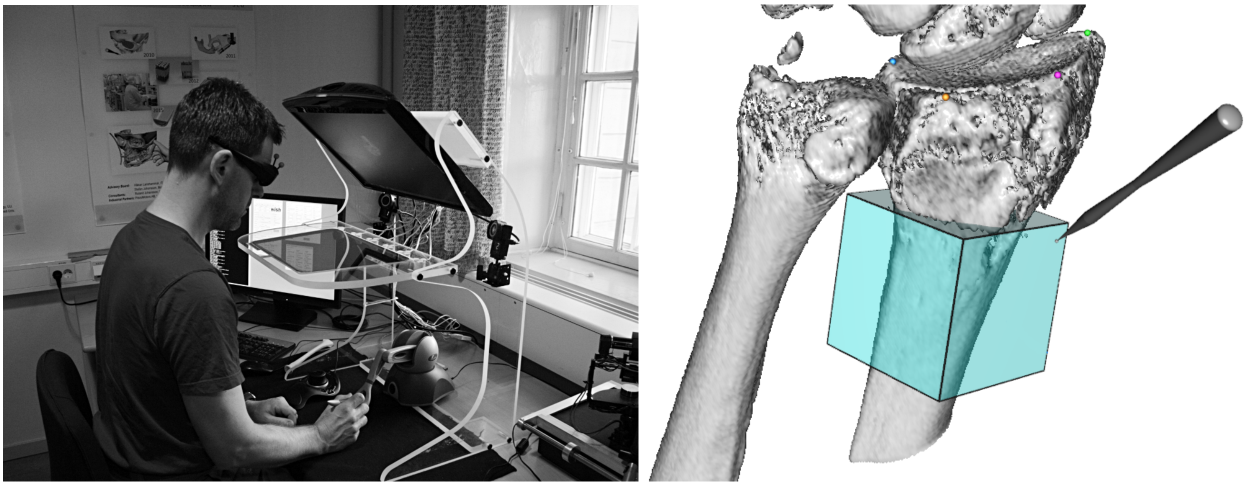


Figure 9: (Left) A user working at the visuo-haptic display. (Right) A volume selection tool used to estimate the central long axis of the radius bone.

9. **Registration of Whole-Body MR-images**
   Robin Strand
   Partner: Joel Kullberg, Håkan Ahlström, Dept. of Radiology, Oncology and Radiation Science, UU
   Funding: Faculty of Medicine, UU
   Period: 1208–
   Abstract: Magnetic Resonance Tomography (MR) is an image acquisition technique that does not use ionizing radiation and is very useful in clinical use and in medical research, e.g., for analyzing the composition of the human body. At the division of Radiology, Uppsala University, a huge amount of whole body-MR data is acquired for research on the connection between the composition of the human body and disease.

   To compare these whole body volume images voxel by voxel, they should be aligned by an image registration process. To robustly register whole body-MR volumes, for example, segmented tissue (see, e.g., Project 5) and landmarks are utilized in a non-rigid registration process in this project.

10. **Analysis and Processing of Three-Dimensional Magnetic Resonance Images on Optimal Lattices**
    Elisabeth Linnér, Robin Strand
    Funding: TN-faculty, UU
    Period: 1005–
    Abstract: Three-dimensional images are widely used in, for example, health care. With optimal sampling lattices, the amount of data can be reduced by 30% without affecting the image quality. In this project, methods for image acquisition, analysis and visualization using optimal sampling lattices are studied and developed, with special focus on magnetic resonance imaging. The intention is that this project will lead to faster and better processing of images with less demands on data storage capacity.

    A paper on normalized convolution on different two-dimensional grids was presented at 21th International Conference on Pattern Recognition (ICPR), Tsukuba, Japan.

11. **Efficient Algorithms for Computer Graphics**
    Ewert Bengtsson, Anders Hast
    Partner: Tony Barrera, Uppsala
    Funding: TN-faculty, UU
    Period: 9911–
    Abstract: Computer graphics is increasingly being used to create realistic images of 3D objects for applications in entertainment, (animated films, games), commerce (showing 3D images of products on the web), industrial design and medicine. For the images to look realistic high quality shading and surface texture and topology rendering is necessary. A proper understanding of the mathematics behind the algorithms can make a big difference in rendering quality as well as speed. We have in this project over the years re-examined several of the established algorithms and found 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. During 2012 a number of new mathematical problems were investigated and one of the previously developed ones was finalized for submission to a conference.

12. **Ubiquitous Visualization in the Built Environment**
    Stefan Seipel, Fei Liu
    Funding: University of Gävle; TN-faculty, UU
    Period: 110801–
    Abstract: Mobile devices have recently seen an enormous advancement in their computational power with many exciting and promising pieces of technology available at the same time such as mobile graphics processing, spatial positioning, and access to geo-spatial databases. This research project in "ubiquitous visualization" will deal with mobile visualization of spatial data in indoor and outdoor environments. It addresses several key problems for robust mobile visualization such as spatial tracking and calibration; image based 2D and 3D registration and efficient graphical representations in mobile user interfaces. Evaluation of developed methods or techniques, mainly with respect to the human factor, will be an integral part of these studies in order to endeavor the best user experience. Application scenarios studied in this project will predominantly, but not exclusively, be in the field of urban spaces and built environment.

13. **Visual Simulation for Solar Energy Planning in the Built Environment**
    Stefan Seipel
    Partners: Joakim Widén, David Lingfors, Solid State Physics, Dept. of Engineering Sciences, UU
    Funding: University of Gävle; TN-faculty, UU
    Period: 1211–
    Abstract: The assessment of solar energy yield in urban environments depends primarily on estimated solar irradiance and local topography or building architecture. To maintain manageable computational complexity, spatial and temporal detail is traditionally sacrificed in irradiation calculations. Often, coarse urban models (LIDAR data) and long-term time-averaged observations of solar irradiance/vegetation indexes/weather are used. An in-depth exploration of the solar yield on building facades would ideally account for very short term variations of solar exposure within given observation intervals. Those variations depend on many factors such as solar angle, local building geometry and nearby occluding building structures. Other variables into these calculations are monthly variation of vegetation and daily variation of weather conditions. Highly detailed analysis of solar energy yield requires numerical integration of the irradiance equations with dense sampling of all temporal and spatially varying variables. This approach allows for insights into the quality of solar energy yield in space over time. On the other hand it is computationally demanding which hampers interactive exploration. The main objective of this project is to develop and study new computational approaches to overcome these limitations and to allow for spatio-temporal visualization and exploration of solar energy yield in the build environment (Figure 10).

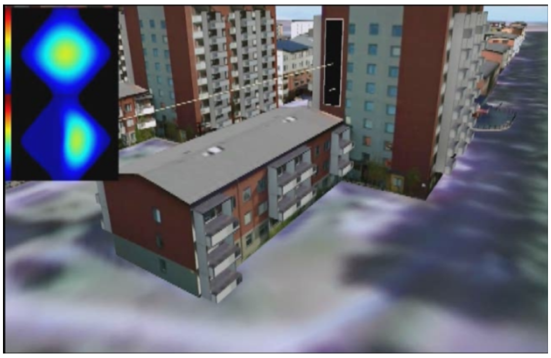


Figure 10: Visual interactive query of annual solar yield in a 3D urban model.

5.2 Analysis of microscopic biomedical images

14. **CerviScan**

Ewert Bengtsson, Patrik Malm, Hyun-Ju Choi, Bo Nordin

Partners: Rajesh Kumar, CDAC, Centre for Development of Advanced Computing, Thiruvananthapuram, India; K Sujathan, Regional Cancer Centre, Thiruvananthapuram, India.

Funding: Swedish Governmental Agency for Innovation Systems (Vinnova); Swedish Research Council

Period: 0801–

Abstract: Cervical cancer is killing a quarter million women every year. Screening based on 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, 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 is in progress at the research institute CDAC in Thiruvananthapuram, Kerala in cooperation with the RCC, Regional Cancer Centre there. We are participating in the project with funding from Vinnova, VR and SIDA.

At CDAC, a program for data collection and a screening program including image segmentation, artifact rejection, feature extraction and cell and specimen classification have been developed. The system has been used to collect and analyze data for well over 1000 cases so far and has reached an acceptable performance level as specified in the original project plan although based on analyzing less than 10% of the specimen area and needing about 10 times longer than acceptable for a final system to do that.

At CBA we initially focused on studying whether the 3D chromatin texture of the cervical cells can be utilized as a robust feature for detecting (pre-) cancerous lesions. For that purpose we scanned the cells at 40 different focus levels creating stacks of data for each nucleus. Dr. Sujathan a cytologist from RCC spent two periods each of two weeks in Uppsala and collected ground-truth annotated data.

In collaboration with Andrew Mehnert at MedTech West, Chalmers new texture analysis approaches were implemented and evaluated. We have also implemented several other feature extraction methods and adapted them for our data stacks. The conclusion is that the high quality perfectly focused images we can obtain through the stacks gives strong textural features for classification, but we have not been able to show any convincing advantages of using 3D data directly. We have also developed methods for evaluating low resolution images to find regions of high interest for a high resolution analysis and methods for rejecting artifacts initially segmented as nuclei. The results have been published as three different conference papers and a paper accepted for journal publication.

The Indian project is currently awaiting final evaluation. We are proposing a follow-up project where some of our improved texture analysis methods will be added to the Indian system at the same time as the hardware solution is redesigned to increase throughput with more than an order of magnitude. During 2012 we visited India for 9 days in April and held a workshop going through all the different parts of our systems and research results. Another visit and workshop is planned for early February 2013.

15. **Tracking of Unstained Cells in Microfluidic Systems**
    Martin Simonsson, Carolina Wählby
    Partners: Johen Kreuger, Sara Thorslund, Gradientech AB, Uppsala
    Funding: SciLife Lab Uppsala; eSSENCE; Dept. of IT, UU
    Period: 1108–
    Abstract: Tracking of cell movements in various cell culture setups is essential to many researchers in the life science sector. Gradientech AB, a Swedish biotech company, has developed CellDirector, a unique microfluidic system that academic researchers can use to study how concentration gradients of soluble proteins impact cell migration. The current project is focused on developing software for analyzing cell behavior and cell migration. The free open-source software CellProfiler developed at the Broad Institute will be used as a platform for a high-throughput system with automated high quality imaging, adapted for unlabeled cells, which are analyzed with regard to directionality of migration, speed, and acceleration. Apart from analyzing cell migration, the cell tracking aims at producing lineages, where cellular events such as cell division and cell death can be scored for single cells. A graphical user interface for visualizing and editing tracks imported from CellProfiler has been developed. This will be used for manual feed back in an iterative parameter optimization process, which aims to improve the automatic tracking. The progress of the project was presented in the poster session at BioImage Informatics 2012 in Dresden.

16. **Detection and Classification of Malaria Infected Cells by LED Spectral Microscopy**
    Carolina Wählby
    Partners: Jeremie Zoueu, Olivier Bagui, Dept. Genie Electrique et Electronique, Institut National Polytechnique, Felix Houbhouet-Boigny, Cote d' Ivoire
    Period: 1109–1201
    Abstract: This project aims to propose an effective optical device based on LED spectral microscopy, which will be low cost, fast and easy to use in the diagnosis of human malaria parasites, especially because the sample will not need any special preparation or staining and the data will be automatically processed to provide real-time diagnosis of the type of the parasite, the parasitic density and its age for an effective prescription. The collaborative project was initiated by a 3-month visit by Olivier Bagui, where we focused on the development of efficient segmentation methods for unstained images of blood cells.

17. **Automated Classification of Immunostaining Patterns in Breast Tissue from the Human Protein Atlas**
    Andreas Kårsnäs, Martin Simonsson, Carolina Wählby, Robin Strand
    Partners: Caroline Kampf, The Human Protein Atlas (HPA); Virginie Uhlmann, Imaging Platform, Broad Institute of Harvard and MIT, Cambridge, Massachusetts MA, USA; S. Issac Niwas, P. Palanisamy, Dept. of ECE, National Institute of Technology (NIT), Tiruchirappalli, India
    Funding: SciLife Lab Uppsala
    Period: 1201-
    Abstract: The Human Protein Atlas (HPA) is an effort to map the location of all human proteins (`http://www.proteinatlas.org/`) and contains a large number of histological images of sections from human tissue. Methods for quantification of staining patterns in histopathology have many applications, ranging from antibody quality control to tumor grading. In this project we have tested a new method based on complex wavelets textural features as well as an approach inspired by WNDCHARM (Weighted Neighbor Distances using a Compound Hierarchy of Algorithms Representing Morphology) for classifying nuclear versus cytoplasmic staining. This project was presented at MICCAI 2012 workshop on Histopathology Image Analysis (HIMA): Image Computing in Digital Pathology, Nice, October 2012 and has also been accepted for publication in Journal of Pathology Informatics.

18. **Studying Exocytosis by Time Lapse Microscopy**
    Martin Simonsson, Carolina Wählby
    Partners: Anne Wuttke, Dept. of Medical Cell Biology, Uppsala University
    Funding: SciLife Lab Uppsala
    Period: 1211-
    Abstract: Insulin secreting cells perform exocytosis and this can be detected with a GFP-modified protein as an increase in fluorescence signal. Time lapse sequences are acquired with a time interval of one second during one hour, observing changes in fluorescence signaling at different treatments of the cells. This results in huge data sets with more than 3000 images for a single experiment. The focus of this project is to extract relevant information from the image data and in an efficient way analyse and visualize the data.

19. **Optical Projection Tomography**
    Alexandra Pacureanu, Omer Ishaq, Carolina Wählby
    Partners: Amin Allalou, Izolde AB, Uppsala; Johan Ledin, Evolutionary Biology Centre, Zebrafish platform, SciLife Lab Uppsala; Carlos Pardo, Mehmet F. Yanik, Research Laboratory of Electronics, Massachusetts Institute of Technology, Cambridge, USA
    Funding: SciLife Lab Uppsala; TN-faculty, UU
    Period: 1009–
    Abstract: Isotropic 3D imaging of biological specimens is instrumental for further breakthroughs in life sciences. Many biological specimens with high relevance for basic research, disease studies and drug discovery, such as model organisms or 3D cell cultures, are semi-transparent to visible light. This lead to the advent of the technique dubbed optical projection tomography (OPT). The 3D internal structure is revealed by the attenuation variations of the light traversing the specimen. In OPT transverse slices of the specimen are reconstructed from a set of angular projections and stacked together into a volumetric image. This method enables in-vivo imaging of relatively large samples with high spatial resolution.

    A high-throughput platform for cellular resolution, in vivo OPT of zebrafish has been developed at MIT, Cambridge, USA. With this system we have shown that OPT of zebrafish embryos can provide 3D information enabling high-throughput screening of subtle phenotypic changes in relation to drug treatment. However, OPT imaging systems in general are still quite sophisticated and costly. We are therefore developing a system for optical 3D isotropic imaging at microscopic scale, based on readily accessible hardware. The total price of the setup is kept under 1000 euros and the components can be easily obtained around the world. We have assembled the image acquisition system and acquired and reconstructed our first 3D images of zebrafish embryos. We are complementing the simple hardware with open source computational tools, embedding algorithms for image alignment, correction and reconstruction. Additionally, we are exploring the potential for compressed-sensing based volumetric reconstruction for optical projection tomography. Potential benefits include low-sensitivity to noise as well as a smaller number of required projections.

    Our goal is to enable every life sciences research laboratory to have access to valuable 3D information on biological specimens.

20. **A Multidisciplinary Approach to Establish Mechanisms for Mitochondrial DNA Segregation in Human Disease**
    Amin Allalou, Carolina Wählby
    Partners: Nils-Göran Larsson, Dept. of Laboratory Medicine, Karolinska Institute; Mats Nilsson, Chatarina Larsson, Dept. of Genetics and Pathology, UU; Anton K. Raap, Roshan S. Jahangir Tafrechi, Frans M. van de Rijke, Karoly Szuhai, Raimond B. G. Ravelli, George M. C. Janssen, Dept. of Molecular Cell Biology, Leiden University Medical Centre, Leiden, The Netherlands;

Angela Pyle, Patrick F. Chinnery, Wellcome Trust Centre for Mitochondrial Research, Newcastle University, Newcastle upon Tyne, United Kingdom; René F. M. de Coo, Dept. of Neurology, Erasmus Medical Center, Rotterdam, The Netherlands; Harsha K. Rajasimha, Center for Human Genetics Research, Vanderbilt University Medical Center, Nashville, Tennessee.
Funding: The Swedish Research Council, Collaboration Grant, Medicine
Period: 0801–
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. A paper describing the non-random segregation pattern was published in PlosOne.

21. **Acceleration of the Faster STORM Algorithm through Graphical Processing Units**
Omer Ishaq, Alexandra Pacureanu, Carolina Wählby
Partners: Johan Elf, Gustaf Ullman, Dept. of Cell & Molecular Biology, Uppsala University
Funding: SciLife Lab Uppsala
Period: 1211-
Abstract: Stochastic optical reconstruction microscopy (STORM) is a super-resolution microscopy image acquisition technique for single-molecule localization. Like other stochastic super-resolution microscopy techniques it incorporates a trade-off between spatial- and temporal-resolution. Recently, a compressed-sensing (CS) based variant of STORM, called FasterSTORM, has been developed which substantially increases the temporal sampling of a stack of STORM image frames. This improvement is realized by increasing the density of activated fluorophores in each frame, followed by a subsequent CS-based retrieval of single-molecule positions even with overlapping fluorescent signals. However, the CS-based retrieval/decoding step is time consuming and can take as much as three hours for each image frame. We are working on accelerating the FasterSTORM method either through processing on a grid or by porting and processing it on the graphical processing units (GPUs). Additionally, we have tested and tried a number of L_1-solvers for CS-based recovery of molecule positions.

22. ***In Situ* Sequencing of mRNA**
Carolina Wählby, Alexandra Pacureanu, Marine Astruc
Partners: Mats Nilsson, Rongqin Ke, Marco Mignardi, SciLife Lab Stockholm
Funding: SciLife Lab Uppsala; TN-faculty, UU
Period: 1109–
Abstract: Typically, isolated individual cells are profiled on RNA level using single cell capture techniques, but these techniques are laborious and limited in terms of number of cells analyzed, and information about the histological context is lost. Our collaborators have developed a new molecular method, enabling in situ sequencing of mRNA, so that protein expression can be observed directly in tissue samples. We are developing image analysis tools for automated RNA sequencing, mapping, and visualization of gene expression patterns in tissue sections and investigated methods and software tools for unsupervised clustering (Figure 11).

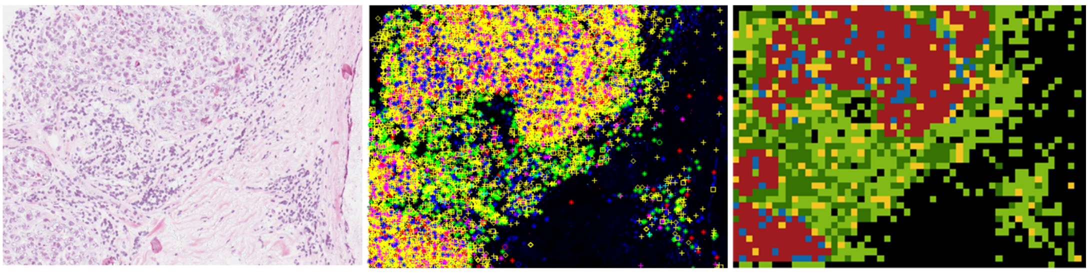


Figure 11: (*Left*) Histological section of breast cancer tissue. (*Center*) Mapping of 24 detected transcripts in the tissue section. (*Right*) K-means clustering (5 clusters) of the found transcripts after binning. The pattern in red corresponds to the distribution of HER2 which is characteristic to tumoral tissue while the regions in green correspond to non-tumoral tissue.

23. **Automated Quantification of Zebrafish Tail Deformation for High-throughput Drug Screening**
    Omer Ishaq, Alexandra Pacureanu, Carolina Wählby
    Partners: Joseph Negri, Mark-Anthony Bray, Randall T. Peterson, Broad Institute of Harvard and MIT
    Funding: SciLife Lab Uppsala
    Period: 1203–
    Abstract: Zebrafish (*Danio rerio*) is an important model organism in biomedical research due to its ease of handling and translucent body and consequently many human disease models have been established in the Zebrafish. Zebrafish embryos undergo spinal deformation upon exposure to chemical agents, such as Camptothecin (Cpt), that inhibit DNA repair. We are developing automated image-based quantification of spine deformation enabling whole-organism based assays for use in early-phase drug discovery campaigns. Our automated method for accurate high-throughput measurement of tail deformations in multi-fish micro-plate wells generates refined medial representations of partial tail-segments. Subsequently, these disjoint segments are analyzed and fused to generate complete Zebrafish tails. Based on these estimated tail curvatures we reach a classification accuracy of 91% on individual animals as compared to known control treatment. This accuracy is increased to 95% when combining scores for fish in the same well.

24. **Computational Methods for Quantification in Vascular Biology**
    Alexandra Pacureanu, Carolina Wählby
    Partners: Lena Claesson-Welsh, Xiujuan Li, Makoto Hayashi, Jeremy Adler, Eric Morin, Dept. of Immunology, Genetics and Pathology, Rudbeck Laboratory, SciLife Lab Uppsala
    Funding: SciLife Lab Uppsala
    Period: 1202–
    Abstract: The formation of new blood vessels, angiogenesis, represents a key process in the growth of tissues from embryonic development to wound healing and cancerous tumors. Our collaborators are working on understanding how angiogenesis is induced, but also how it can be suppressed. We developed image analysis pipelines for several projects concerning assessment of endothelial cell response to treatment, the role of neuropilin-1 in wound healing or quantification of vessel formation in mice tumors. The methods include image enhancement, cell segmentation, detection and quantification of phenotypic changes. The image analysis pipelines were built in the open source software CellProfiler (Figure 12).

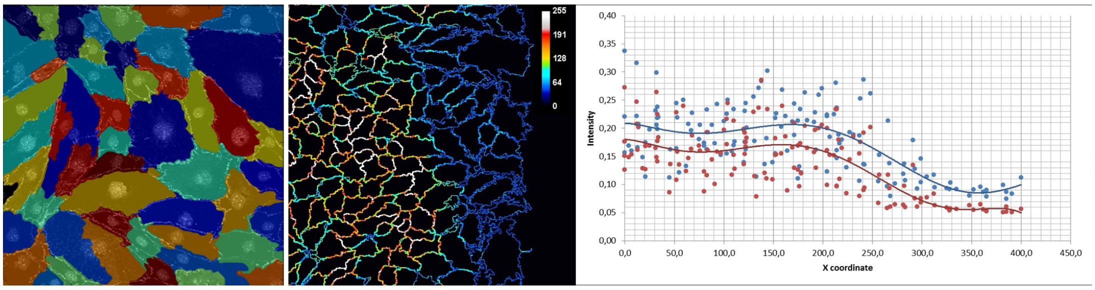


Figure 12: (*Left*) Segmentation of endothelial cells for an angiogenesis related assay. (*Center*) Map showing the intensity of the Neuropilin-1 expression in endothelial cell membranes, in the vicinity of a scratch (the right side of the image). Note that the Neuropilin-1 is less expressed in the region close to the scratch. (*Right*) Graph showing the variation in the distribution of Neuropilin-1 with the distance from the scratch. The per cell mean intensities in the cytoplasm (blue) and membranes (red) are represented as function of the position of the cell centers.

25. **Computational Methods for Quantification in Neural Stem Cells**
    Alexandra Pacureanu, Carolina Wählby, Martin Simonsson
    Partners: Karin Forsberg-Nilsson, Tanja Paavilainen, Soumi Kundu, Grzegorz Wicher, Lisa Rebello, Anqi Xiong, Dept. of Immunology, Genetics and Pathology, Rudbeck Laboratory, SciLife Lab Uppsala
    Funding: SciLife Lab Uppsala
    Period: 1210–
    Abstract: Neural stem cells are the building blocks of the nervous system. In the view of finding better treatments for neurodegenerative diseases and for deeper understanding of mammalian development, our collaborators are investigating how neural stem cells proliferate and differentiate and which factors govern these processes. For theses studies, thousands of images of cell cultures need to be quantitatively analysed, in order to determine for example how effective are various techniques for control of the stem cells differentiation. Based on CellProfiler and CellProfiler Analyst, we have developed methods for automatic analysis of these images.

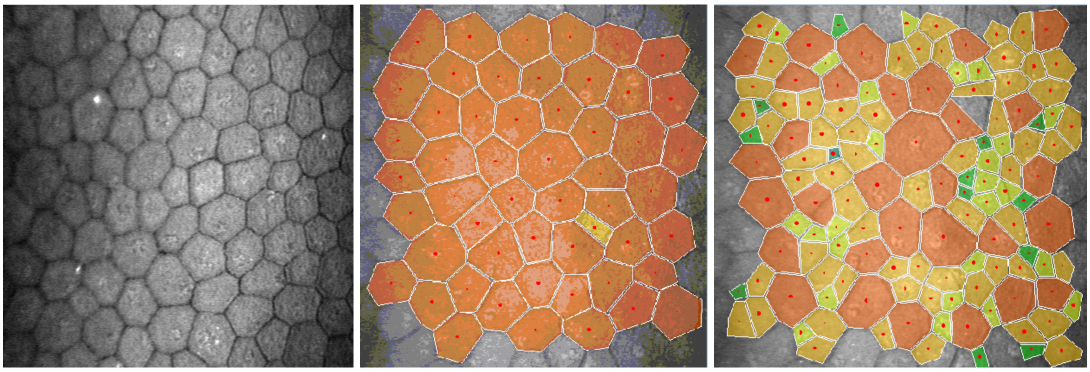
26. **Image-based Approaches for Drug Tablet Quality Assessment**
    Ida-Maria Sintorn, Carolina Wählby
    Partners: Mark Nicholas, Mats Josefson, AstraZeneca, Mölndal, Sweden
    Funding: Pre-study grant from AIMDay Image, UU Innovation
    Period: 1204–
    Abstract: It is known qualitatively that microstructural differences in solid dosage forms (e.g. tablets and inhalation powders) affect the performance of the medication. The microstructural differences are differences in the spatial distribution of active and inactive compounds. The aim of this project is to characterize these microstructural differences in order to determine whether imaging techniques such as CLSM (confocal laser scanning microscopy), wide-field fluorescence microscopy, and TOF-SIMS (Time-Of-Flight Secondary Ion Mass Spectroscopy) can reveal quantifiable differences in structure. AstraZeneca researchers will then test if the quantified structural differences can be correlated with performance measures such as drug release. If successful, this research could lead to methods for drug quality control as well as an improved design of formulation and production protocols for AstraZeneca.

27. **Modelling Diffusion on Cellsurfaces**
    Ida-Maria Sintorn, Robin Strand
    Partners: Ingela Parmryd, Dept. of Medical Cell Biology, UU; Jeremy Adler, Dept. Of Immunology, Genetics and Pathology, UU
    Funding: TN-faculty, UU; S-faculty, SLU; VINNMER programme, Swedish Governmental Agency for Innovation Systems
    Period: 1101–
    Abstract: A cell surface is a highly irregular and rough. The surface topography is however usually ignored in current models of the plasma membrane, which are based on 2D observations of diffusion that really occurs in 3D. In this project we model diffusion on non-flat surfaces to explain biological processes occurring on the cellsurface. During 2012, an abstract was accepted for the Biophysical Society 2013 Annual Meeting, Philadelphia, PA.

28. **Combating Breast Cancer by Digital Pathology**
    Andreas Kårsnäs, Robin Strand, Carolina Wählby, Ewert Bengtsson
    Partners: Visiopharm, Hørsholm, Denmark; 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 that can facilitate the workflow and ensure objective and more precise results of the quantitative microscopy procedures in breast cancer.

    During 2012, we have, in collaboration with the Human Protein Atlas project, worked on a project for verifying antibodies by comparing staining patterns in immune-stained histological images. We made a comparison of different methods for classifying staining patterns in histology. This work was presented at MICCAI'12 in Nice. We have also presented the vectorial minimum barrier distance, a new method for computing gray-weighted distance transforms while incorporating vectorial data, at ICPR'12 in Tsukuba, Japan. Finally, we started a new project aimed at developing a new method for registering histological images of consecutive sections with different staining.

29. **Endothelial Cell Segmentation of the Cornea of Human Eyes**
    Bettina Selig, Cris Luengo
    Partners: Bernd Rieger, Quantitative Imaging Group, Delft University of Technology, Netherlands; Koen Vermeer, Eye Hospital Rotterdam, Netherlands
    Funding: S-faculty, SLU
    Period: 1103–
    Abstract: In many corneal studies, endothelial cell density and morphology is used to assess the quality of the cornea. Based on these parameters, important therapeutic decisions are made. The endothelium may be imaged by specular microscopy or by confocal scanners and measurements can be obtained manually, automatically with manual corrections or fully automatically with current software (e.g., Nidek's Navis). Unfortunately, the results of the automatic mode are insufficient (see Figure 13) when the image quality is affected or when irregular shaped endothelial cells are present. In this project, we are developing a new segmentation method, using stochastic watershed, that enables a better estimation of endothelial quality.



(a) (b) (c)

Figure 13: (a) Original image of endothelial cells (b) Automatic segmentation with manually set seed points (by the commercial software Nidek's Navis) (c) Fully automatic segmentation (by the commercial software Nidek's Navis).

30. **Automatic, Quantitative Malignancy Grading of Prostate Cancer using Image Analysis**
Ingrid Carlbom, Ewert Bengtsson, Jimmy Azar, Carolina Wählby
Partners: Christer Busch, Dept. of Genetics and Pathology, University Hospital; Marene Landström, Medical Biosciences, Umeå University.
Funding: Vetenskapsrådet (2009-5418): 2400000 SEK
Period: 1001–1212
Abstract: Pathologists rely on multiple, contrasting stains to analyze tissue samples, but histological stains were developed for visual analysis and are not always ideal for automatic analysis. However, the choice of histological stain for automatic analysis should be based on its classification and clustering performance which are indicators of the performance of automatic segmentation of tissue into morphological components which in turn may be the basis for diagnosis. This year we explored a methodology for assessing the performance of both supervised and unsupervised classification on a given dataset. For supervised classification we measured the nonlinear support vector machines error rate, and for unsupervised classification we use the Rand index and the F-measure to assess the clustering results of a Gaussian mixture model based on expectation-maximization. Finally we investigated class separability measures based on scatter criteria.

Our data comprised adjacent sections of prostate tissue from radical prostatectomies prepared by the Department of Pathology at the Uppsala University Hospital. The sections were stained with 13 different histological stains; three of the stains, hematoxylin-eosin, Mallory's trichrome, and Sirius-hematoxylin, are shown in Figure 14. While the 13 stains are typically not all used for prostate cancer malignancy grading, they were included for illustration purposes.

We are interested in three stain / tissue combinations, or classes, namely nuclei, stroma, and cytoplasm. For the supervised case, we required a training set constituting the ground truth as defined by a pathologist, and this was obtained by the manual selection of regions in each of the stained images and by the labeling of each region according to its class. We trained and optimized a support vector classifier and obtained the classification error using ten-fold cross-validation. We chose the support vector classifier with a radial basis function, as it provides a significant range of complexity that may be controlled by optimizing the kernel and regularization parameters based on the cross-validated classification error.

For the unsupervised case, we assessed the clustering performance of the Gaussian mixture model by comparing the cluster labels with those of the ground truth, using precision and recall. We use the Gaussian mixture model, as it is not constrained by the assumption of spherical clusters as are the k-means and fuzzy c-means. For cluster separability we use two measures, the Fisher Criterion and the Mahalanobis distance.

We demonstrated that for a specific tissue type, in this case prostate tissue, the same five stains perform consistently better than the others according to objective error criteria for both the supervised and the unsupervised cases, as well as for the separability measures. The blind classification using the Gaussian mixture model and the Rand and F_1-measures, show that Mallory Trichrome and Sirius-Htx+ outperform other stains in terms of clustering accuracy.

Based on these results we are creating a training data set for our continued work on prostate tissue segmentation. We selected the top performing stains in our ranking based on clustering efficacy, Sirius-Htx+ and Mallory Trichrome, and the widely used Hematoxylin-eosin as reference. We are creating new TMAs from the existing 180 patients in the Uppsala cohorts, where the tissue will be three consecutive sections from each patient, stained by the three stains, respectively. Since the tissue sections will be consecutive, they will be morphologically nearly equivalent, which will allow us to select an optimal stain based on the segmentation results.

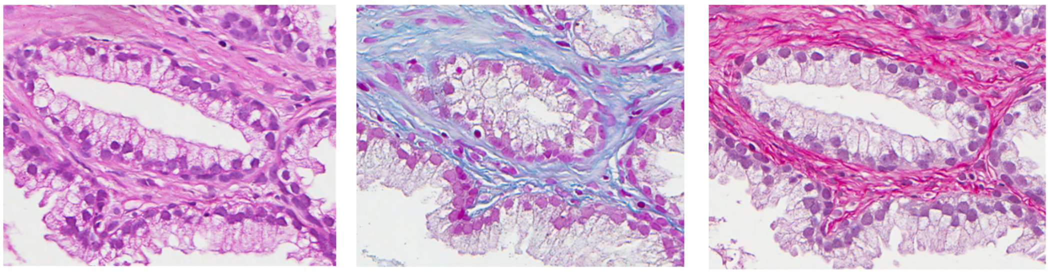


Figure 14: Hematoxylin-eosin (left); Mallory's trichrome (middle); Sirius-hematoxylin (right).

31. **Analysis of Virus Morphology in Electron Microscopy Images**
Ida-Maria Sintorn
Partner: Vironova AB, Stockholm
Funding: VINNMER programme, Swedish Governmental Agency for Innovation Systems
Period: 0801–1207
Abstract: Electron Microscopy allows for studying the shape and morphology of biological particles such as viruses at the nm level. This means for example 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 efficiently identifying and quantifying such structural differences are developed. This Project is related to the Project (33) and a paper about a new texture measure based on a filtering approach of Zernike Moments was presented at ICPR in Tsukuba, in November.

32. **Automated TEM Image Acquisition for Virus Identification**
Gustaf Kylberg, Ida-Maria Sintorn, Ewert Bengtsson, Gunilla Borgefors
Partner: Vironova AB; Delong Instruments, Brno, Czech Republic; Ali Mirazimi, Kjell-Olof Höglund, Centre for Microbiological Preparedness; Swedish Institute for Infectious Disease Control (SMI)
Funding: 2008–2011 Swedish Civil Contingencies Agency (MSB); Swedish Defense Materiel Administration (FMV); Swedish Agency for Innovative Systems (VINNOVA). 2011– Eurostar

project E!6143
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 needs to perform the analysis at the microscope, an often very time consuming task.

The project aim is to develop methods for a multi-scale analysis at the microscope to automatically acquire high magnification focused images of possible virus particles. This is an important step towards automating the virus identification process and thereby creating a rapid, objective, and user independent virus diagnostic system. By introducing the multi-scale approach the search area where high magnification images need to be acquired is estimated to be reduced with more than 99.99%.

Delong Instruments has joined the project. They will develop a novel bench-top low-voltage TEM where the methods for automated acquisition will be incorporated. This work will intensify the development of methods for the automatic acquisition of images including methods for automatic focusing and astigmatism correction.

33. **Identification of Highly Pathogenic Viruses in Transmission Electron Microscopy Images**
Gustaf Kylberg, Ida-Maria Sintorn, Ewert Bengtsson, Gunilla Borgefors
Partner: Vironova AB; Delong Instruments, Brno, Czech Republic; Ali Mirazimi, Kjell-Olof Höglund, Centre for Microbiological Preparedness; Swedish Institute for Infectious Disease Control (SMI)
Funding: 2008–2011 Swedish Civil Contingencies Agency (MSB); Swedish Defense Materiel Administration (FMV); Swedish Agency for Innovative Systems (VINNOVA). 2011– Eurostar project E!6143
Period: 0801–
Abstract: This project aims at automating the virus identification process in high resolution TEM images. This, in combination with Project 32 create a rapid, objective, and user independent virus diagnostic system. The identification task consists of method development for segmenting virus particles with different shapes and sizes and extracting descriptive features of both shape and texture to enable the classification into virus species. A paper describing such a segmentation method was published in Journal of Microscopy in early 2012. Texture features such as variants of Local Binary Patterns are being evaluated on virus textures as well as other texture datasets to get a deeper understanding of the discriminant power of the features under different conditions.

Work on texture features based on Zernike moments was presented at the 21st International Conference on Pattern Recognition (ICPR 2012) in Tsukuba, Japan. Figure 15 shows Zernike moments from order 1 to 6.

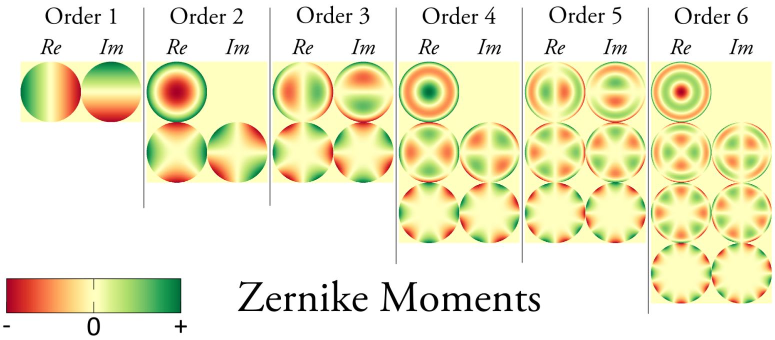


Figure 15: Zernike moments from order 1 to 6.

34. **Analysis of Male Reproductive Tract Morphology in Reproductive Toxicology**
Azadeh Fakhrzadeh, Cris Luengo, Gunilla Borgefors
Partners: Ellinor Spörndly-Nees, Lena Holm, Dept. of Anatomy, Physiology and Biochemistry, SLU
Funding: SLU (KoN)
Period: 1009–
Abstract: Reproductive toxicology is the study of chemicals and their effects on the reproductive system of humans and animals. In reproductive toxicology, there is a strong need to detect structural differences in organs that often have both a complex microscopic structure and function. This problem is further complicated because standard techniques are based on the examination of two-dimensional sections of a three-dimensional structure. The aim of this project is to develop methods to objectively describe microscopic structures of male reproductive organs and to test these in reproductive toxicology research. The project is comparative and includes studies of organs from rooster and mink. We are developing automatic and interactive methods to analyze the relevant structures in the histology images of testis. We have constructed an automatic method to delineate the seminiferous tubule border and lumen. We use a level set based active contour method to delineate the lumen border. Detecting the border of tubules is a challenging problem. The tubules have low contrast borders and they appears broken in some parts. We use a method based on geodistic distance transform to separate the clustered tubules. We compute the evolving curve inside a connected component using the geodesic distance transform. The lumen will serve as initialization for the evolving curve. The length of the curve increases until it reaches the border of object, then it starts to decrease, and as soon as the curve enters another tubule, the length of curve increases again. We will thus have a clear minimum where the tubules connect to each other. The result of segmentation is shown in Figure 16. This is published in DICTA 2012.

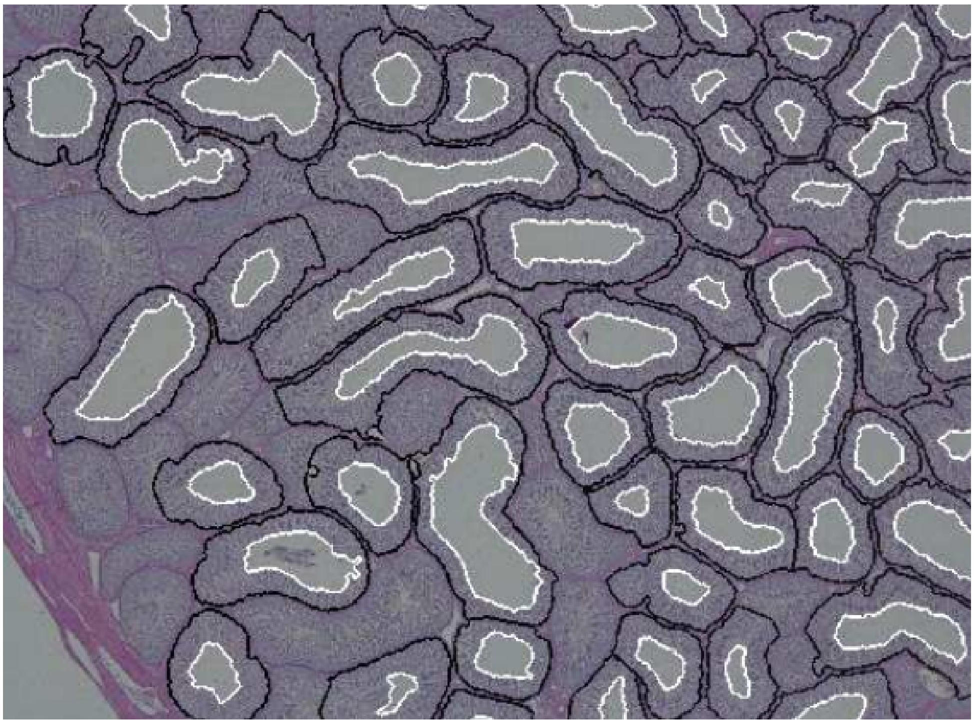


Figure 16: Cross section of the testis, PAS stained. Our algorithm delineates the seminiferous tubules border (in black) and lumen border (in white)

35. **Assessing Bone Implant Integration Using Microscopic and Synchrotron µCT Data**
Hamid Sarve, Gunilla Borgefors
Partners: Carina Johansson, The Sahlgrenska Academy, Göteborg
Funding: 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 and bone reacts on implants, the interface at the implant and tissue must be studied. The aim of this project is to develop automatic image analysis methods for evaluating images of the interface region of tissue and implant. The images come both from traditional light microscopy that gives detailed 2D images and from synchrotron micro-CT (SRµCT) images that gives less detailed but fully 3D images. The project has developed image analysis methods for both modalities separately and for comparing them. We have also developed new techniques for interactive 3D visualization of bone anchored implants in order to facilitate the understanding of the mechanisms of implant integration. The new methods were applied on real clinical data; a case study involving retrieved human oral implants. All methods were collected in the thesis of Sarve, that was presented in 2011. This year, a semi-popular summary was published in Tandläkartidningen, the journal of the Swedish dentists.

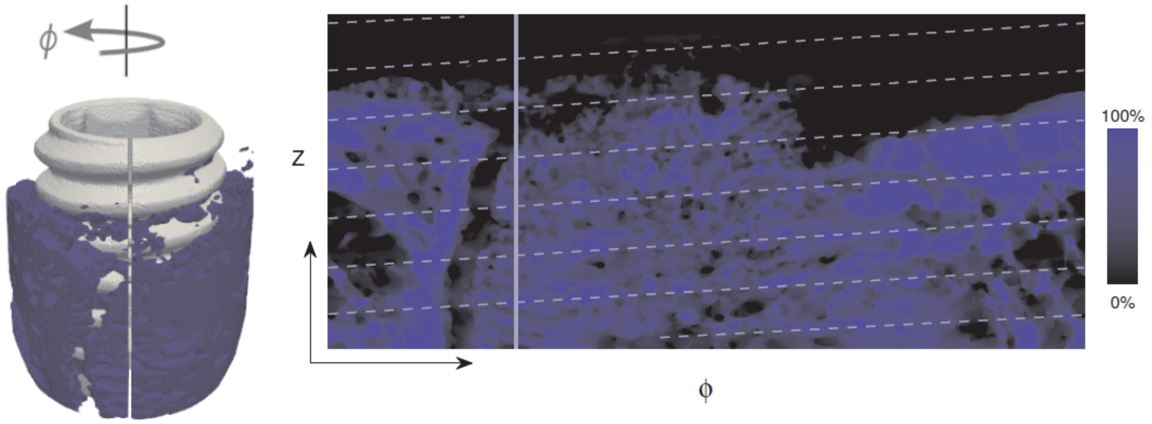


Figure 17: (Left) Rendered surface of the implant with bone tissue volume in the region of interest superimposed. (Right) The unfolded surface, where the blue regions indicate high concentration of bone tissue (see the bar to the right). White dashed lines show the peaks of the threads. The vertical line indicates the corresponding angles in the two images.

5.3 Theory: discrete geometry, volumes and fuzzy methods

36. **The Stochastic Watershed**
Bettina Selig, Cris Luengo, Ida-Maria Sintorn
Funding: S-faculty, SLU
Period: 1102–
Abstract: The stochastic watershed is a method recently presented that builds on the classical seeded watershed algorithm. It creates a probability density function for edges in the image by repeated applications of the seeded watershed with random seeds. We have investigated several ways of overcoming some obvious disadvantages of the method, and found that adding noise to the input image before every application of the seeded watershed greatly improves the properties of the output. We have submitted these results to Pattern Recognition Letters.

37. **Adaptive Mathematical Morphology**
Vladimir Curic, Cris Luengo, Gunilla Borgefors
Partner: Sébastien Lefèvre, VALORIA Research Laboratory in Computer Science, University of South Brittany, Vannes, France; Jesús Angulo, Centre for Mathematical Morphology, Ecole des Mines de Paris - MINES ParisTech, Fontainebleau, France; Anders Landström, Matthew Thurley, Luleå University of Technology, Luleå
Funding: Graduate School in Mathematics and Computing (FMB)
Period: 1101–
Abstract: The construction of adaptive structuring elements that adjust their shape and size to the local structures in the image has recently been a popular topic in mathematical morphology. Despite that several methods for the construction of spatially adaptive structuring elements have been proposed, it is still an open problem, both from a theoretical and implementation point of view.

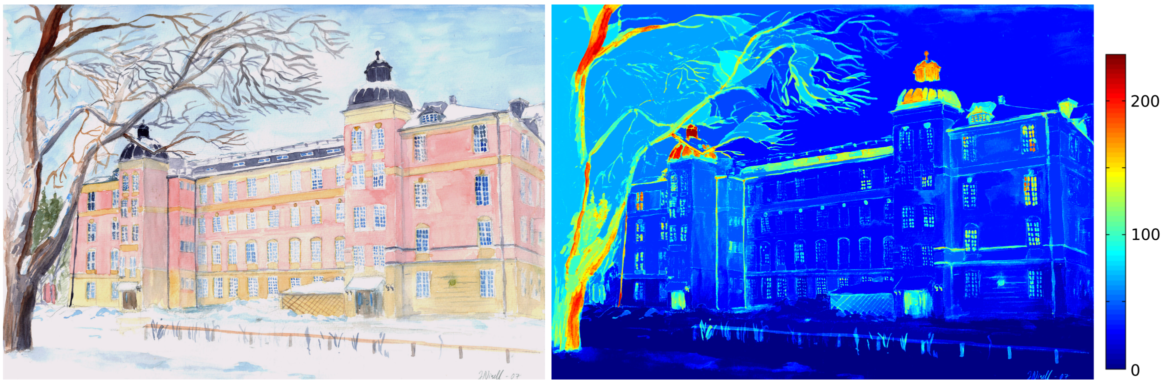
We have proposed salience adaptive structuring elements that modify their shape and size according to the saliency of the edges in the image. We have examined topological properties of salience adaptive structuring elements and investigated their applicability to image filtering. This work has been published in IEEE Journal of Selected Topics in Signal Processing, Special Issue on Filtering and Segmentation With Mathematical Morphology. In addition, we have proposed structuring elements with the adaptive size of structuring elements based on similar type of the salience map as it was used for the construction of the salience adaptive structuring elements. Results of this study were presented at the International Conference on Computer Vision and Graphics (ICCVG'2012). Furthermore, we extended this work to salience-based structuring functions, which is currently under review.

We intend to further develop new methods for adaptive structuring elements as well as to extend the salience adaptive structuring elements toward multi-valued images and sparse image representations. Nonlocal morphological operators and adaptive morphological operators for both discrete and continuous framework are of interest in future studies.

38. **The Minimum Barrier Distance**
Robin Strand, Filip Malmberg, Andreas Kårsnäs
Partner: Punam K. Saha, Dept. of Electrical and Computer Engineering and the Dept. of Radiology, University of Iowa, IA, USA; Krzysztof C. Ciesielski, Dept. of Mathematics, West Virginia University, Morgantown, WV, USA; Dept. of Radiology, MIPG, University of Pennsylvania, PA, USA
Funding: TN-faculty, UU
Period: 1103–

Abstract: In this project, we introduce a distance function on a fuzzy subset that gives the minimum barrier that has to be passed to go from one point to another, see Figure 18. Theoretical properties as well as efficient computational solutions for minimum barrier distance have been developed. An initial application of minimum barrier distance in image segmentation is presented. The experiments show that the minimum barrier distance is robust to noise and blur, and also seed point position, since it captures the total change in membership values across an interface instead of gradient as a measure of slope that is sensitive to noise and blur.

A paper on the theoretical foundation of the minimum barrier distance was written and accepted for publication in Computer Vision and Image Understanding and a paper on the vectorial minimum barrier distance was presented at ICPR'12, see Project 28.



(a) (b)

Figure 18: (a) Original image. (b) Each pixel is set to the minimum barrier distance from a single seed point in (a). The intensity values from (a) are used as weights (i.e., color information is not used).

39. **Geodesic Computations in Sampled Manifolds**

Anders Brun

Partners: Ola Nilsson, Dept. of Science and Technology, Linköping University; Martin Reimers, Centre of Mathematics for Applications, University of Oslo, Norway

Funding: S-faculty, SLU

Period: 0806–

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 2012 a paper on accurate distance computation in anisotropic metrics was accepted and presented at ISVC 2012.

40. **Digital Distance Functions and Distance Transforms**
Robin Strand, Gunilla Borgefors
Partner: Benedek Nagy, Dept. of Computer Science, Faculty of Informatics, University of Debrecen, Hungary; Nicols Normand, IRCCyN, University of Nantes, France
Funding: TN-faculty, UU; S-faculty, SLU
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 allows the size of the neighborhood to vary along the paths. In 2012, Strand visited Normand for a month, and examined the link between integer sequences and distance functions. Also, a paper on distance transform computation by Strand and Normand was published in Theoretical Computer Science.

41. **Skeleton-Based Vascular Segmentation at Interactive Speed**
Kristína Lidayová, Hans Frimmel, Ewert Bengtsson
Partner: Örjan Smedby, Chunliang Wang, Center for Medical Image Science and Visualization (CMIV), Linköping University
Funding: VR grant to Örjan Smedby
Period: 1207–
Abstract: Precise segmentation of vascular structures is crucial for studying the effect of stenoses on arterial blood flow. The goal of this project is to develop and evaluate vascular segmentation, which will be fast enough to permit interactive clinical use. The first part is the extraction of the centerline tree (skeleton) from the gray-scale CT image. Later this skeleton is used as a seed region. The method should offer sub-voxel accuracy.

    The first half year we focused on familiarizing with the software and the previously developed methods for vascular segmentation.

42. **Set Distances and their Application in Image Analysis**
Vladimir Curic, Hamid Sarve, Gunilla Borgefors
Partner: Joakim Lindblad, Nataša Sladoje, Faculty of Technical Sciences, University of Novi Sad, Serbia
Funding: Graduate School in Mathematics and Computing (FMB)
Period: 0908–
Abstract: Methods for measuring distances between sets, which is a measure of how similar the sets are, 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. In this project, we evaluate existing and develop new set distances which are useful in image registration related problems.

    We have proposed a new set distance between crisp sets of points and evaluated its usefulness for rigid body registration of binary images as well as its applicability for the real task of multi-modal 2D-3D registration of 2D histological sections of bone implant with corresponding 3D synchrotron radiation micro computed tomography (SRμCT) bone implant volumes. In addition, it has been shown that this set distance has good performances when applicable to the task of recognition of handwritten characters. This work has been accepted for publication to Pattern Analysis and Applications.

We extended our study to fuzzy objects and proposed four novel point-to-set distances defined for fuzzy or gray-level image data, two based on integration of alpha cuts and two based on the fuzzy distance transform. We further used these point-to-set distances to define distances between fuzzy sets. Theoretical study and performance evaluation of the proposed distances confirm their excellent behaviour in template matching and object classification. New distance measures enable to include and consider both spatial and intensity information, which makes them applicable to texture matching problems as well. The results of our study are submitted to a journal.

43. **Direct Curvature Calculation of Surfaces in 3D Volumes**
Erik Wernersson, Cris Luengo, Anders Brun, Gunilla Borgefors
Funding: S-faculty, SLU
Period: 1009 –
Abstract: Curvature is known as a useful local descriptor of 2D surfaces, embedded in 3D space with applications ranging from visualisation to segmentation. With this project, we aim to find elegant ways to calculate curvature directly from volumetric data which might be flawed with artifacts and noise. No intermediate surface representations are used to ensure stability. The methods will be useful in the analysis of µCT images of composite materials where curvature can be used as a descriptor of several local properties of wood fibres.

5.4 Forestry related applications

44. **Image Analysis of the Internal Structure of Paper and Wood Fibre Based Composite Materials in 3D images**

    Erik Wernersson, Anders Brun, Joakim Lindblad, Cris Luengo, Catherine Östlund, Gunilla Borgefors

    Partners: Norwegian Pulp and Paper Research Institute, Trondheim, Norway; Innventia, Stockholm; Dept. of Engineering Sciences, Applied Mechanics, UU; Dept. of Physics, University of Jyväskylä (UJ), Finland; SINTEF Materials and Chemistry, Norway; University of Novi Sad, Serbia; Svetlana Borodulina, Dept. of Solid Mechanics and BiMaC Innovation Center, KTH

    Funding: S-faculty, SLU; WoodWisdom-Net

    Period: 0406–

    Abstract: The internal structure of paper is important because many of its 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 whereas paper is a complex, three-dimensional (3D) structure.

    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 the interaction between the fibres and the polymer matrix surrounding the fibres.

    Advances in imaging technology have 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 desired measurement of the internal structure is available. Measurements on individual fibres and the structural arrangement of fibres can then be related to macroscopic material properties.

    In this project, different volume images of paper and composite materials are available: 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 Synchrotron Radiation Facility (ESRF) in Grenoble, France, at the Paul Scherrer Institut (PSI) in Villigen, Switzerland and also from tabletop scanners at University of Jyväskylä, Finland and Innventia, Stockholm.

45. **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 Engineering Sciences, Applied Mechanics, UU; 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. It is often hard to do so, when working with natural materials, since no true answer is available. With this project we aim to create highly realistic reference images that can be used to evaluate new and existing methods designed for characterisation of fibrous materials from µCT.

    Within the project, methods have been developed to generate and pack synthetic wood fibres as well as to simulate µCT acquisition systems with characteristic artifacts.

46. **Diffraction Artifact Reduction in µCT Imaging**
Erik Wernersson, Cris Luengo, Anders Brun, Gunilla Borgefors
Partners: Jan Van den Bulcke, Dept. of Forest and Water Management, Ghent University, Belgium; Matthieu Boone, Dept. of Physics and Astronomy, Ghent University, Belgium
Funding: S-faculty, SLU
Period: 1009 –
Abstract: When imaging wood based materials, diffraction causes artifacts especially around sharp edges. In this project, different ways to reduce such artifacts are investigated, especially in already reconstructed images.

47. **Quantification of the Quality of Wood Fibers**
Bettina Selig, Cris Luengo, Gunilla Borgefors
Partners: Stig Bardage, SP Technical Research Institute of Sweden; Geoffrey Daniel, Dept. of Forest Products, SLU
Funding: S-faculty, SLU
Period: 0709–
Abstract: Abnormal wood known as compression wood is present in almost every softwood tree harvested. Compression wood fibers have different mechanical properties and therefore they are considered detrimental for both construction wood and pulp and paper purposes. With a UV-light microscope we can analyze the lignin distribution in wood fiber walls and therewith quantify the quality of the wood fibers. In this project we have developed an automatic method that detects and delineates softwood fibers. Results have been published this year in Journal of Microscopy.

5.5 Other projects

48. **Image Analysis for Landscape Analysis**
Anders Brun
Partners: Bo Malmberg, Michael Nielsen, Dept. of Human Geography, Stockholm University; Anders Wästfelt, Dept. of Economics, SLU
Funding: S-faculty, SLU
Period: 0901–
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 focuses on using texture analysis of images rather than only pixelwise spectral analysis to segment the image into different meaningful regions.

49. **Tracking Honey Bees and Their Interactions**
Cris Luengo
Partners: Olle Terenius, Ingemar Fries, Joachim Rodrigues de Miranda, Eva Forsgren, Barbara Locke, Dept. of Ecology, SLU; Fredrik Liljeros, Dept. of Sociology, Stockholm University
Funding: Åke Wiberg foundation
Period: 1003–
Abstract: In this project, we are creating a system in which we can observe a portion of a bee hive (containing about one thousand individuals, each tagged with a unique identifier on its back) over days or weeks. Bees will be free to enter and exit the hive, and the environment will be set up to be as natural as possible for the bees. The purpose is to observe the natural behaviour of the bees, and record the type and duration of interaction between individuals. In 2012, Ziquan Yu finished his MSc thesis within this project, developing a new tag, and algorithms to track and read those tags. See Figure 19.

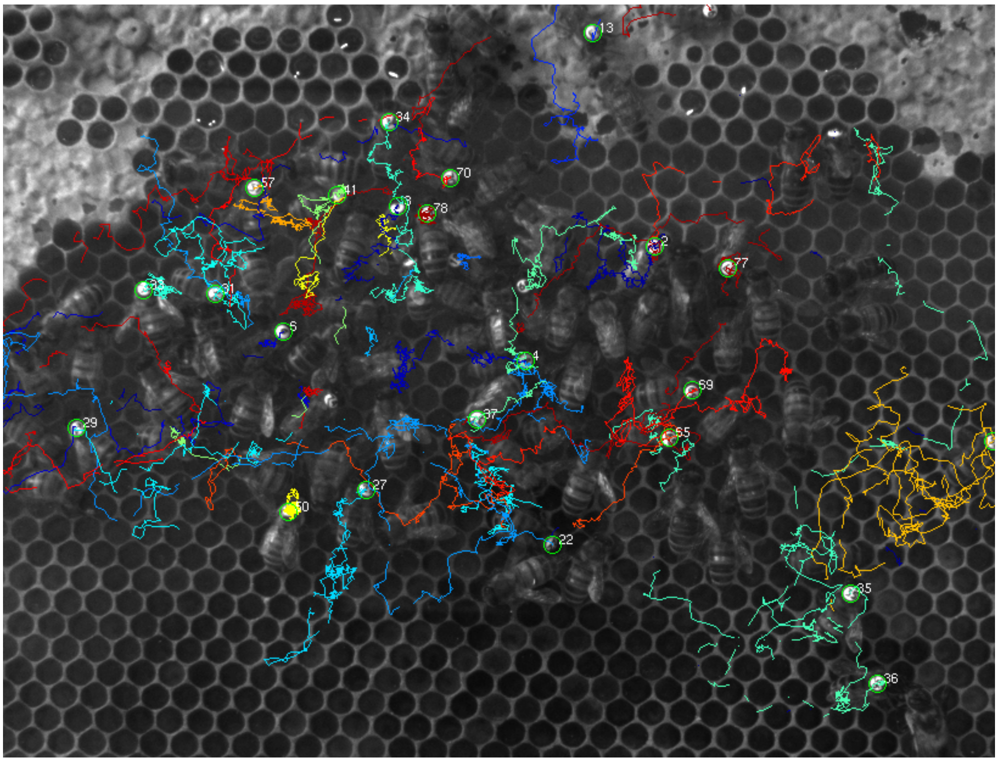


Figure 19: Result of bee tracking.

50. **Optical Character Recognition of Handwritten Texts**
Anders Brun, Ewert Bengtsson, Fredrik Wahlberg
Partners: Lasse Mårtensson, Dept. of Scandinavian Languages, UU; Mats Dahllöf, Dept. of Linguistics and Philology, UU
Funding: Faculty of Languages and Humanities, UU
Period: 1008–
Abstract: Optical character recognition (OCR) is still, after nearly 100 years of research, an active area of research. Currently one of the frontiers is the recognition of handwritten text (HTR), in particular from historical documents. During 2012 a paper on text line segmentation was accepted at ICPR. A grant application for 13.7M SEK was sent to Vetenskapsrådet and it was accepted in late 2012. It will finance three senior researchers working part time, two PhD students and a technical/administrative assistant for four years.

51. **Image Analysis for Grain Quality Assessment**
Cris Luengo
Partners: Lantmännen Lantbruk, Lidköping & Uppsala; Maxx automation AB, Uppsala
Funding: Lantmännen Lantbruk
Period: 1006–
Abstract: In this project we develop novel algorithms and systems to assess the quality of a batch of grain (oats, barley, wheat), based on the Seedscanner 2003 seed sorting robot from Maxx automation AB. We have developed new hardware to modernize the imaging, and have been creating new algorithms to identify various forms of defects that affect seed quality in different ways. In 2012 a second MSc student finished his thesis within this project.

52. **GeoMemories**
Anders Hast
Partners: Salvatore Minutoli, Alessandro Prosperi, Alessandro Lugari, Maurizio Tesconi, Beatrice Rapisarda, Matteo Abrate, Clara Bacciu, Davide Gazzé, Sergio Bianchi, Istituto di Informatica e Telematica (IIT), Pisa, Italy
Abstract: The GeoMemories project is aimed at making publicly available, through web access, heritage preserved in the archives of Aerofototeca Nazionale in Rome, which contains photographs covering the Italian territory from the end of 1800 till modern days. The web application is based on google earth but oriented towards the management of the temporal variable, so that geospatial changes can be monitored over time. The historical aerial photos need to be digitized, illumination corrected, orthorectified, georeferenced and finally stitched together.

    Anders Hast spent one year (2011) at IIT, CNR in Pisa Italy as an ERCIM fellow working with image processing and computer vision aspects in the project. Since returning to Uppsala University in January he is a research associate at IIT, CNR and continues working with the project.

    So far four publications have been published and two others have been submitted for publication. One paper deals with the problem of how to remove uneven illumination in the historical aerial photos that are to be stitched together. Two others describe how to remove false matches in the stitching process in an efficient way. This is something we continue to work with in the project as well as how to improve feature matching in general so it will be possible to match historical photos with modern satellite images in order to perform georeferencing.

    Figure 20 shows the photos from two different flights over Pisa, Italy during WWII, which are automatically stitched together.

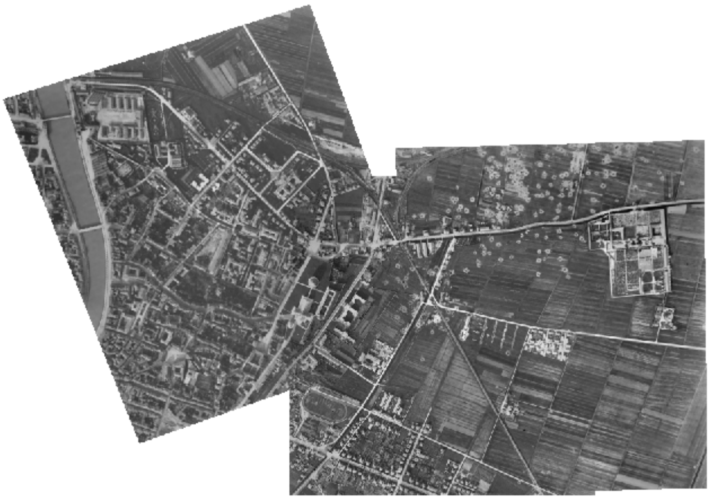


Figure 20: Photos from two different flights over Pisa, Italy during WWII, which are automatically stitched together.

53. **UPPMAX Cluster Computing**
    Martin Simonsson, Carolina Wählby
    Partners: Hans Karlsson, Elias Rudberg, Ola Spjuth, UPPMAX
    Funding: SciLife Lab Uppsala; eSSENCE; Dept. of IT, UU
    Period: 1110-
    Abstract: Life science applications generate a huge amount of image data that has to be stored and analysed in an efficient way. This project is focused on providing easy access to high-performance computers and large-scale storage. In collaboration with Uppsala Multidisciplinary Center for Advanced Computational Science (UPPMAX) image analysis software are being installed and maintained on the cluster. Database solutions with easy web access to image data are also being developed and maintained. This project has also provided workshops and seminars to help life science researchers to get started and use the resources.

54. **DIPimage and DIPlib**
    Cris Luengo
    Partners: Bernd Rieger, Lucas van Vliet, Quantitative Imaging Group, Delft University of Technology, The Netherlands; Michael van Ginkel, Unilever Research and Development, Colworth House, Bedford, UK
    Funding: S-faculty, SLU
    Period: 0807–
    Abstract: DIPimage is a MATLAB toolbox for scientific image analysis, useful for both teaching and research (`http://www.diplib.org`). It has been in active development since 1999, when it was created at Delft University of Technology. In 2008, when Cris Luengo moved to Uppsala, CBA was added to the project as a main development site. DIPlib, created in 1995, is a C library containing many hundreds of image analysis routines. DIPlib is the core of the DIPimage toolbox, and both projects are developed in parallel. Because DIPlib provides efficient algorithms, MATLAB is useful for image analysis beyond the prototyping stage. Together, MATLAB and DIPimage form a powerful tool for working with scalar and vector images in any number of dimensions. The year 2012 saw the release of version 2.4, with several new features including new measurement functionality and faster arithmetic operations.

5.6 Cooperation partners

International

Dept. of Forest and Water Management, Ghent University, Belgium

Dept. of Physics and Astronomy, Ghent University, Belgium

Delong Instruments, Brno, Czech Republic

Dept. Genie Electrique et Electronique, Institut National Polytechnique, Felix Houbhouet-Boigny, Cote d'Ivoire

Clinical Pathology Division, Vejle hospital, Vejle, Denmark

Risø National Laboratory, Technical University of Denmark

Visiopharm, Hørsholm, Denmark

Dept. of Physics, University of Jyväskylä (UJ), Finland

IRCCyN, University of Nantes, France

VALORIA Research Laboratory in Computer Science, University of South Brittany, Vannes, France

Dept. of Computer Science, University of Debrecen, Hungary

Centre for Development of Advanced Computing, Thiruvananthapuram, India

Regional Cancer Centre, Thiruvananthapuram, India

Dept. of ECE, National Institute of Technology (NIT), Tiruchirappalli, India

Istituto di Informatica e Telematica (IIT), Pisa, Italy

Eye Hospital Rotterdam, Netherlands

Quantitative Imaging Group, Delft University of Technology, Netherlands

Department of Molecular Cell Biology, Leiden University Medical Centre, Leiden, The Netherlands

Department of Neurology, Erasmus Medical Center, Rotterdam, The Netherlands

Centre of Mathematics for Applications, University of Oslo, Norway

Norwegian Pulp and Paper Research Institute, Trondheim, Norway

SINTEF Materials and Chemistry, Norway

Faculty of Technical Sciences, University of Novi Sad, Serbia

Unilever Research and Development, Colworth House, Bedford, UK

Wellcome Trust Centre for Mitochondrial Research, Newcastle University, Newcastle upon Tyne, UK

Broad Institute of Harvard and MIT, USA

Dept. of Electrical and Computer Engineering, University of Iowa, IA, USA

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

Dept. of Mathematics, West Virginia University, Morgantown, WV, USA

Research Laboratory of Electronics, Massachusetts Institute of Technology, Cambridge, USA

Center for Human Genetics Research, Vanderbilt University Medical Center, Nashville, Tennessee

National

Dept. of Cell and Molecular Biology, Karolinska Institute
Dept. of Engineering Sciences, UU
Dept. of Genetics and Pathology, UU
Dept. of Immunology, Genetics and Pathology, UU
Dept. of Information Technology, UU
Dept. of Linguistics and Philology, UU
Dept. of Medical Cell Biology, UU
Dept. of Cell and Molecular Biology, UU
Dept. of Plastic- and Maxillofacial Surgery, UU Hospital
Dept. of Orthopedics, UU Hospital
Dept. of Radiology, Oncology and Radiation Science, UU
Dept. of Scandinavian Languages, UU
Dept. of Surgical Sciences, UU
Science for Life Laboratory, Stockholm
Science for Life Laboratory, UU
Division of Microsystems Technology, UU
Dept. of Anatomy, Physiology and Biochemistry, SLU
Dept. of Ecology, SLU
Dept. of Economics, SLU
Dept. of Forest Products, SLU
SP Technical Research Institute of Sweden, Borås
Institute of Odontology, The Sahlgrenska Academy, Göteborg
SenseGraphics AB, Kista
Lantmännen Lantbruk, Lidköping & Uppsala
Dept. of Science and Technology, Linköping University
Center for Medical Image Science and Visualization (CMIV), Linköping University
AstraTech, Mölndal
Centre for Microbiological Preparedness; Swedish Institute for Infectious Disease Control (SMI), Solna
Dept. of Human Geography, Stockholms University
Dept. of Laboratory Medicine, Karolinska Institute, Stockholm
Dept. of Sociology, Stockholm University
Dept. of Solid Mechanics, KTH, Stockholm
Industrial Metrology and Optics Group, KTH, Stockholm
Innventia, Stockholm
Vironova AB, Stockholm
Dept. of Neurophysiology, Umeå University
Dept. of Medical Biosciences, Umeå University
Maxx automation AB, Uppsala
PiezoMotors AB, Uppsala
Technovest AB

Tony Barrera, Uppsala
UPPMAX, UU
The Human Protein Atlas

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 work both on theory and on different applications.

In our research field, the impact factor of some of the conferences is higher than well-reputed journals, so in some cases we prefer 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 aim to produce some popular science articles, but are less successful in this respect. However, we do give a number of such seminars each year.

This list covers all publications with publication date in 2012. We have published 14 journal articles and 20 articles in fully-reviewed international conference proceedings. In addition, we published 14 papers in workshops, non-refereed or abstract refereed conference proceedings, and three other reports. The number of fully reviewed publications from CBA between 2001–2012 is shown in Figure 21.

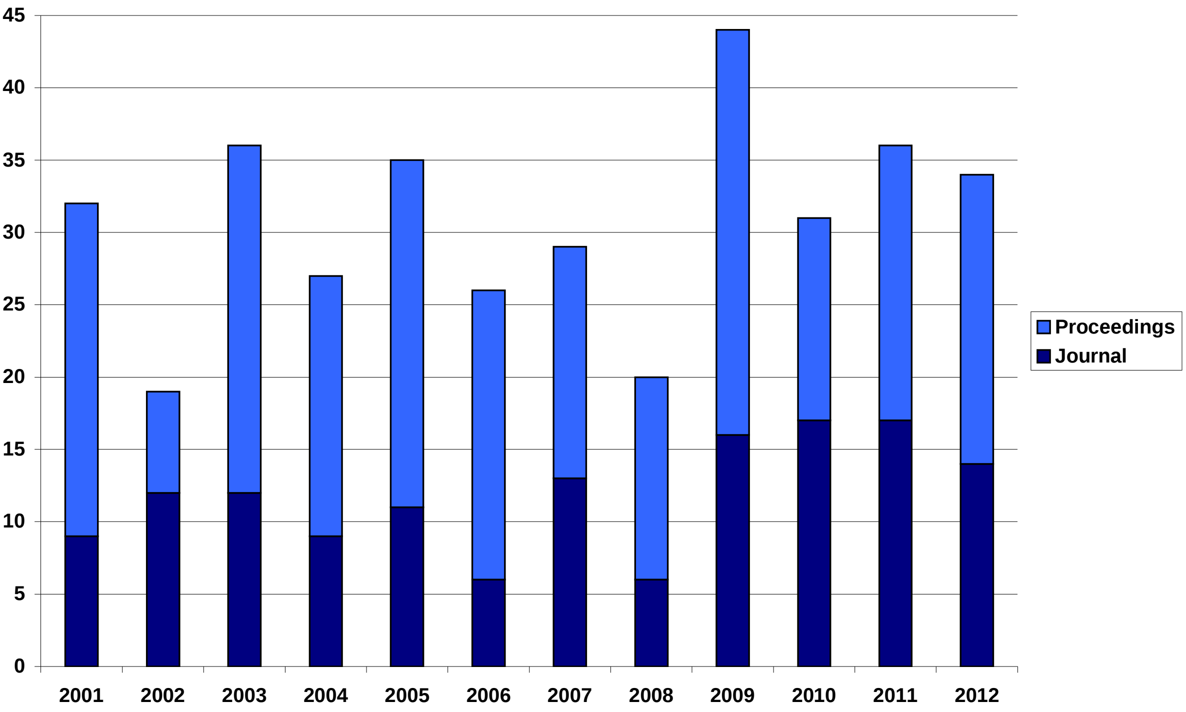


Figure 21: The number of publications from CBA.

6.1 Journal articles

1. **Microarray Detection by Geometric Restoration**
   Authors: **Jimmy Azar**, Christer Busch (1), **Ingrid Carlbom**
   (1) Dept. Immunology, Genetics and Pathology, UU
   Journal: Analytical Cellular Pathology, volume 35, number 5-6, pp 381-393
   Abstract: Whole-slide imaging of tissue microarrays (TMAs) holds the promise of automated image analysis of a large number of histopathological samples from a single slide. This demands high-throughput image processing to enable analysis of these tissue samples for diagnosis of cancer and other conditions. In this paper, we present a completely automated method for the accurate detection and localization of tissue cores that is based on geometric restoration of the core shapes without placing any assumptions on grid geometry. The method relies on hierarchical clustering in conjunction with the Davies-Bouldin index for cluster validation in order to estimate the number of cores in the image where from we estimate the core radius and refine this estimate using morphological granulometry. The final stage of the algorithm reconstructs circular discs from core sections such that these discs cover the entire region of each core regardless of the precise shape of the core. The results show that the proposed method is able to reconstruct core locations without any evidence of localization. Furthermore, the algorithm is more efficient than existing methods based on the Hough transform for circle detection. The algorithm's simplicity, accuracy, and computational efficiency allow for automated high-throughput analysis of microarray images.

2. **Osseointegration Using Image Analysis (Osseointegration med hjälp av Datoriserad Bildanalys, in Swedish)**
   Authors: **Gunilla Borgefors**, **Hamid Sarve**, Carina B. Johansson (1), Bertil Friberg (2)
   (1) Dept. Prosthodontics/Dental Materials Science, University of Gothenburg, Gothenburg
   (2) Brånemarkkliniken, Gothenburg
   Journal: Tandläkartidningen, volume 104, number 12, pp 66-71
   Abstract: Using computerized image processing we can quantify the bone tissue around implants. In addition to quantification methods in both 2D and 3D, we have developed two new 3D visualization methods for the contact between bone and implant.

3. **Fully Automated Cellular-Resolution Vertebrate Screening Platform with Parallel Animal Processing**
   Authors: Tsung-Yao Chang (1), Carlos Pardo-Martin (1), **Amin Allalou** (2), **Carolina Wählby** (2), Mehmet Fatih Yanik (1)
   (1) Research Laboratory of Electronics, Massachusetts Institute of Technology, MA, USA
   (2) SciLifeLab, UU
   Journal: Lab on a Chip, volume 12, Issue 4, pp 711-716
   Abstract: The zebrafish larva is an optically-transparent vertebrate model with complex organs that is widely used to study genetics, developmental biology, and to model various human diseases. In this article, we present a set of novel technologies that significantly increase the throughput and capabilities of our previously described vertebrate automated screening technology (VAST). We developed a robust multi-thread system that can simultaneously process multiple animals. System throughput is limited only by the image acquisition speed rather than by the fluidic or mechanical processes. We developed image recognition algorithms that fully automate manipulation of animals, including orienting and positioning regions of interest within the microscope's field of view. We also identified the optimal capillary materials for high-resolution, distortion-free, low-background imaging of zebrafish larvae.

4. **Salience Adaptive Structuring Elements**
   Authors: **Vladimir Curic**, **Cris L. Luengo Hendriks**, **Gunilla Borgefors**
   Journal: IEEE Journal on Selected Topics in Signal Processing, volume 6, number 7, pp 809-819
   Abstract: Spatially adaptive structuring elements adjust their shape to the local structures in the image, and are often defined by a ball in a geodesic distance or gray-weighted distance metric space. This paper introduces salience adaptive structuring elements as spatially variant structuring elements that modify not only their shape, but also their size according to the salience of the edges in the image. Morphological operators with salience adaptive structuring elements shift edges with high salience to a less extent than those with low salience. Salience adaptive structuring elements are less flexible than morphological amoebas and their shape is less affected by noise in the image. Consequently, morphological operators using salience adaptive structuring elements have better properties.

5. **Pharmacological Characterization of 18F-labeled Vorozole Analogs**
   Authors: Håkan Hall (1), Kayo Takahashi(2), Maria Erlandsson (3,4), Sergio Estrada (1), **Pasha Razifar** (5), Elisabeth Bergström (6), Bengt Långström(4)
   (1) Dept. of Medicinal Chemistry, Preclinical PET Platform, UU
   (2) RIKEN Center for Molecular Imaging Science, Kobe, Japan
   (3) Dept. of Clinical Physiology, Nuclear Medicine & PET and Cluster for Molecular Imaging Rigshospitalet, University of Copenhagen, Copenhagen, Denmark
   (4) Dept. of Biochemistry and Organic Chemistry, UU
   (5) RM-Medic-Tech AB, Uppsala
   (6) Uppsala Imanet, Uppsala
   Journal: Journal of labelled compounds & radiopharmaceuticals, volume 55, number 14, pp 484-490
   Abstract: Two 18F-labeled analogs of vorozole ([18F]FVOZ and [18F]FVOO) have been developed as potential tools for the in vivo characterization of aromatase. The pharmacological properties of these radioligands were evaluated using in vitro binding and in vivo distribution studies in the rat and primate. Saturation binding studies using rat ovary gave KD and Bmax values of $0.21 \pm 0.1 nM$ and $210 \pm 20 fmol/mg$, respectively, for [18F]FVOZ, and $7.6 \pm 1 nM$ and $293 \pm 12 fmol/mg$, respectively, for [18F]FVOO. Organ distribution studies in rats showed the highest accumulation in the adrenal glands, with standardized uptake values (SUVs) of 15 to 20, followed by ovaries and liver with SUVs of approximately 5. Ex vivo and in vitro autoradiography of the rat brain showed specific binding of both [18F]FVOZ and [18F]FVOO mainly in the amygdala. Positron emission tomography (PET) studies were performed in the Rhesus monkey, and these showed displaceable binding in the amygdala and the hypothalamus preoptic area. The PET images were also analyzed using masked volume-wise principal component analysis. These studies suggest that [18F]FVOZ might be a suitable tracer for the study of aromatase in vitro and in vivo, and could be an alternative to [11C]vorozole in human PET studies.

6. **Learning Histopathological Patterns**
   Authors: **Andreas Kårsnäs**, Anders L. Dahl(1), Rasmus Larsen(1)
   (1) Technical University of Denmark, Department of Informatics and Mathematical Modelling, Technical University of Denmark, Copenhagen, Denmark
   Journal: Journal of Pathology Informatics, number 2:12
   Abstract: Aims: The aim was to demonstrate a method for automated image analysis of immunohistochemically stained tissue samples for extracting features that correlate with patient disease. We address the problem of quantifying tumor tissue and segmenting and counting cell nuclei. Materials and Methods: Our method utilizes a flexible segmentation method based on sparse coding trained from representative image samples. Nuclei counting is based on a nucleus model that takes size, shape, and nucleus probability into account. Nuclei clustering and overlays are resolved using a gray-weighted distance transform. We obtain a probability measure for pixels belonging to a nucleus from our segmentation procedure. Experiments are carried out on two sets of immunohistochemically stained images - one set based on the estrogen receptor (ER) and the other on antigen KI-67. For the nuclei separation we have selected 207 ER image samples from 58 tissue micro array-cores corresponding to 58 patients and 136 KI-67 image samples also from 58 cores. The images are hand-annotated by marking the center position of each nucleus. For the ER data we have a total of 1006 nuclei and for the KI-67 we have 796 nuclei. Segmentation performance was evaluated in terms of missing nuclei, falsely detected nuclei, and multiple detections. The proposed method is compared to state-of-the-art Bayesian classification. Statistical analysis used: The performance of the proposed method and a state-of-the-art algorithm including variations thereof is compared using the Wilcoxon rank sum test. Results: For both the ER experiment and the KI-67 experiment the proposed method exhibits lower error rates than the state-of-the-art method. Total error rates were 4.8 % and 7.7 % in the two experiments, corresponding to an average of 0.23 and 0.45 errors per image, respectively. The Wilcoxon rank sum tests show statistically significant improvements over the state-of-the-art method. Conclusions: We have demonstrated a method and obtained good performance compared to state-of-the-art nuclei separation. The segmentation procedure is simple, highly flexible, and we demonstrate how it, in addition to the nuclei separation, can perform precise segmentation of cancerous tissue. The complexity of the segmentation procedure is linear in the image size and the nuclei separation is linear in the number of nuclei. Additionally the method can be parallelized to obtain high-speed computations.

7. **Segmentation of Virus Particle Candidates in Transmission Electron Microscopy Images**
   Authors: **Gustaf Kylberg**, Mats Uppström (1), and **Ida-Maria Sintorn**
   (1) Vironova AB, Stockholm
   Journal: Journal of Microscopy, volume 245, Issue 2, pages 140-147
   Abstract: In this paper, we present an automatic segmentation method that detects virus particles of various shapes in transmission electron microscopy images. The method is based on a statistical analysis of local neighbourhoods of all the pixels in the image followed by an object width discrimination and finally, for elongated objects, a border refinement step. It requires only one input parameter, the approximate width of the virus particles searched for. The proposed method is evaluated on a large number of viruses. It successfully segments viruses regardless of shape, from polyhedral to highly pleomorphic.

8. **Automatic Measurement of Compression Wood Cell Attributes in Fluorescence Microscopy Images**
   Authors: **Bettina Selig**, **Cris L. Luengo Hendriks**, Stig Bardage (1), Geoffrey Daniel (2), **Gunilla Borgefors**
   (1) SP Technical Research Institute of Sweden, SP Trätek, Stockholm
   (2) Dept. of Wood Science, SLU, Uppsala
   Journal: Journal of Microscopy, volume 246, number 3, pp 298-308
   Abstract: This paper presents a new automated method for analyzing compression wood fibers in fluorescence microscopy. Abnormal wood known as compression wood is present in almost every softwood tree harvested. Compression wood fibers show a different cell wall morphology and chemistry compared to normal wood fibers, and their mechanical and physical characteristics are considered detrimental for both construction wood and pulp and paper purposes. Currently there is the need for improved methodologies for characterization of lignin distribution in wood cell walls, such as from compression wood fibers, that will allow for a better understanding of fiber mechanical properties. Traditionally, analysis of fluorescence microscopy images of fiber cross-sections has been done manually, which is time consuming and subjective. Here, we present an automatic method, using digital image analysis, that detects and delineates softwood fibers in fluorescence microscopy images, dividing them into cell lumen, normal and highly lignified areas. It also quantifies the different areas, as well as measures cell wall thickness. The method is evaluated by comparing the automatic with a manual delineation. While the boundaries between the various fiber wall regions are detected using the automatic method with precision similar to inter and intra expert variability, the position of the boundary between lumen and the cell wall has a systematic shift that can be corrected. Our method allows for transverse structural characterization of compression wood fibers, which may allow for improved understanding of the micro-mechanical modeling of wood and pulp fibers.

9. **Coverage Segmentation Based on Linear Unmixing and Minimization of Perimeter and Boundary Thickness**
   Authors: **Joakim Lindblad** (1), Nataša Sladoje (1)
   (1) Faculty of Technical Sciences, University of Novi Sad, Serbia
   Journal: Pattern Recognition Letters, volume 33, number 6, pp 728-738
   Abstract: We present a method for coverage segmentation, where the, possibly partial, coverage of each image element by each of the image components is estimated. The method combines intensity information with spatial smoothness criteria. A model for linear unmixing of image intensities is enhanced by introducing two additional conditions: (i) minimization of object perimeter, leading to smooth object boundaries, and (ii) minimization of the thickness of the fuzzy object boundary, and to some extent overall image fuzziness, to respond to a natural assumption that imaged objects are crisp, and that fuzziness is mainly due to the imaging and digitization process. The segmentation is formulated as an optimization problem and solved by the Spectral Projected Gradient method. This fast, deterministic optimization method enables practical applicability of the proposed segmentation method. Evaluation on both synthetic and real images confirms very good performance of the algorithm.

10. **Distance Transform Computation for Digital Distance Functions**
Authors: **Robin Strand**, Nicolas Normand (1)
(1) LUNAM Université, Université de Nantes, Nantes, France
Journal: Theoretical Computer Science,volume 448, pp 80-93
Abstract: In image processing, the distance transform (DT), in which each object grid point is assigned the distance to the closest background grid point, is a powerful and often used tool. In this paper, distance functions defined as minimal cost-paths are used and a number of algorithms that can be used to compute the DT are presented. We give proofs of the correctness of the algorithms.

11. **A Non-destructive X-ray Microtomography Approach for Measuring Fibre Length in Short-fibre Composites**
Authors: Arttu Miettinen (1), **Cris L. Luengo Hendriks**, Gary Chinga-Carrasco (2), E. Kristofer Gamstedt (3), Markku Kataja (1)
(1) Dept. of Physics, University of Jyväskylä, Finland
(2) Paper and Fibre Research Institute, Trondheim, Norway
(3) Dept. of Engineer Sciences, UU
Journal: Composites Science And Technology, volume 72, number 15, pp 1901-1908
Abstract: An improved method based on X-ray microtomography is developed for estimating fibre length distribution of short-fibre composite materials. In particular, a new method is proposed for correcting the biasing effects caused by the finite sample size as defined by the limited field of view of the tomographic devices. The method is first tested for computer generated fibre data and then applied in analyzing the fibre length distribution in three different types of wood fibre reinforced composite materials. The results were compared with those obtained by an independent method based on manual registration of fibres in images from a light microscope. The method can be applied in quality control and in verifying the effects of processing parameters on the fibre length and on the relevant mechanical properties of short fibre composite materials, e.g. stiffness, strength and fracture toughness.

12. **Non-Random mtDNA Segregation Patterns Indicate a Metastable Heteroplasmic Segregation Unit in m.3243A>G Cybrid Cells**
Authors: Anton K. Raap (1), Roshan S. Jahangir Tafrechi (1), Frans M. van de Rijke (1), Angela Pyle (2), **Carolina Wählby** (3), Karoly Szuhai (1), Raimond B. G. Ravelli (1), René F. M. de Coo (4), Harsha K. Rajasimha (5), Mats Nilsson (6), Patrick F. Chinnery (2), David C. Samuels (5), George M. C. Janssen (1)
(1) Dept. of Molecular Cell Biology, Leiden University Medical Centre, Leiden, The Netherlands
(2) Wellcome Trust Centre for Mitochondrial Research, Newcastle University, Newcastle upon Tyne, United Kingdom
(3) Imaging Platform, Broad Institute of MIT and Harvard, Cambridge, MA, USA
(4) Dept of Neurology, Erasmus Medical Center, Rotterdam, The Netherlands
(5) Center for Human Genetics Research, Vanderbilt University Medical Center, Nashville, Tennessee, USA
(6) Dept. of Immunology, Genetics and Pathology, UU
Journal: PLoS ONE, volume 7, number 12, pp e52080
Abstract: Many pathogenic mitochondrial DNA mutations are heteroplasmic, with a mixture of mutated and wild-type mtDNA present within individual cells. The severity and extent of the clinical phenotype is largely due to the distribution of mutated molecules between cells in different tissues, but mechanisms underpinning segregation are not fully understood. To facilitate mtDNA segregation studies we developed assays that measure m.3243A>G point mutation loads directly in hundreds of individual cells to determine the mechanisms of segregation over time. In the first study of this size, we observed a number of discrete shifts in cellular heteroplasmy between periods of stable heteroplasmy. The observed patterns could not be parsimoniously explained by random mitotic drift of individual mtDNAs. Instead, a genetically metastable, heteroplasmic mtDNA segregation unit provides the likely explanation, where stable heteroplasmy is maintained through the faithful replication of segregating units with a fixed wild-type/m.3243A¿G mutant ratio, and shifts occur through the temporary disruption and re-organization of the segregation units. While the nature of the physical equivalent of the segregation unit remains uncertain, the factors regulating its organization are of major importance for the pathogenesis of mtDNA diseases.

13. **Visualising Individual Sequence-specific Protein-DNA Interactions in situ**
Authors: Irene Weibrecht (1,2), **Milan Gavrilovic** (2), Lena Lindbom (1,2), Ulf Landegren (1,2), **Carolina Wählby** (2), Ola Söderberg (1,2)
(1) Dept. of Immunology, Genetics and Pathology, UU
(2) SciLifeLab, UU
Journal: New Biotechnology, volume 29, number 5, pp 589-598
Abstract: Gene expression-a key feature for modulating cell fate-is regulated in part by histone modifications, which modulate accessibility of the chromatin to transcription factors. Until now, protein-DNA interactions (PDIs) have mostly been studied in bulk without retrieving spatial information from the sample or with poor sequence resolution. New tools are needed to reveal proteins interacting with specific DNA sequences in situ for further understanding of the orchestration of transcriptional control within the nucleus. We present herein an approach to visualise individual PDIs within cells, based on the in situ proximity ligation assay (PLA). This assay, previously used for the detection of protein-protein interactions in situ, was adapted for analysis of target PDIs, using padlock probes to identify unique DNA sequences in complex genomes. As a proof-of-principle we detected histone H3 interacting with a 26bp consensus sequence of the Alu-repeat abundantly expressed in the human genome, but absent in mice. However, the mouse genome contains a highly similar sequence, providing a model system to analyse the selectivity of the developed methods. Although efficiency of detection currently is limiting, we conclude that in situ PLA can be used to achieve a highly selective analysis of PDIs in single cells.

14. **An Image Analysis Toolbox for High-throughput C. Elegans Assays**
Authors: **Carolina Wählby** (1,2), Lee Kamentsky (2), Zihan H. Liu (2), Tammy Riklin-Raviv (3), Annie L. Conery (4), Eyleen O'Rourke (4), Katherine Sokolnicki (2), Orane Visvikis (5), Vebjorn Ljosa (2), Javier E. Irazoqui (5), Polina Golland (3), Gary Ruvkun (4), Frederick M. Ausubel (4), Anne E. Carpenter (2)
(1) SciLifeLab, UU
(2) Imaging Platform, Broad Institute of MIT and Harvard, Cambridge, MA, USA
(3) Computer Science and Artificial Intelligence Laboratory, MIT, Cambridge, MA, USA
(4) Dept. of Molecular Biology and Center for Computational and Integrative Biology, Mass. General Hospital, Boston, MA, USA
(5) Developmental Immunology Program, Dept of Pediatrics, Mass. General Hospital, Boston, MA, USA
Journal: Nature Methods, volume 9, number 7, pp 714-716
Abstract: We present a toolbox for high-throughput screening of image-based Caenorhabditis elegans phenotypes. The image analysis algorithms measure morphological phenotypes in individual worms and are effective for a variety of assays and imaging systems from different laboratories. The toolbox is available via the open-source CellProfiler project and enables objective scoring of whole-animal high-throughput image-based assays using this unique model organism for the study of diverse biological pathways relevant to human disease.

6.2 Refereed conference proceedings

1. **Histological Stain Evaluation for Machine Learning Applications**
   Authors: **Jimmy Azar**, Christer Busch (1), **Ingrid Carlbom**
   (1) Dept. Immunology, Genetics and Pathology
   Conference: Workshop on: Histopathology Image Analysis (HIMA), 15th International Conference on Medical Image Computing and Computer Assisted Intervention (MICCAI), Nice, France
   Publisher: Journal of Pathology Informatics
   Editors: Anant Madabhushi, Metin Gurcan, Nasir Rajpoot
   Abstract: Machine learning and image analysis are increasingly important in pathology applications, such as for automatic analysis of histological tissue samples. Pathologists rely on multiple, contrasting stains to analyze tissue samples, but histological stains were developed for visual analysis and are not always ideal for automatic analysis. We present a methodology for evaluating histological stains in terms of their classification and clustering efficacy with the aim of improving segmentation and color decomposition. We evaluate the stains for both supervised and unsupervised classification of stain/tissue combinations. For supervised classification we measure the nonlinear support vector machines error rate and for unsupervised classification we use the Rand index and the F-measure to assess the clustering results of a Gaussian mixture model based on expectation-maximization. Finally we investigate class separability measures based on scatter criteria. We demonstrate that for a specific tissue type the same stains perform best according to all measures.

2. **Automated Classification of Immunostaining Patterns in Breast Tissue from the Human Protein Atlas**
   Authors: **Swamidoss Issac Niwas**, **Andreas Kårsnäs**, Virginie Uhlmann (2,3), P. Palanisamy (4), Caroline Kampf (5), **Martin Simonsson** (1), **Carolina Wählby** (1), **Robin Strand**
   (1) SciLifeLab, UU
   (2) Imaging Platform, Broad Institute of Harvard and MIT, Cambridge, Massachusetts MA, USA
   (3) Biomedical Imaging Group, École Polytechnique Fédérale de Lausanne (EPFL), Switzerland
   (4) Dept. of Electronics and Communication Engineering (ECE), National Institute of Technology (NIT), Tiruchirappalli, India
   (5) Dept. of Immunology, Genetics and Pathology,UU
   Conference: Workshop on: Histopathology Image Analysis (HIMA), 15th International Conference on Medical Image Computing and Computer Assisted Intervention (MICCAI), Nice, France
   Abstract: Background: The Human Protein Atlas (HPA) is an effort to map the location of all human proteins (http://www.proteinatlas.org/). It contains a large number of histological images of sections from human tissue. Tissue micro arrays are imaged by a slide scanning microscope, and each image represents a thin slice of a tissue core with a dark brown antibody specific stain and a blue counter stain. When generating antibodies for protein profiling of the human proteome, an important step in the quality control is to compare staining patterns of different antibodies directed towards the same protein. This comparison is an ultimate control that the antibody recognizes the right protein. In this paper, we propose and evaluate different approaches for classifying sub-cellular antibody staining patterns in breast tissue samples.

   Methods and Material: The proposed methods include the computation of various features including gray level co-occurrence matrix (GLCM) features, complex wavelet co-occurrence matrix (CWCM) features and WND-CHARM-inspired features. The extracted features are used into two different multivariate classifiers (SVM and LDA classifier). Before extracting features, we use color deconvolution to separate different tissue components, such as the brownly stained positive regions and the blue cellular regions, in the immunostained TMA images of breast tissue.

   Results: Good results have been obtained by using the combinations of GLCM and wavelets and texture features, edge features, histograms, transforms, etc. (WND-CHARM). The proposed complex wavelet features and the WND-CHARM features have accuracy similar to that of a human expert.

   Conclusions: Both human experts and the proposed automated methods have difficulties discriminating between nuclear and cytoplasmic staining patterns. This is to a large extent due to mixed staining of nucleus and cytoplasm. Methods for quantification of staining patterns in histopathology have many applications, ranging from antibody quality control to tumour grading.

3. **Smart Paint – A New Interactive Segmentation Method Applied to MR Prostate Segmentation**
   Authors: **Filip Malmberg**, **Robin Strand**, Joel Kullberg (1), Richard Nordenskjöld (1), **Ewert Bengtsson**
   (1) Dept. of Radiology, Oncology and Radiation Science, UU
   Conference: Workshop on: Prostate MR Image Segmentation Grand Challenge (PROMISE'12), 15th International Conference on Medical Image Computing and Computer Assisted Intervention (MICCAI), Nice, France
   Abstract: This paper describes a general method for interactive segmentation, Smart Paint. The user interaction is inspired by the way an airbrush is used, objects are segmented by ”sweeping” with the mouse cursor in the image. The user adds or removes details in 3D by the proposed segmentation tool and the user interface shows the segmentation result in 2D slices through the object. We use the novel method for prostate segmentation in transversal T2-weighted MR images from multiple centers and vendors and with differences in scanning protocol.

   The method was evaluated on the training set obtained from http://promise12.grand-challenge.org. In the first round, all 50 volumes were segmented and the mean of Dice's coefficient was 0.82 with standard deviation 0.09. In a second round, the first 30 volumes were re-segmented by the same user and the result was slightly improved – Dice's coefficient 0.86 ± 0.05 was obtained. For the training data, the mean time to segment a volume was 3 minutes and 30 seconds.

   The proposed method is a generic tool for interactive image segmentation and this paper illustrates that it is well-suited for prostate segmentation.

4. **Cluster Detection in Cytology Images Using the Cellgraph Method**
   Authors: P. S. Chandran, N. B. Byju, R. U. Deepak, R. Kumar Rajesh, S. Sudhamony, **Patrik Malm**, **Ewert Bengtsson**
   Conference: International Symposium on Information Technology in Medicine and Education (ITME), Hokodate, Hokkaido, Japan, number 2, pp 923-927
   Abstract: Automated cervical cancer detection system is primarily based on delineating the cell nuclei and analyzing their textural and morphometric features for malignant characteristics. The presence of cell clusters in the slides have diagnostic value, since malignant cells have a greater tendency to stick together forming clusters than normal cells. However, cell clusters pose difficulty in delineating nucleus and extracting features reliably for malignancy detection in comparison to free lying cells. LBC slide preparation techniques remove biological artifacts and clustering to some extent but not completely. Hence cluster detection in automated cervical cancer screening becomes significant. In this work, a graph theoretical technique is adopted which can identify and compute quantitative metrics for this purpose. This method constructs a cell graph of the image in accordance with the Waxman model, using the positional coordinates of cells. The computed graph metrics from the cell graphs are used as the feature set for the classifier to deal with cell clusters. It is a preliminary exploration of using the topological analysis of the cellgraph to cytological images and the accuracy of classification using SVM showed that the results are well suited for cluster detection.

5. **Adaptive Structuring Elements Based on Salience Information**
   Authors: **Vladimir Curic**, **Cris L. Luengo Hendriks**
   Conference: International Conference on Computer Vision and Graphics (ICCVG), Warsaw, Poland, volume 7594 of Lecture Notes in Computer Science, pp 321-328
   Publisher: Springer Berlin/Heidelberg
   Editors: L. Bolc, K. Wojciechowski, R. Tadeusiewicz, L.J. Chmielewski
   Abstract: Adaptive structuring elements modify their shape and size according to the image content and may outperform fixed structuring elements. Without any restrictions, they suffer from a high computational complexity, which is often higher than linear with respect to the number of pixels in the image. This paper introduces adaptive structuring elements that have predefined shape, but where the size is adjusted to the local image structures. The size of adaptive structuring elements is determined by the salience map that corresponds to the salience of the edges in the image, which can be computed in linear time. We illustrate the difference between the new adaptive structuring elements and morphological amoebas. As an example of its usefulness, we show how the new adaptive morphological operations can isolate the text in historical documents.

6. **Towards User-Guided Quantitative Evaluation of Wrist Fractures in CT Images**
   Authors: **Johan Nysjö**, Albert Christersson (1), **Filip Malmberg**, **Ida-Maria Sintorn**, **Ingela Nyström**
   (1) Dept. of Surgical Sciences, UU
   Conference: International Conference on Computer Vision and Graphics (ICCVG), Warsaw, Poland, volume 7594 of Lecture Notes in Computer Science, pp 204-2011
   Publisher: Springer Berlin/Heidelberg
   Editors: L. Bolc, R. Tadeusiewicz, L.J. Chmielewski, K. Wojciechowski
   Abstract: The wrist is the most common location for long-bone fractures in humans. To evaluate the healing process of such fractures, it is of interest to measure the fracture displacement, particularly the angle between the joint line and the long axis of the fractured long bone. We propose to measure this angle in 3D computed tomography (CT) images of fractured wrists. As a first step towards this goal, we here present a fast and precise semi-automatic method for determining the long axis of the radius bone in CT images. To facilitate user interaction in 3D, we utilize stereo graphics, head tracking, 3D input, and haptic feedback.
7. **An Efficient Preconditioner and a Modified RANSAC for Fast and Robust Feature Matching**
   Authors: **Anders Hast**, Andrea Marchetti (1)
   (1) CNR, Institute of Informatics and Telematics, Pisa, Italy
   Conference: International Conferences in Central Europe on Computer Graphics, Visualization and Computer Vision (WSCG'12), Communcations Paper, pp 11-18
   Abstract: Standard RANSAC does not perform very well for contaminated sets, when there is a majority of outliers. We present a method that overcomes this problem by transforming the problem into a 2D position vector space, where an ordinary cluster algorithm can be used to find a set of putative inliers. This set can then easily be handled by a modified version of RANSAC that draws samples from this set only and scores using the entire set. This approach works well for moderate differences in scale and rotation. For contaminated sets the increase in performance is in several orders of magnitude. We present results from testing the algorithm using the Direct Linear Transformation on aerial images and photographs used for panographs.
8. **Putative Match Analysis : A Repeatable Alternative to RANSAC for Matching of Aerial Images**
   Authors: **Anders Hast**, Andrea Marchetti (1)
   (1) Institute of Informatics and Telematics, Pisa, Italy
   Conference: International Conference on Computer Vision Theory and Applications (VISAPP), Rome, Italy, Volume 2, pp 341-344
   Publisher: SciTePress
   Editors: Gabriela Csurka, José Braz
   Abstract: One disadvantage with RANSAC is that it is based on randomness and will therefore often yield a different set of inliers in each run, especially if the dataset contains a large number of outliers. A repeatable algorithm for finding both matches and the homography is proposed, which in our case is used for image stitching and the obtained points are also used for georeferencing. This algorithm will yield the same set of matches every time and is therefore a useful tool when trying to evaluate other algorithms involved and their parameters. Moreover a refining step is proposed that finds the best matches depending on what geometric transformation is used, which also can be utilized as a refining step for RANSAC.
9. **Rigid Template Registration in MET Images Using CUDA**
   Authors: **Lennart Svensson**, **Johan Nysjö**, **Anders Brun**, **Ingela Nyström**, **Ida-Maria Sintorn**
   Conference: International Conference on Computer Vision Theory and Applications (VISAPP), Rome, Italy, Volume 2, pp 418-422
   Publisher: SciTePress
   Editors: Gabriela Csurka, José Braz
   Abstract: Rigid registration is a basic tool in many applications, especially in Molecular Electron Tomography (MET), and also in, e.g., registration of rigid implants in medical images and as initialization for deformable registration. As MET volumes have a low signal to noise ratio, a complete search of the six-dimensional (6D) parameter space is often employed. In this paper, we describe how rigid registration with normalized cross-correlation can be implemented on the GPU using NVIDIA's parallel computing architecture CUDA. We compare the performance to the Colores software and two Matlab implementations, one of which is using the GPU accelerated JACKET library. With well-aligned padding and using CUDA, the performance increases by an order of a magnitude, making it feasible to work with three-dimensional fitness landscapes, here denoted scoring volumes, that are generated on the fly. This will eventually enable the biologists to interactively register macromolecule chains in MET volumes piece by piece.

10. **A Novel Algorithm for Computing Riemannian Geodesic Distance in Rectangular 2D Grids**
Authors: Ola Nilsson (1), Martin Reimers, Ken Museth, **Anders Brun**
(1) Dept. of Science and Technology, Linköping University
(2) Dept. of Informatics, University of Oslo, Norway
Conference: Advances in Visual Computing : 8th International Symposium (ISVC), Rethymnon, Crete, Greece, Revised Selected Papers, Part II, volume 7432 of Lecture Notes in Computer Science, pp 265-274
Publisher: Springer
Abstract: We present a novel way to efficiently compute Riemannian geodesic distance over a two-dimensional domain. It is based on a previ- ously presented method for computation of geodesic distances on surface meshes. Our method is adapted for rectangular grids, equipped with a variable anisotropic metric tensor. Processing and visualization of such tensor fields is common in certain applications, for instance structure ten- sor fields in image analysis and diffusion tensor fields in medical imaging. The included benchmark study shows that our method provides signif- icantly better results in anisotropic regions and is faster than current stat-of-the-art solvers. Additionally, our method is straightforward to code; the test implementation is less than 150 lines of C++ code.

11. **Rendering Stiffness with a Prototype Haptic Glove Actuated by an Integrated Piezoelectric Motor**
Authors: **Pontus Olsson**, Stefan Johansson (1), **Fredrik Nysjö**, **Ingrid Carlbom**
(1) Dept. of Engineering Sciences UU
Conference: Haptics: Perception, Devices, Mobility, and Communication: Part I, EuroHaptics, Tampere, Finland, volume 7282 of Lecture Notes in Computer Science, pp 361-372
Publisher: Springer Berlin/Heidelberg
Abstract: Bi-directional haptic devices incorporate both sensors and actuators. While small and compact sensors are readily available, actuators in haptic interfaces require a significant volume to produce needed forces. With many actuated degrees of freedom, the mass and size of the actuators become a problem in devices such as haptic gloves. Piezo-technology offers the possibility of compact actuators which can be controlled with high accuracy. We describe a prototype admittance-type haptic device for the hand with a compact integrated piezoelectric motor. The current implementation provides one degree of freedom, but it could be extended with more motors for additional degrees of freedom. We demonstrate both the accuracy with which the device can reproduce force-displacement responses of non-linear elastic material stiffness and the device's fast and stable response to an applied load.

12. **Physically Co-Located Haptic Interaction with 3D Displays**
Authors: **Pontus Olsson**, **Fredrik Nysjö**, **Stefan Seipel**, **Ingrid Carlbom**
Conference: Haptics Symposium (HAPTICS), pp 267-272
Publisher: IEEE Computer Society
Abstract: Studies indicate that haptic interaction with a computer generated virtual scene may become more intuitive by aligning (co-locating) the visual and haptic workspaces so that the visual and haptic feedback coincide as they do in the real world. Co-located haptics may gain importance when more advanced haptic interfaces, such as high-fidelity whole hand devices, become available. We describe a user study that investigates the pros and cons with physically co-located versus non-collocated haptics on two different display types: a commercial half-transparent mirror 3D display with shutter glasses and a prototype autostereoscopic display based on a Holographic Optical Element (HOE). We use two accuracy tasks with spatial accuracy as the dependent variable and one manipulation task with time as the dependent variable. The study shows that on both displays co-location significantly improves completion time in the manipulation task. However, the study shows that co-location does not improve the accuracy in the spatial accuracy tasks.

13. **Solving Combined Geospatial Tasks Using 2D and 3D Bar Charts**
Authors: **Stefan Seipel**, L. Carvalho
Conference: 16th International Conference on Information Visualisation (IV), Montpellier, France, pp 157-163
Abstract: This paper presents a user study that investigates 2D and 3D visualizations of bar charts in geographic maps. The task to be solved by the participants in this study required estimation of the ratio of two different spatial distance measures and relative ranking among potential candidates. The results of this experiment show that subjects were equally fast and accurate when using both the 2D and 3D visualizations. Visual discomfort was reported by almost half of the test population, but performance was not affected. Our study also showed that frequent game players did not benefit more from a 3D visualization than inexperienced game-players.

14. **Seeded Segmentation Based on Object Homogeneity**
Authors: **Filip Malmberg**, **Robin Strand**, Richard Nordenskjöld (1), Joel Kullberg (1)
(1) Dept. of Radiology, Oncology and Radiation Science, UU
Conference: 21st International Conference on Pattern Recognition (ICPR), Tsukuba, Japan
Abstract: Seeded segmentation methods attempt to solve the segmentation problem in the presence of prior knowledge in the form of a partial segmentation, where a small subset of the image elements (seed-points) have been assigned correct segmentation labels. Common for most of the leading methods in this area is that they seek to find a segmentation where the boundaries of the segmented regions coincide with sharp edges in the image. Here, we instead propose a method for seeded segmentation that seeks to divide the image into areas of homogeneous pixel values. The method is based on the computation of minimal cost paths in a discrete representation of the image, using a novel path-cost function. The utility of the proposed method is demonstrated in a case study on segmentation of white matter hyper intensities in MR images of the human brain.

15. **Comparison of Restoration Quality on Square and Hexagonal Grids using Normalized Convolution**
Authors: **Elisabeth Linnér**, **Robin Strand**
Conference: 21st International Conference on Pattern Recognition (ICPR), Tsukuba, Japan
Abstract: Normalized convolution can be used to restore information that has been lost from an image, such as dead pixels, using the remaining information, and ignoring the incorrect pixels. It is known that the representation quality of an image consisting of a given number of pixels depends on how these pixels are distributed. In this paper, we investigate whether the ability to restore information using normalized convolution is affected by the sampling grid of the image. We compare square and hexagonal grids, and find that, in general, more pixels can be restored in hexagonal grids.

16. **The Vectorial Minimum Barrier Distance**
Authors: **Andreas Kårsnäs**, **Robin Strand**, Punam K. Saha (1)
(1) Dept. of Electrical and Computer Engineering and the Dept. of Radiology, The University of Iowa, Iowa City, IA, USA
Conference: 21st International Conference on Pattern Recognition (ICPR), Tsukuba, Japan
Abstract: We introduce the vectorial Minimum Barrier Distance (MBD), a method for computing a gray-weighted distance transform while also incorporating information from vectorial data. Compared to other similar tools that use vectorial data, the proposed method requires no training and does not assume having only one background class. We describe a region growing algorithm for computing the vectorial MBD efficiently.

    The method is evaluated on two types of multi-channel images: color images and textural features. Different path-cost functions for calculating the multi-dimensional path-cost distance are also compared.

    The results show that by combining multi-channel images into vectorial information the performance ofthe vectorial MBD segmentation is improved compared to when one channel is used. This implies that the method can be a good way of incorporating multi-channel information in interactive segmentation.

17. **Regional Zernike Moments for Texture Recognition**
Authors: **Ida-Maria Sintorn**, **Gustaf Kylberg**
Conference: 21st International Conference on Pattern Recognition (ICPR), Tsukuba, Japan, pp 1635-1638
Abstract: Zernike moments are commonly used in pattern recognition but are not suited for texture analysis. In this paper we introduce regional Zernike moments (RZM) where we combine the Zernike moments for the pixels in a region to create a measure suitable for texture analysis. We compare our proposed measures to texture measures based on Gabor filters, Haralick co-occurrence matrices and local binary patterns on two different texture image sets, and show that they are noise insensitive and very well suited for texture recognition.

18. **Graph Based Line Segmentation on Cluttered Handwritten Manuscripts**
Authors: **Fredrik Wahlberg**, **Anders Brun**
Conference: 21st International Conference on Pattern Recognition (ICPR), Tsukuba, Japan, pp 1635-1638
Abstract: We propose a two phase line segmentation method for handwritten pre-modern densely writ- ten manuscripts. The proposed method combines the robustness of projection based methods with the flexibility of graph based methods. The result are cut-outs of the image containing each text line. Overlapping characters, help lines and degradation can create foreground elements spanning several lines that are hard to separate. We treat the problem of finding a cut through the text line separation as a graph optimization problem, which allows for flexible separation of entangled components.

    The proposed method has been tested on two medieval sources with satisfying results. A comparison to similar methods, using standard metrics, is presented.

19. **Identifying all Individuals in a Honeybee Hive : Progress Towards Mapping all Social Interactions**
Authors: **Cris L. Luengo Hendriks**, **Zi Quan Yu**, Antoine Lecocq (1,2), Teatske Bakker(1), Barbara Locke (1), Olle Terenius (1)
(1) Dept. of Ecology, SLU, Uppsala
(2) Currently at: Department of Agriculture & Ecology, University of Copenhagen
Conference: Workshop on: Visual observation and analysis of animal and insect behavior, 21st International Conference on Pattern Recognition (ICPR), Tsukuba, Japan, pp 5-8
Editors: R. Fisher, J. Hallam, B. Boom
Abstract: Here we present work in progress towards a fully automatic system that monitors a honeybee hive over many days, deriving information on the position and velocity of each bee, and detecting and identifying each instance of a social interaction. Each bee is tagged with a unique identifier, enabling the system to know exactly which individuals interacted in each case. The final result should be a map of all interactions, from which it is possible to derive, for example, a sociogram.

20. **Analyzing Tubular Tissue in Histopathological Thin Sections**
Authors: **Azadeh Fakhrzadeh**, Ellinor Spörndly-Nees (1), Lena Holm (1), **Cris L. Luengo Hendriks**
(1) Department of Anatomy, Physiology and Biochemistry, SLU, Uppsala
Conference: International Conference on Digital Image Computing Techniques and Applications (DICTA), Perth, Australia, pp 1-6
Publisher: IEEE Publications
Abstract: We propose a method for automatic segmentation of tubules in the stained thin sections of various tissue types. Tubules consist of one or more layers of cells surrounding a cavity. The segmented tubules can be used to study the morphology of the tissue. Some research has been done to automatically estimate the density of tubules. To the best of our knowledge, no one has been able to, fully automatically, segment the whole tubule. Usually the border between tubules is subtle and appears broken in a straight-forward segmentation. Here we suggest delineating these borders using the geodesic distance transform. We apply this method on images of Periodic Acid Shiffs (PAS) stained thin sections of testicular tissue, delineating 89% of the tubules correctly.

6.3 Non-refereed conferences and workshops

1. **An Image Based High-throughput Assay for Chemical Screening Using Zebrafish**
   Authors: **Omer Ishaq** (1), Joseph Negri (2), Mark-Anthony Bray (2), **Alexandra Pacureanu**, **Carolina Wählby** (1,2)
   (1) SciLifeLab, UU
   (2) Imaging Platform, Broad Institute of MIT and Harvard, Cambridge, MA, USA
   Conference: BioImage Informatics, Dresden, Germany
   abstract review
2. **Making Isotropic 3D Imaging at Microscopic Scale Accessible to Every Lab**
   Authors: **Alexandra Pacureanu** (1), **Omer Ishaq** (1), **Amin Allalou**, **Carolina Wählby** (1)
   (1) SciLifeLab, UU
   Conference: Bioimage Informatics, Dresden, Germany
   abstract review
3. **Optimization of Semi-automated Cell Tracking Using Application-expert Feed-back**
   Authors: **Martin Simonsson** (1), **Ahmet Tugrul Bayrak**, **Carolina Wählby** (1)
   (1) SciLifeLab, UU
   Conference: Bioimage Informatics, Dresden, Germany
   abstract review
4. **High Throughput Phenotyping of Model Organisms**
   Author: **Carolina Wählby** (1)
   (1) SciLifeLab, UU
   Conference: BioImage Informatics, Dresden, Germany, p 45 invited talk
5. **Adaptive Structuring Elements Based on Salience Distance Transform**
   Authors: **Vladimir Curic**, **Cris L. Luengo Hendriks**, **Gunilla Borgefors**
   Conference: Swedish Symposium on Image Analysis (SSBA), Stockholm (electronic publication)
6. **Automated Measurement of Epithelial Height of Testicular Tissue**
   Authors: **Azadeh Fakhrzadeh**, Ellinor Spörndly-Nees (1), Lena Holm (1), **Cris L. Luengo Hendriks**
   (1) Department of Anatomy, Physiology and Biochemistry, SLU, Uppsala
   Conference: Swedish Symposium on Image Analysis (SSBA), Stockholm (electronic publication)
7. **An Investigation on Nuclei of Histopathological Images using Curvelet Statistical Features**
   Authors: **Swamidoss Issac Niwas**, P. Palanisamy (1), **Ewert Bengtsson**
   (1) National Institute of Technology (NIT), Tiruchirappalli, India
   Conference: Swedish Symposium on Image Analysis (SSBA), Stockholm (electronic publication)
8. **Imaging of the Bone Cell Network with Nanoscale Synchrotron Radiation Computed Tomography**
   Authors: **Alexandra Pacureanu**, Max Langer (1), Chantal Revol-Muller (2), Francoise Peyrin (1)
   (1) European Synchrotron Radiation Facility, Creatis, Université de Lyon, Lyon, France
   (2) Creatis, Université de Lyon, Lyon, France
   Conference: Swedish Symposium on Image Analysis (SSBA), Stockholm (electronic publication)
9. **Stochastic Watershed - An Analysis**
   Authors: **Bettina Selig**, **Cris L. Luengo Hendriks**
   Conference: Swedish Symposium on Image Analysis (SSBA), Stockholm (electronic publication)
10. **Rigid Registration for MET Image Exploration Using CUDA**
    Authors: **Lennart Svensson**, **Johan Nysjö**, **Anders Brun**, **Ingela Nyström**, **Ida-Maria Sintorn**
    Conference: Swedish Symposium on Image Analysis (SSBA), Stockholm (electronic publication)
11. **Word Spotting in Pre-Modern Manuscripts using Dynamic Time Warping**
    Authors: **Fredrik Wahlberg**, Mats Dahllöf (1), Lasse Mårtensson (2), **Anders Brun**
    (1) Dept. of Linguistics and Philology, UU
    (2) Dept. of Scandinavian Languages, UU
    Conference: Swedish Symposium on Image Analysis (SSBA), Stockholm (electronic publication)

12. **3D Nano-CT: A new Approach for Imaging at Cellular Scale**
    Authors: **Alexandra Pacureanu** (1), Max Langer (2), Jean-Loïc Rose (3), Chantal Revol-Muller (3), Francoise Peyrin (2)
    (1) SciLifeLab, UU
    (2) European Synchrotron Radiation Facility, Creatis, Université de Lyon, Lyon, France
    (3) Creatis, Université de Lyon, Lyon, France
    Conference: General Assembly of the French Society for Signal and Image Processing in Life Sciences invited talk

13. **Isotropic 3D Imaging of Biological Specimens at Micro and Nano Scale**
    Authors: **Alexandra Pacureanu** (1), Francoise Peyrin (2), Max Langer (2), **Omer Ishaq** (1), **Amin Allalou**, **Carolina Wählby** (1)
    (1) SciLifeLab, UU
    (2) European Synchrotron Radiation Facility, Creatis, Université de Lyon, Lyon, France
    Conference: Berlin-Brandenburg School for Regenerative Therapies Symposium on Visualization for Regenerative Medicine

14. **Synchrotron Radiation CT from the Micro to Nanoscale for the Investigation of None Tissue**
    Authors: Francoise Peyrin (1), Pei Dong, **Alexandra Pacureanu** (2), Maria Zuluaga, Cecile Olivier, Max Langer (1), Peter Cloetens
    (1) European Synchrotron Radiation Facility, Creatis, Université de Lyon, Lyon, France
    (2) SciLifeLab, UU
    Conference: Developments in X-Ray Tomography, SPIE

6.4 Other publications

See also Section 3.2 for Master theses finished during 2012.

1. **CBA Annual Report 2011**
   Editors: **Ewert Bengtsson**, **Vladimir Curic**, **Lena Nordström**, **Ida-Maria Sintorn**, **Robin Strand**, **Erik Wernersson**
   Publisher: Centre for Image Analysis, 96 pages

2. **Short descriptions of International Journals on Image Processing and its Applications**
   Editor: **Gunilla Borgefors**
   Publisher: Centre for Image Analysis, CBA Internal Report No. 50

3. **Projects in Quantitative Microscopy – From Sample Preparation to Image Analysis**
   Editor: **Carolina Wählby**
   Publisher: Centre for Image Analysis, CBA Internal Report No. 51

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 2012. 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.

Professor Stefan Seipel has served as Vice-chair of the Swedish Society for Computer Graphics (SIGRAD). Professor Ewert Bengtsson has for many years served 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. These appointments ended in March 31. Professor Gunilla Borgefors is Editor in Chief for Pattern Recognition Letters. Professor Ingela Nyström served as Secretary of the International Association of Pattern Recognition (IAPR).

To give some figures: We held 13 seminars outside CBA, mostly in the Uppsala area. We had six invited seminars at CBA. In addition, we held 39 seminars in our “Monday seminar series”. We gave seven special invited talks as well as ten oral and twelve poster presentations at international fully reviewed conferences, and ten other oral conference presentations. We have also had a large number of national and international short-term visitors at many different occasions and have often visited others ourselves. Finally, we have listed 49 international and 44 national “committees” of the most varying types in which we have served.

7.1 Organised conferences and workshops

1. **AIMday Image 2012**
   Organisers: Ingrid Carlbom, UU Innovation
   Address: KTH, Stockholm
   Date: 120307
   Comment: Organized the events: solicited questions from companies and invited researchers to address these questions during the AIMday.

2. **Workshop on Quantitative Automated Analysis of Phenotypes from Microscopic Images Using Cell Profiler**
   Organisers: Carolina Wählby, Alexandra Pacureanu, Martin Simonsson
   Address: Rudbeck Laboratory, Uppsala
   Date: 120511

3. **Workshop on Quantitative Automated Analysis of Phenotypes from Microscopic Images Using Cell Profiler**
   Organisers: Carolina Wählby, Alexandra Pacureanu, Martin Simonsson
   Address: Rudbeck Laboratory, Uppsala
   Date: 120614

4. **CERN School of Computing 2012**
   Organisers: Ingela Nyström, UPPMAX, eSSENCE, CERN
   Address: Ångström laboratoriet, UU
   Date: 120813–24
   Comment: eSSENCE and UPPMAX hosted the 35th edition of this CERN school with 60 participants from world-wide. The school contained lectures and computer exercises in software development, security, networking, hardware architecture, etc. for high-performance computing areas. Nyström was the local organising chair in this CERN project.

5. **eSSENCE Academy**
   Organisers: Ingela Nyström, eSSENCE
   Address: Sigtunahöjden, Sigtuna
   Date: 121016–17
   Comment: 60 researchers within the e-Science community gathered for this workshop to present, discuss, and find synergies among researchers from Lund University, UmeåUniversity, and Uppsala University.

6. **Workshop on Quantitative Automated Analysis of Microscopy Data Using Cell Profiler**
   Organisers: Carolina Wählby, Alexandra Pacureanu, Martin Simonsson
   Address: Karolinska Institutet, Huddinge
   Date: 121107–08

7.2 Seminars held outside CBA

1. **Ingrid Carlbom**
   Date: 120119
   Address: Uppsala Science Park, Oscar II seminar room Jupiter, Uppsala
   Title: PET/MR research opportunity
   Comment: A seminar to discuss possible interdisciplinary project proposals on PET/MR research.

2. **Ewert Bengtsson**
   Date: 120207
   Address: IVA Conference Centre, Stockholm
   Title: Swedish Academy of Engineering Sciences, IVA, Academy Collegium
   Comment: Representing IVA Section VII in the semi-annual collegium meeting.

3. **Ida-Maria Sintorn**
   Date: 120216
   Address: Biomedical Centre, Uppsala University
   Title: Image Analysis of Biomoecules at the Nanometer Scale
   Comment: Sintorn was invited to give this talk as part of the Celsius-Linne symposium.

4. **Martin Simonsson**
   Date: 120424
   Address: BMS seminar, Rudbeck
   Title: Quantitative Microscopy and Image Analysis with CellProfiler and CellProfiler Analyst

5. **Stefan Seipel**
   Date: 120426
   Address: University of Gävle
   Faculty of Engineering and Sustainable Development
   Title: On the Usability of 3D Visualizations

6. **Carolina Wählby**
   Date: 120508
   Address: Retreat on Regenerative Medicine, Karolinska Institute. Körunda, Ösmo.
   Title: Digital Image Analysis of 2D, 3D and Time-lapse Microscopy Data

7. **Gunilla Borgefors**
   Date: 120509
   Address: Ångström, UU
   Title: Math and Science in the Newspaper - Possibilities and Limitations?
   Comment: One of six lectures in the PhD course ”Science, Scientists, and Media”, organized by Bengt Lundberg.

8. **Carolina Wählby and Ida-Maria Sintorn**
   Date: 120523
   Address: Invited lecture at course on Cellular Imaging and Confocal Techniques at the Karolinska Institute, Stockholm.

Title: "Introduction to Digital Images, Image Processing and Digital Filters and its Applications to Quantitative Microscopy" and "Object Detection, Feature Measurements and Object Classification, with Example Applications using CellProfiler".

9. **Ewert Bengtsson**
   Date: 120823
   Address: IVA Conference Centre, Stockholm
   Title: Swedish Academy of Engineering Sciences, IVA, Academy Collegium
   Comment: Represented IVA Section VII on the Collegium meeting presenting our workplans.
10. **Carolina Wählby**
   Date: 120926
   Address: Invited lecture at course on Methods for Cell Analysis Course, BioVis, IGP, UU.
   Title: Image Analysis
   Comment: Alexandra Pacureanu and Martin Simonsson organized a computer exercise in connection with the course.
11. **Gunilla Borgefors**
   Date: 121108
   Address: Royal Swedish Academy of Engineering Sciences (IVA), Stockholm
   Title: The Big Global Society Challenges
   Comment: Presentation of the work of IVA Committee for Future Strategy, Work group 1.
12. **Martin Simonsson, Carolina Wählby**
   Date: 121129
   Address: Marie Curie, Rudbeck
   Title: Running CellProfiler and CellProfiler Analyst on the UPPMAX Cluster
13. **Ida-Maria Sintorn**
   Date: 121204
   Address: Dept. of Physics and Astronomy, UU
   Title: Image Analysis with Application Examples in Electron Microscopy

7.3 Seminars at CBA with invited guest lecturers

1. **Matthew Thurley**
   Address: Luleå Technical University
   Date: 120209
   Title: Automated, Online, Non-Contact Particle Size Measurement on Conveyor using 3D Surface Profile Data
2. **Hans Blom**
   Address: Science for Life Laboratory, KTH
   Date: 120521
   Title: Stimulated Emission Depletion (STED) Microscopy for Nanoscale Proteomics
3. **Clas Linnman**
   Address: Childrens Hospital, Harvard, Boston, USA
   Date: 120525
   Title: PET and fMRI of Fear and Pain Processing
4. **Anders Ländström**
   Address: Luleå Technical University
   Date: 120612
   Title: Tensor-Based Adaptive Morphology applied to Crack Detection for Steel Slabs
5. **Alfred M. Bruckstein**
   Address: Computer Science Department, Technion, Haifa, Israel
   Date: 120620
   Title: Digital Geometry for Metrology Tasks
   Comment: CoSy-seminar.

6. **Michael Ashcroft**
   Date: 120924
   Title: An Introduction to Bayesian Network based technologies

7.4 Seminars at CBA

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

1. **Filip Malmberg**
   Date: 120109
   Title: Interactive Segmentation – Making it Work in Practice!
2. **Gunilla Borgefors**
   Date: 120116
   Title: Impression from Onsala Space Observatory
3. **Jimmy Azar**
   Date: 120123
   Title: Complexity & Regularization in Classification
4. **Michael Brennan**
   Date: 120124
   Title: Comparison of Automated Feature Extraction Methods for Image Based Screening of Cancer Cells
   Comment: Master thesis presentation.
5. **Erik Wernersson**
   Date: 120130
   Title: Enhanced (micro) Computerized Tomography
6. **Vladimir Curic**
   Date: 120206
   Title: Salience Adaptive Structuring Elements
7. **Bettina Selig**
   Date: 120213
   Title: Stochastic Watershed – An Analysis
8. **Patrik Malm, Mikael Laaksoharju, Gustaf Kylberg, and Simon Tschirner**
   Date: 120220
   Title: Designing the VI2 Web Presence
9. **Gustaf Kylberg**
   Date: 120227
   Title: Evaluating Texture Measures Related to Local Binary Patterns
10. **Lennart Svensson**
    Date: 120305
    Title: Protein Modelling and Recent Developments in the ProViz Project
11. **Omer Ishaq**
    Date: 120312
    Title: Previous Work on Image Analysis and Computer Vision
12. **Ewert Bengtsson**
    Date: 120319
    Title: Image Analysis on Different Levels – European Flagship and High School Project Work
13. **Anders Hast**
    Date: 120326
    Title: GeoMemories a Spatial-Temporal Atlas of the Italian Landscape

14. **Anders Dånmark**
    Date: 120328
    Address: The seminar room at CBA
    Title: Volume Reconstruction From Calibrated Image Series
    Comment: Master thesis presentation.

15. **Anders Brun**
    Date: 120402
    Title: The Grand Challenges of Handwritten Text Recognition

16. **Robin Strand**
    Date: 120416
    Title: Sampling Efficiency of Three-dimensional Sampling Grids

17. **Johan Nysjö**
    Date: 20120423
    Title: Haptic-Enabled 3D Angle Measurements in CT Wrist Images

18. **Carolina Wählby**
    Date: 120507
    Title: The WormToolbox of CellProfiler and Life & work at the Broad Institute of Harvard and MIT

19. **Issac Niwas Swamidoss**
    Date: 120514
    Title: Classification of Immunostaining Patterns in Breast Tissue from the Human Protein Atlas (HPA) using the Wavelet Transform

20. **Martin Simonsson**
    Date: 120528
    Title: Cell tracking with CellProfiler

21. **Abdolrahim Kadkhodamohammadi**
    Date: 120530
    Title: Counting Sertoli Cells in Testicular Tissue Thin Sections
    Comment: Master thesis presentation.

22. **Max Morén**
    Date: 120530
    Title: Efficient Volume Rendering on the FCC and BCC grids
    Comment: Master thesis presentation.

23. **Jing Liu**
    Date: 120530
    Title: Implementation of a Semi-automatic Tool for Analysis of TEM Images of Kidney Samples
    Comment: Master thesis presentation.

24. **Karl Bengtsson Bernander and Kenneth Gustavsson**
    Date: 120604
    Address: The seminar room at CBA
    Title: Stochastic Watershed – A Comparison of Different Seeding Methods
    Comment: Master thesis presentation.

25. **Fei Liu**
    Date: 120611
    Title: Ubiquitous Visualisation of Spatial Data

26. **Tomas Toss**
    Date: 120614
    Title: Automatic Identification and Cropping of Rectangular Objects in Digital Images
    Comment: Master thesis presentation.

27. **Meng Liang**
    Date: 120618
    Title: 3D Co-occurrence Matrix Based Texture Analysis Applied to Cervical Cancer Screening
28. **Kristina Lidayova**
    Date: 20120827
    Title: Semantic Categorization and Retrieval of Natural Scene Images
29. **Alexandra Pacureanu**
    Date: 120910
    Title: Making Isotropic 3D Imaging at Microscopic Scale Accessible to Every Lab
30. **Cris Luengo**
    Date: 120917
    Title: A Review of Stereological Principles for Image Analysis
31. **Ahmet Tugrul Bayrak**
    Date: 120926
    Title: Software Development for Automated Tracking of Unlabelled Cells in Advanced Microfluidic Cell Culture Systems
    Comment: Master thesis presentation.
32. **Marine Astruc**
    Date: 120926
    Title: Cluster Detection and Field-of-View Quality Rating Applied to Automated Pap-smear Analysis
    Comment: Master thesis presentation.
33. **Elisabeth Linnér**
    Date: 121001
    Title: BCC and FCC Lattices in Medical Image Processing
34. **Erik Wernersson**
    Date: 121008
    Title: Computerized Dendrochronology
35. **Iordanis Kavathatzopoulos**
    Date: 121015
    Title: Icon and Aporia: Can Images Help us Build Better IT Systems?
36. **Xuan Tuan Trinh**
    Date: 121019
    Title: Online Learning of Multi-class SVMs
    Comment: Master thesis presentation.
37. **Lars Oestreicher**
    Date: 121022
    Title: Accessibility: A matter of Technology or of Attitudes?
38. **Krishna Paudel**
    Date: 121026
    Title: Stitching of X-Ray Images
    Comment: Master thesis presentation.
39. **Ewert Bengtsson**
    Date: 121029
    Title: Computer Assisted Pathology; Past Experiences and Future Prospects
40. **Prabhu Mani**
    Date: 121031
    Title: Seed Surface Measurements from Multiple Views
    Comment: Master thesis presentation.

41. **Gustaf Kylberg**
    Date: 121105
    Title: Investigation of Rotation Invariance of Texture Descriptors
42. **Azadeh Fakhrzadeh**
    Date: 121112
    Title: An Automated Method for Segmentation of Epithelial Height in Testicular Tissue
43. **Bengt Sandblad**
    Date: 121119
    Title: Humans in Complex Dynamic Work. The Case of Train Traffic Control
44. **Stefan Seipel**
    Date: 121126
    Title: Visual Computing for Resource Management
45. **Ziquan Yu**
    Date: 121130
    Title: Tracking Individual Bees in a Beehive
    Comment: Master thesis presentation.
46. **Anders Jansson**
    Date: 121203
    Title: Collegial Verbalisation: A Method for Knowledge Elicitation in Cognitive Analysis
47. **Fredrik Wahlberg**
    Date: 121210
    Title: Word-spotting, What is it and Why do we do it.
48. **Håkan Selg**
    Date: 121217
    Address: The seminar room at CBA
    Title: New Contact Patterns in Professional Life: SMS, Chat, Email and Telephony – What Tool for Which Use?

7.5 Conference participation

7.5.1 Special invited speaker

1. *Conference:* MIBISOC: Medical Imaging Using Bio-inspired and Soft Computing
   Ingela Nyström
   Date: 120221–25
   Address: Parma University, Parma, Italy
   Title: Visualization and haptics for cranio-maxillofacial surgery planning
   Comment: Nyström was one of the lecturers at this technical course, mainly aimed at PhD students and PostDocs, granted by the European Commission.
2. *Conference:* Röntgenveckan 2012
   Ingela Nyström
   Date: 120914
   Address: Svenska mässan, Göteborg
   Title: Image-based planning of craniomaxillofacial surgery using haptics and 3D visualisation
   Comment: Participated in the workshop “Looking to the future: Imaging, image analysis, visualisation and haptic interaction”.

3. *Conference:* HIMA Histopathology Image Analysis Workshop
   Ewert Bengtsson
   Date: 121005
   Address: NICE Conference Centre, France
   Title: Computer assisted pathology - past experiences and future prospects
   Comment: A one hour invited key-note address. Also participated in the panel discussion at the end of the day.

4. *Conference:* IVA Section VII
   Ewert Bengtsson, Gunilla Borgefors
   Date: 121108
   Address: IVA conference centre, Stockholm
   Title: Report from IVA strategy groups
   Comment: Bengtsson was chair of the meeting, Borgefors was one of the three speakers.

5. *Conference:* General Assembly of the French Society for Signal and Image Processing in Life Sciences
   Alexandra Pacureanu
   Date: 121022–1024
   Address: Lyon, France
   Title: 3D nano-CT: a new approach for imaging at cellular scale.

6. *Conference:* IVA Science and Society Forum
   Stefan Seipel
   Date: 121025
   Address: The Royal Swedish Academy of Engineering Sciences, IVA, Stockholm
   Title: Visualization for Resource and Risk Management.

7. Participant type: Invited Speaker
   Conference: British Colombia Cancer Research Centre Seminars
   Ewert Bengtsson
   Date: 121120
   Address: BCCRC Conference Hall , Vancouver, Canada
   Title: Computer assisted cytology and pathology - past experiences and future prospects
   Comment: Bengtsson was invited as the only speaker of this seminar.

7.5.2 Oral presentations – refereed conferences

1. *Conference:* Journé du groupe de travail Géomérie Discrète (Workshop of the French Discrete Geometry Working Group)
   Robin Strand
   Date: 120608
   Address: IRCCyN, University of Nantes, France
   Title: The minimum barrier distance

2. *Conference:* International Conferences in Central Europe on Computer Graphics, Visualization and Computer Vision (WSCG'12)
   Anders Hast
   Date: 120625–28
   Title: An Efficient Preconditioner and a Modified RANSAC for Fast and Robust Feature Matching

3. *Conference:* 16th International Conference on Information Visualization 2012 (IV'2012)
   Stefan Seipel
   Date: 120710–13
   Address: Montpellier, France
   Title: Solving combined geospatial tasks using 2D and 3D bar charts

4. *Conference:* 9th International Symposium on Visual Computing
   Anders Brun
   Date: 120729–31
   Address: Rethymnon, Crete, Greece
   Title: A Novel Algorithm for Computing Riemannian Geodesic Distance in Rectangular 2D Grids.
   Comment: Brun was a program committee member
5. *Conference:* BioImage Informatics
   Alexandra Pacureanu
   Date: 120916–19
   Address: Dresden, Germany
   Title: Making isotropic 3D imaging at microscopic scale accessible to every lab
6. *Conference:* International Conference on Computer Vision and Graphics (ICCVG'2012)
   Johan Nysjö
   Date: 120924–26
   Address: Warsaw, Poland
   Title: Towards User-Guided Quantitative Analysis of Wrist Fractures in CT Images
7. *Conference:* International Conference on Computer Vision and Graphics (ICCVG'2012)
   Vladimir Curic
   Date: 120924–26
   Address: Warsaw, Poland
   Title: Adaptive Structuring Elements Based on Salience Information
8. *Conference:* Visual observation and analysis of animal and insect behavior 2012
   Cris Luengo
   Date: 121111
   Address: Tsukuba, Japan
   Title: Identifying All Individuals in a Honeybee Hive - Progress Towards Mapping All Social Interactions
   Comment: Workshop in conjunction with ICPR 2012.
9. *Conference:* 21st International Conference on Pattern Recognition (ICPR 2012)
   Ida-Maria Sintorn
   Date: 121112–15
   Address: Tsukuba, Japan
   Title: Regional Zernike Moments for texture recognition
10. *Conference:* 21st International Conference on Pattern Recognition (ICPR 2012)
    Fredrik Wahlberg
    Date: 121112–15
    Address: Tsukuba, Japan
    Title: Graph-based line segmentation non-cluttered handwritten manuscripts

7.5.3 Poster presentations – refereed conferences

1. *Conference:* International Joint Conference on Computer Vision, Imaging, Computer Graphics Theory and Applications (VISIGRAPP'2012)
   Anders Hast
   Date: 120224–26
   Address: Rome, Italy
   Title: Putative Match Analysis - A Repeatable Alternative to RANSAC for Matching of Aerial Images
2. *Conference:* International Joint Conference on Computer Vision, Imaging, Computer Graphics Theory and Applications (VISIGRAPP'2012)
   Lennart Svensson
   Date: 120224–26
   Address: Rome, Italy
   Title: Rigid template registration in MET images using CUDA

3. *Conference:* 2012 IEEE Haptics Symposium
   Pontus Olsson
   Date: 120304–07
   Address: Vancouver, Canada
   Title: Physically Co-Located Haptic Interaction with 3D Displays
4. *Conference:* Eurohaptics
   Pontus Olsson
   Date: 120612–15
   Address: Tampere, Finland
   Title: Rendering Stiffness with a Prototype Haptic Glove Actuated by an Integrated Piezoelectric Motor
5. *Conference:* International Conference on Medical Image Computing and Computer Assisted Intervention (MICCAI)
   Ingrid Carlbom
   Date: 121001–05
   Address: Nice, France.
   Title: Histological Stain Evaluation for Machine Learning Applications
6. *Conference:* PROMISE challenge
   Ewert Bengtsson
   Date: 121001
   Address: NICE Conference Centre, France
   Title: Smart Paint an interactive segmentation tool
   Comment: Participated also in the live segmentation contest, ending up in third place among a dozen participants
7. *Conference:* Workshop on Histopathology Image Analysis (HIMA), a MICCAI Workshop on Histopathology Image Analysis
   Andreas Kårsnäs
   Date: 121001–05
   Address: Nice, France
   Title: Automated classification of immunostaining patterns in breast tissue from the Human Protein Atlas
8. *Conference:* Workshop on Histopathology Image Analysis (HIMA), a MICCAI Workshop on Histopathology Image Analysis
   Ingrid Carlbom
   Date: 121005
   Address: Nice, France
   Title: Histological Stain Evaluation for Machine Learning Applications
9. *Conference:* International Conference on Pattern Recognition (ICPR'2012)
   Andreas Kårsnäs
   Date: 121111–15
   Address: Tsukuba, Japan
   Title: The vectorial minimum barrier distance
10. *Conference:* International Conference on Pattern Recognition (ICPR'2012)
    Elisabeth Linnér
    Date: 121111–15
    Address: Tsukuba, Japan
    Title: Comparison of restoration quality on square and hexagonal grids using normalized convolution
11. *Conference:* International Conference on Pattern Recognition (ICPR'2012)
    Robin Strand
    Date: 121111–15
    Address: Tsukuba, Japan
    Title: Seeded Segmentation Based on Object Homogeneity
    Comment: Strand also chaired the session “Image and Video Superresolution”

12. *Conference:* Digital Image Computing: Techniques and Applications (DICTA'2012)
    Azadeh Fakhrzadeh
    Date: 121203–05
    Address: Fremantle, Australia
    Title: Analyzing Tubular Tissue in Histopathological Thin Sections

7.5.4 Oral presentations – non-refereed conferences

1. *Conference:* Swedish Symposium on Image Analysis (SSBA'2012)
   Azadeh Fakhrzadeh
   Date: 120307–09
   Address: KTH, Stockholm
   Title: Automated Measurement of Epithelial Height of Testicular Tissue

2. *Conference:* Swedish Symposium on Image Analysis (SSBA'2012)
   Johan Nysjö
   Date: 120307–09
   Address: KTH, Stockholm
   Title: Haptic-Enabled 3D Angle Measurements in CT Wrist Images

3. *Conference:* Swedish Symposium on Image Analysis (SSBA'2012)
   Elisabeth Linnér
   Date: 120307–09
   Address: KTH, Stockholm
   Title: Comparison of Normalized Convolution on Square and Hexagonal Grids

4. *Conference:* Swedish Symposium on Image Analysis (SSBA'2012)
   Bettina Selig
   Date: 120307–09
   Address: KTH, Stockholm
   Title: Stochastic Watershed – An Analysis

5. *Conference:* Swedish Symposium on Image Analysis (SSBA'2012)
   Alexandra Pacureanu
   Date: 120307–09
   Address: KTH, Stockholm
   Title: Imaging of the Bone Cell Network with Nanoscale Synchrotron Radiation Computed Tomography

6. *Conference:* Swedish Symposium on Image Analysis (SSBA'2012)
   Vladimir Curic
   Date: 120307–09
   Address: KTH, Stockholm
   Title: Adaptive Structuring Elements Based on the Salience Distance Transform

7. *Conference:* Workshop on Cerviscan project
   Ewert Bengtsson, Patrik Malm
   Date: 120420–27
   Address: Centre for Advanced Computing, CDAC, Thiruvananthapuram, Kerala, India
   Title: Progress and plans of the project
   Comment: A week-long workshop discussing the progress and future strategies for our joint Cerviscan project

8. *Conference:* BioImage Informatics
   Alexandra Pacureanu
   Date: 120916–19
   Address: Dresden, Germany
   Title: Making isotropic 3D imaging at microscopic scale accessible to every lab

9. *Conference:* IT Department strategy day
Ewert Bengtsson
Date: 121128
Address: Evolutionsbiologist centrum, Uppsala
Title: Machine learning
Comment: Presented ideas about a new senior position on machine learning at this department strategy day where many from CBA were participants

10. *Conference:* Berlin-Brandenburg School for Regenerative Therapies Symposium on Visualization for Regenerative Medicine
Alexandra Pacureanu
Date: 121205–07
Address: Berlin, Germany
Title: Isotropic 3D imaging of biological specimens at micro and nano scale

7.5.5 Poster presentations – non-refereed conferences

1. *Conference:* SciLifeLab-DAY
Omer Ishaq
Date: 120823
Address: Akademiska sjukhuset, Uppsala
Title: An image based high-throughput assay for chemical screening on using zebrafish

2. *Conference:* SciLifeLab Day
Alexandra Pacureanu
Date: 120823
Address: Akademiska sjukhuset, Uppsala
Title: Making isotropic 3D imaging at microscopic scale accessible to every lab

3. *Conference:* SciLifeLab Day
Carolina Wählby
Date: 120823
Address: Akademiska sjukhuset, Uppsala
Title: Quantitative Microscopy; from drug discovery in model organisms to in situ RNA sequencing

4. *Conference:* SciLifeLab Day
Martin Simonsson
Date: 120823
Address: Akademiska sjukhuset, Uppsala
Title: Optimization of semi-automated cell tracking using application-expert feed-back

5. *Conference:* BioImage Informatics
Omer Ishaq
Date: 120919
Address: Max Planck Institute of Molecular Cell Biology and Genetics, Dresden, Germany
Title: An image based high-throughput assay for chemical screening on using zebrafish

6. *Conference:* Joint battle against infectious disease and antimicrobial resistance
Carolina Wählby
Date: 121123
Address: Universitetshuset, UU
Title: High throughput screening for novel anitinfectives using model organisms

7. *Conference:* Joint battle against infectious disease and antimicrobial resistance
Ida-Maria Sintorn
Date: 121123
Address: Universitetshuset, UU
Title: Image Based Virus Diagnostics

7.5.6 Attended conferences

1. *Conference:* ITfOM Consortium Meeting
   Carolina Wählby, Ewert Bengtsson
   Date: 120209–10
   Address: MaxPlanck Institute, Berlin
   Comment: A meeting of the 120 partners in the flagship proposal ”IT Future of Medicine” discussing proposal strategy and content
2. *Conference:* 2012 Celsius-Linné Symposium: A cross-disciplinary symposium on XFEL, imaging, physics and function of molecules and basic bio-systems
   Gunilla Borgefors
   Date: 120217
   Address: Uppsala Biomedical Center (BMC), UU
3. *Conference:* 2012 IEEE Haptics Symposium
   Pontus Olsson
   Date: 20120304–20120307
   Address: Vancouver, Canada
   Title: Physically Co-Located Haptic Interaction with 3D Displays
4. *Conference:* AIM-day Image
   Ewert Bengtsson, Robin Strand, Alexandra Pacureanu, Martin Simonsson, Ida-Maria Sintorn, Ingela Nyström, Stefan Seipel
   Date: 120307
   Address: Royal Institute of Technology (KTH), Stockholm
5. *Conference:* Swedish Symposium on Image analysis (SSBA’2012)
   Ewert Bengtsson, Gunilla Borgefors, Omer Ishaq, Gustaf Kylberg, Ingela Nyström, Martin Simonsson, Ida-Maria Sintorn, Robin Strand, Lennart Svensson, Carolina Wählby
   Date: 120307–09
   Address: Royal Institute of Technology (KTH), Stockholm
6. *Conference:* Workshop on Cerviscan project
   Ewert Bengtsson, Patrik Malm
   Date: 120420–27
   Address: Centre for Advanced Computing, CDAC, Thiruvananthapuram, Kerala, India
   Title: Progress and plans of the project
   Comment: A week-long workshop discussing the progress and future strategies for our joint Cerviscan project
7. *Conference:* Digital Geometry Tools and Algorithms (DGTal) meeting
   Robin Strand
   Date: 120607
   Address: IRCCyN, University of Nantes, France
8. *Conference:* Eurohaptics
   Ingrid Carlbom, Fredrik Nysjö
   Date: 120612–15
   Address: Tampere, Finland
9. *Conference:* MICCAI 2012
   Ingrid Carlbom
   Date: 121001–04
   Address: Nice, France
10. *Conference:* MICCAI
    Ewert Bengtsson
    Date: 121002–04
    Address: Nice, France
    Comment: Participated in the main MICCAI conference in addition to the workshops before and after it

11. *Conference:* 8th IEEE International Conference on e-Science
Ingela Nyström
Date: 121008–12
Address: Chicago, IL, USA
12. *Conference:* Image based diagnostics - a Swedish area of strength with great potential
Ewert Bengtsson, Ingrid Carlbom
Date: 121011
Address: Hotel Ekoxen, Linköping
Comment: A full day workshop to work out our agenda for the Vinnova sponsored project. Eight persons attended, Carlbom was the chair of the meeting.
13. *Conference:* Breakfast seminar on the Government's resource and innovation bill
Ewert Bengtsson
Date: 121024
Address: Ingenjörshuset, Stockholm
14. *Conference:* Visualisation and Virtualisation - IVA Science and Society Forum
Gunilla Borgefors
Date: 121025
Address: Royal Academy of Engineering Sciences (IVA), Stockholm
15. *Conference:* Symposium om dentala och medicinska biomaterial
Ewert Bengtsson, Ingrid Carlbom
Date: 121107
Address: Skoogsalen, Akademiska sjukhuset, Uppsala
Comment: A symposium to honour Jan Hirsch for his retirement
16. *Conference:* 21st International Conference on Pattern Recognition (ICPR'2012)
Ingela Nyström, Ewert Bengtsson, Gustaf Kylberg, Cris Luengo
Date: 121111–15
Address: Tsukuba International Congress Center, Tsukuba, Japan
Comment: Ingela Nyström participated in IAPR Executive Committee meetings and she was re-elected as Secretary of the IAPR The planned organisation of ICPR 2014 in Stockholm was presented.
17. *Conference:* IT Department strategy day
Gunilla Borgefors, Anders Hast, Ingela Nyström, Stefan Seipel, Martin Simonsson, Robin Strand, Carolina Wählby
Date: 20121128–20121128
Address: Evolutionary Biology Centre, Uppsala
Comment: Strategic planning day for the whole Dept. of Information technology, UU
18. *Conference:* National Annual Computer Graphics Conference SIGRAD 2012
Stefan Seipel
Date: 121128–30
Address: Linnaeus University, Växjö
19. *Conference:* Bioimaging workshop
Ewert Bengtsson, Ingrid Carlbom, Carolina Wählby
Date: 20121211–20121211
Address: SciLife Stockholm
Comment: Workshop as part of the Vinnova agenda project. Carlbom was a chair, and Wählby an invited speaker

7.5.7 Other conferences

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

1. *Conference:* ERC PE7 Panel Evaluation Meeting
   Ewert Bengtsson
   Date: 120502–04
   Address: ERC Office, Place Rogier, Brussels
   Title: Presenting and discussing grant proposals
   Comment: A three day panel meeting to select which proposals will go to the final evaluation round
2. *Conference:* ERC PE7 Panel Evaluation Meeting
   Ewert Bengtsson
   Date: 120904–06
   Address: ERC offices, Place Rogier, Brussels
   Title: Presenting and discussing grant proposals
   Comment: This second panel meeting led to decisions about which proposals were granted.

7.6 Visiting scientists (staying at least 2 weeks)

1. **Joakim Lindblad, Nataša Sladoje**
   Address: Faculty Of Technical Sciences, University of Novi Sad, Serbia
   Date: 120907–121025
   Topic: Lindblad and Sladoje (both formerly affiliated at CBA) gave the course Models and Methods for Precise Image Analysis at CBA

7.7 Other visitors

1. **Hans Thunander, Östen Thoresson**
   Address: Private consultant with collaboration with SLU
   Host: Ewert Bengtsson, Cris Luengo
   Date: 120117
   Topic: Use of image analysis for forestry work
   Comments: Discussed the possibility of using image analysis to automate clearing bushes in forests
2. **Per Gunningberg, Lena Gunningberg**
   Address: Department of Public Health and Caring Sciences and Department of Information Technology, Uppsala University
   Host: Ewert Bengtsson
   Date: 120125
   Topic: Image analysis of wounds
   Comments: Discussed the possibility of using image analysis to quantify the extent and healing of wounds
3. **Robert Pettersson, Jakob Larsson, Vidar Swenning**
   Address: Rosedahlsgymnasiet (Rosenhadhl High School)
   Host: Ewert Bengtsson
   Date: 120202
   Topic: Tracking a ball in 3D using image analysis
   Comments: Gave some advice to these high school students who carried out a very challenging project work on real-time tracking a ball in 3D using a webcam
4. **Matthew Thurley**
   Address: Luleå University
   Host: Cris Luengo
   Date: 120209–10
   Comments: Thurley visited CBA to discuss a possible cooperation.

5. **Risto Kontio, Jukka Kanerva**
   Address: Dept. of OMFS, Helsinki University Hospital; Product & Production Manager Planmeca
   Host: Ingrid Carlbom
   Date: 120330
   Topic: Haptics-assisted cranio-maxillofacial surgery
   Comments: Other Attendees: Jan Hirsch, Uppsala University Hospital; Ingela Nyström, Pontus Olsson, Fredrik Nysjö, Johan Nysjö
6. **Tim Wing, Bengt Nielsen, Ronny Matula**
   Address: GE Healthcare, England; GE Healthcare, Sweden
   Host: Ingrid Carlbom
   Date: 120403
   Topic: Prostate Cancer Malignancy Grading
   Comments: We described our work on prostate cancer malignancy grading and got a demo of the GE just released digital pathology workstation, Omnyx. Other attendees: Christer Busch, University Hospital; Mateo Santurio, UU Innovation; Jimmy Azar and Ewert Bengtsson
7. **Sébastien Lefévre**
   Address: Université de Bretagne Sud, Vannes, France
   Host: Vladimir Curic, Cris Luengo
   Date: 120410–13
   Topic: Mathematical morphology
   Comments: We invited Lefévre to discuss possible collaboration and to give a seminar in the CoSy lunch seminar series.
8. **Helianna Puhlin, Henri Veistera, Jukka Kanerva**
   Address: Planmeca, Finland
   Host: Ingrid Carlbom
   Date: 120425
   Topic: Haptics-assisted cranio-maxillofacial surgery
   Comments: Other participants: Jan Hirsch, University Hospital; Ingela Nyström, Pontus Olsson, Fredrik Nysjö, Johan Nysjö; Stefan Johansson
9. **Alkwin Wanders**
   Address: Dept. of Immunology, Genetics and Pathology, UU
   Host: Ida-Maria Sintorn, Gustaf Kylberg
   Date: 120503
   Topic: virus detection in TEM images
   Comments: We discussed our work on automated electron microscopy and virus detection and identification in TEM images and how that could be applied to his research field of gastrointestinal diseases.
10. **Gabriella Sanniti di Baja**
    Address: Istituto di Cibernetica “E. Caianiello”, C.N.R., Pozzuoli, Italy
    Date: 120503–07
    Topic: Sanniti di Baja gave a seminar at the Royal Society of Sciences in Uppsala
    Comments: One of many visits since the 1990s
11. **Alexandre Falcao**
    Address: IC-UNICAMP, Campinas, Brazil
    Host: Filip Malmberg
    Date: 120507–16
    Topic: Image Processing Using Graphs
    Topic: During his visit, Falcao gave four lectures at the course “Image Processing Using Graphs”, and also gave a seminar at the Center for Interdisciplinary Mathematics.

12. **Linda Sandblad**
    Address: Department of Molecular Biology, Umeå University
    Host: Ida-Maria Sintorn, Lennart Svensson, Ingela Nyström
    Date: 120508
    Topic: Molecular electron tomography
    Comments: We discussed potential future collaborations regarding MET image analysis and demonstrated the ProViz software.

13. **Kent Åberg**
    Address: Newformat AB, Hässelby
    Host: Ewert Bengtsson
    Date: 120514
    Topic: IT at Uppsala University
    Comments: Discussed trends, plans and strategies in IT in general and in relation to Uppsala University

14. **Matthew Thurley, Håkan Jonsson, Anders Landström**
    Address: Luleå University
    Host: Cris Luengo
    Date: 120612
    Comments: Thurley visited CBA with colleagues to build a link between CBA and his group in Luleå.

15. **Delong Instruments, Vironova AB**
    Address: Brno, Czech Republic (Delong Instruments), Stockholm (Vironova AB)
    Host: Ida-Maria Sintorn, Gustaf Kylberg, Gunilla Borgefors
    Date: 120619–20
    Number of visitors: 8
    Topic: miniTEM project meeting
    Comments: It was CBAs turn to host the biannual miniTEM project meeting to report and discuss progress and issues.

16. **Stefaan Motte, Lies Pieters**
    Address: Materialise, Brussels, Belgium
    Host: Ingrid Carlbom
    Date: 120620
    Topic: Haptics-assisted cranio-maxillofacial surgery
    Comments: Other participants from CBA: Ingela Nyström, Pontus Olsson, Johan Nysjö, Fredrik Nysjö; Attendees from Division of Microsystems Technology, Uppsala University: Stefan Johansson; Attendees from Dept. of Surgical Sciences, Oral & Maxillo-Facial Surgery, Uppsala University Hospital: Jan Hirsch

17. **Jan Peter Axelsson**
    Address: Vascaia AB, Stockholm
    Host: Martin Simonsson
    Date: 120903
    Topic: Quantitative Microscopy

18. **Jerome Perret**
    Address: Haption, SOULGE SUR OUETTE, France
    Host: Ingrid Carlbom
    Date: 120905
    Topic: Haptics Hardware
    Comments: Other attendees: Stefan Johansson, Pontus Olsson, Fredrik Nysjö, Johan Nysjö

19. **Lambert Schomacher**
    Address: University of Groningen, The Netherlands
    Host: Anders Brun
    Date: 120913–14
    Topic: Handwritten Text Recognition
    Comments: Visited CBA and Datorlingvistik, gave a SALT seminar in Engelska parken

20. **Örjan Smedby**
    Address: Linköping University
    Host: Ewert Bengtsson, Ingrid Carlbom
    Date: 120914
    Topic: Planning Bioimaging Agenda project
    Comments: Planned how the work in the agenda project granted by Vinnova is to be carried out with Smedby as a chairperson and Carlbom as a project leader

21. **Anna Schnurer**
    Address: Dept. of Microbiology, SLU
    Host: Ida-Maria Sintorn
    Date: 120920
    Topic: Image based analysis of microbes in biogas production

22. **Tommy Forsell, Daniel Evestedt**
    Address: SenseGraphics, Kista
    Host: Ingrid Carlbom
    Date: 121122
    Topic: Haptics
    Comments: Other Attendees: Jan Hirsch; Pontus Olsson, Fredrik Nysjö,Johan Nysjö, Stefan Johansson

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

1. **Robin Strand**
   Host: Nicolas Normand
   Address: LUNAM Université, Université de Nantes, IRCCyN, Polytech Nantes, Nantes, France
   Date: 120601–30
   Topic: Guest researcher

7.9 Short visits to other research groups and meetings outside CBA

Note: Meetings occasioned by permanent appointments are listed in section 7.10

1. **Anders Hast**
   Host: Erwin Laure (PDC-HPC) , Ian Gilbert, Björn Thuresson
   Address: KTH, Stockholm
   Date: 120117
   Topic: Remote Visualization Workshop

2. **Ida-Maria Sintorn, Gustaf Kylberg, Gunilla Borgefors**
   Host: Eva Coufalova
   Address: Delong Instruments, Brno, Czech Republic
   Date: 120213–14
   Topic: MiniTEM project meeting
   Comments: Meeting with Delong Instruments and Vironova AB about progress and issues in the miniTEM project

3. **Anders Hast**
   Host: Andrea Marchetti
   Address: IIT, CNR, Pisa, Italy
   Date: 120222–23
   Topic: GeoMemories

4. **Ida-Maria Sintorn, Lennart Svensson**
   Host: Samuel Flores
   Address: Cell and Molecular Biology, Uppsala University
   Date: 120302
   Topic: Collaboration discussions

5. **Anders Hast**
   Host: Hans Svensson, prefekt.
   Address: Högskolan på Gotland
   Date: 120312
   Topic: Studiebesök

6. **Anders Hast**
   Host: UPPMAX
   Address: Uppsala University
   Date: 120314–15
   Topic: Application Experts meeting

7. **Vladimir Curic**
   Host: Michael Wilkinson
   Address: Institute for Mathematics and Computing Science, University of Groningen, The Netherlands
   Date: 120329
   Topic: Mathematical morphology
   Comments: Several topics related to mathematical morphology were discussed.

8. **Ida-Maria Sintorn, Gustaf Kylberg**
   Host: Johan Elf, Gustaf Ullman
   Address: Dept. Cell and Molecular Biology, Uppsala University
   Date: 120330
   Topic: Segmenting bacteria
   Comments: Discussion about potential collaboration regarding segmenting bacteria

9. **Ida-Maria Sintorn**
   Host: Ozan Öktem
   Address: Centre for Industrial and Applied Mathematics, KTH
   Date: 120426
   Topic: Electron tomography
   Comments: Discussion about potential collaboration regarding image analysis of molecular electron tomography images

10. **Lennart Svensson**
    Host: Aurelie Laloeuf
    Address: Department of Cell and Molecular Biology, Karolinska Institutet, Stockholm
    Date: 120507
    Topic: Collaboration discussions

11. **Ewert Bengtsson, Ingela Nyström**
    Host: Waterfront Customer Relations
    Address: Waterfront Conference Centre Stockholm
    Date: 120522
    Topic: Planning ICPR 2014
    Comments: Looking at the premises in preparation for the 2014 ICPR conference

12. **Ewert Bengtsson**
    Host: Sofia Medin och Johanna Camö
    Address: Ministry of Enterprise, Energy and Communications, Stockholm
    Date: 120529
    Topic: Medical Engineering Funding in Sweden
    Comments: Participated in a delegation to lobby for more research funding for medical engineering

13. **Ingela Nyström**
    Host: Francois Fluckiger
    Address: CERN, Geneva, Switzerland
    Date: 120531–0601
    Topic: Preparation of CERN School of Computing 2012
    Comments: Visiting of the LHC sites, including the visualization center

14. **Ingrid Carlbom, Pontus Olsson, Fredrik Nysjö**
Host: Jukka Kanerva
Address: Planmeca, Helsinki, Finland
Date: 120615
Topic: Cranio-Maxillofacial Surgery Planning

15. **Anders Hast**
Host: Jiri Matas
Address: The Center for Machine Perception, Department of Cybernetics, Faculty of Electrical Engineering, Czech Technical University, Prague
Date: 120624
Topic: RANSAC

16. **Ingela Nyström, Gunilla Borgefors**
Host: Waterfront
Address: Stockholm Waterfront Congress Centre
Date: 120626
Topic: Checking ICPR2014 venue

17. **Ewert Bengtsson**
Host: Peter Honeth, State Secretary
Address: Ministry of Education and Research, Stockholm
Date: 120822
Topic: Medical Engineering Funding In Sweden
Comments: Trying to convince the ministry that medical engineering needs to be specificly addressed in the research budget

18. **Ewert Bengtsson, Robin Strand**
Host: Håkan Ahlström
Address: Radiology Department, MR unit, UAS hospital
Date: 120918
Topic: ITfOM collaboration on whole body MR
Comments: Discussing future collaboration for which we hope to get funding through the ITfOM proposal

19. **Anders Hast**
Host: Chalmers, Gothenburg.
Address: Chalmers, Gothenburg.
Date: 120920
Topic: Application Experts meeting

20. **Ingela Nyström**
Host: Francois Fluckiger
Address: CERN, Geneva, Switzerland
Date: 121108–09
Topic: Final report of CERN School of Computing 2012
Comments: Visiting of the LHC sites, including the computer center

21. **Carolina Wählby**
Host: Virginie Delporte, VD CONNECT Uppsala
Address: Hotel Gillet, Uppsala
Date: 20121116
Topic: ICT-PUB with Niklas Zennström
Comments: Wählby was part of the pannel discussion with Niklas Zennström, entrepreneur and former Uppsala University student. Loth Hammar, head of the eGovernment Delegation, led the discussion organized by CONNECT Uppsala and attended by 150 persons.

22. **Ewert Bengtsson**
    Host: Calum MacAuley
    Address: British Colombia Cancer Research Centre, BCCRC, Vancouver, Canada
    Date: 121117–21
    Topic: Research on cancer image analysis
    Comments: Met several researchers at BCCRC and collaborating organizations during my visit in connection with my invited seminar presentation

23. **Cris Luengo, Ida-Maria Sintorn, Lennart Svensson, Lena Nordström, Ewert Bengtsson, Ingela Nyström**
    Host: Thomas Moritz
    Address: Umeå Plant Science Centre, Umeå
    Date: 121127
    Topic: New department for CBA-SLU

7.10 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–
- Scientific committee for International Conference on Signal Processing, Image Processing and Pattern recognition (ICSIPR13) 201208–
- Scientific committee for International Conference on Computer Vision and Graphics (ICCVG 2012), 20120920–20120922
- International Program Committee for 20th and 21st International Conference on Computer Graphics, Visualization and Computer Vision (WSCG 2012) and (WSCG 2013)
- Planning group for workshop Sweden-Singapore March 2013, 201209–
  Comment: Appointed to be member of this committee by VR.
- Member of the Evaluation Panel PE7 for advanced grant applications to the European Research Council (ERC): Natural and Engineering Sciences-Biomedical Engineering, 2008–2012

National:

- Member of the Royal Swedish Academy of Engineering Sciences, Section VII: Basic and Interdisciplinary Engineering Sciences. 2006–
- Vice Chair of Section VII of the Royal Swedish Academy of Engineering Sciences, 091119–121231
- Member of the Royal Society of Sciences in Uppsala (Kungliga Vetenskapssocieteten), 1998–
- Chair of Uppsala University IT Council, 2008–2012
- Advisor to the Rector on Information Technology at UU, 1998–2012
  Comment: Advisor appointed to lead the strategic planning of UU and give advice to the Rector.
- Member of the Board of UpGIS, the network for Geographical Information Systems at UU, 1999–
- Member of the UU student cooperation group, 2000–2012
  Comment: A group where the leadership of the university and the student unions meets to discuss matters of common interest.

- 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.
- Member of the UU Library Council 2011–
- Member of the Board of Swedish Bioimaging, 20120301–
  Comment: A Swedish network for researchers in biomedical imaging and image analysis.
- Member of the board of the Department of Information Technology, 20120701–
- Member of the Uppsala University IT strategy group, 20120615–
  Comment: A committee headed by the university director to create a new strategy for support of administrative IT at UU.
- Licentiate Thesis Opponent for Mohammed Ali Khorshidis, 20120222
  Comment: A Licentiate Thesis at KTH School of Engineering
- PhD half time seminar, 20121022
  Comment: One of two external experts at this half time PhD seminar for Janne West at CMIV, Linköping University

Gunilla Borgefors
International:

- Editor-in-Chief of Pattern Recognition Letters, 20110101–
  Comment: Pattern Recognition Letters is published by Elsevier and is an official journal of the International Association of Pattern Recognition. Borgefors was Associate Editor and Area Editor 2004-2010.
- Fellow of the Institute of Electrical and Electronics Engineers, Inc. (IEEE), 2007–
  Comment: Senior member since 1998.
- Fellow of the International Association for Pattern Recognition (IAPR), 1998–
- Member of Nominating Committee of the International Association for Pattern Recognition, 2010–2012
- Editorial Board member of the journal Image Processing and Communications, 1994–
  Comment: Published by the Institute of Telecommunications, Bydgoszcz, Poland.
- Editorial Board member of the journal Pattern Recognition and Image Analysis: Advances in Mathematical Theory and Applications, 1993–
  Comment: Published by Interperiodica Publishing in cooperation with the "Cybernetics" Scientific Council, Russian Academy of Sciences.
- Editorial Board of the book series Computational Imaging and Vision, published by Springer, 2003–
- Steering committee for Discrete Geometry for Computer Imagery (DGCI) conferences, 2000–
- Steering committee for International Symposium on Mathematical Morphology (ISMM), 2011–
- Programme committee member, International Conference on Computer Vision and and Graphics, ICCVG 2012, Warsaw, Poland Sep. 2012

- Programme committee member, 7th International Conference on Neural Networks and Artificial Intelligence, ICNNAI 2012, Minsk, Belarus Oct. 2012

National:

- Royal Society of Sciences in Uppsala (Kungliga Vetenskaps–Societeten), Member No. 19, 2000–
  Comment: Elected member of the oldest scientific society in Sweden (founded 1710), (5 meetings).
- Member of the Royal Swedish Academy of Engineering Sciences (IVA), 2011–
  Comment: Member of Division VII: Basic and Interdisciplinary Engineering Sciences (4 meetings).
- Member of the Committee for Future Strategy, Work group 1: The Big Global Society Challenges, Royal Swedish Academy of Engineering Sciences (IVA), 20120601–20130228
  Comment: 5 meetings
- Swedish Parliamentarians and Scientists, 1987–
  Comment: Members are elected. Only one scientist per field admitted.
- Board/Steering Committee for Onsala Space Observatory, 2011–
  Comment: (2 whole day meetings)
- Celsius-Linné committee, TN-faculty, UU, 2007–
  Comment: The committee selects the speakers for the annual Celsius and Linné lectures, (4 meetings).
- Member of the Board of UpGIS, the net for Geographical Information Systems at UU, 1999–2012
  Comment: Representing TN-faculty, UU.
- Expert Evaluator for two positions as Full Professors in Medical imaging and image analysis at Chalmers University of Technology and The Sahlgrenska Academy, University of Gothenburg, both in Göteborg.
  Comment: 15 applicants.
- Expert evaluator of Matthew Thurley's application to become Associate Professor/Docent in Signal processing at Luleå Technical University.

Anders Brun
International:

- Program Committee member of the SSPR2012 Workshop organized in conjunction with ICPR, 20121107

Ingrid Carlbom
International:

- Member of ACM (Association for Computing Machinery)
- Member of ACM SIGGRAPH (Special Interest Group on Computer Graphics and Interactive Techniques)
- Member of SIGMA XI, The Scientific Research Society

National:

- Expert advisor for promotion to full professor at Mid Sweden University, 121115

- Project leader for the Vinnova Agenda for “Image-based medical diagnostics - a Swedish area of strength with great potential”

Anders Hast

International:

- Founding Organizer and program committee member for the UnConventional High Performance Computing (UCHP)
- Member of the program committee of the International Conference on Computer Graphics Theory and Applications (GRAPP)
- Member of the program committee of the Asian Simulation Technology Conference (ASTEC)
- Member of the program committee of the Industrial Simulation Conference, Virtual Reality and Graphical Simulation in Industrial Simulation
- Member of the program committee of the The Middle Eastern Modelling and Simulation Multi-Conference Simulation in Archaeology (MEMS)
- Member of the program committee of the The Simulation and AI in Games Conference (GAMEON ASIA)

Cris Luengo
International:

- Senior member of the Institute of Electrical and Electronics Engineers (IEEE) 2010–
  Comment: Member since 2001.
- Member of the International Society for Analytical Cytology (ISAC), 2006–
- Reviewer for the Habilitation Thesis of Petr Matula, Centre for Biomedical Image Analysis, Masaryk University, Brno, Czech Republic
- Member of the Technical Programme Committee of the 21st International Conference on Pattern Recognition (ICPR’2012), 121111–15
- Associate Editor for Pattern Recognition Letters 110606–121231

National:

- Member of evaluation panel TN-A (medical technology) of the Swedish Research Council
- Opponent for licentiate thesis Anders Landström, Luleå Univeristy of Technology, 20121121

Ingela Nyström
International:

- Member of the Executive Committee, International Association for Pattern Recognition (IAPR)
  - 2nd Vice President 2008–2010
  - Secretary 2010–
- Member of Advisory Committee of CERN School of Computing, 2011-
- Local Arrangements Chair of 35th CERN School of Computing, Uppsala, Sweden, Aug 2012

National:

- Member of the Royal Society of Arts and Sciences of Uppsala (*Kungliga Vetenskapssamhället i Uppsala*), 2012–
- Board Member of Swedish Society for Automated Image Analysis (SSBA), 2000–2012
  Comment: President 2002–2006
- Board Member of the Swedish University computer NETwork (SUNET), 2008–
- Board Member of the Faculty of Science and Technology, UU, 2011–
- Member of the Docent Committee of the Faculty of Science and Technology, UU, 2011–
- Member of the Electorial Board (”elektorsförsamlingen”) of the Faculty of Science and Technology, UU, 2011-
- Member of the Evaluation Panel for grant applications to the Swedish Research Council: Infrastructures for e-Science (Beredningsgrupp 4), 2011—

Stefan Seipel
International:

- Program Committee for the 16th International Conference on Information Visualization (IV2012), Montpellier, France, 20120710–20120713
- Member of Eurographics, the European Association for Computer Graphics, 20120101–20121231
- Member of the Evaluation Panel of the European Research Council Executive Agency, Unit B3: Advanced Grants, 20120901

National:

- Chair of SIGRAD - Swedish Computer Graphics Association, 20120420–20121231
  Comment: Chair since 20th of April 2012
- Chair of the Postgraduate Education Board at the University of Gävle, 20120101–20121231
- Dissertation committee member of Daniel Johansson, NT-Faculty, Örebro University, 20120210 *Comment:* Title: Convergence in Mixed Reality – Virtuality Environments: Facilitating Natural User Behaviour
- Co-chair of the National Annual Computer Graphics Conference 2012, 20120901–20121128
- Member of the Evaluation Panel of the Swedish National Agency for Higher Education, 20120920
  Comment: IT&Media Technology cluster
- Dissertation committee member of Anja Johansson, ITN, Linköping University, 20121109
  Comment: Title: Affective Decision Making in Artificial Intelligence: Making Virtual Characters With High Believability

Ida-Maria Sintorn
National:

- Board member of Swedish Society for Automated Image Analysis (SSBA), 2008–
  Comment: Treasurer from 2009.

Robin Strand
International:

- Member of the Editorial Board, Journal of Discrete Mathematics
- Member of the technical program committee, 21st International Conference on Pattern Recognition, ICPR 2012, 2012, Tsukuba Science City, Japan
- Member of the program committee, S+SSPR 2012, November 7-9, 2012, Miyajima-Itsukushima, Hiroshima, Japan (ICPR 2012 pre-conference workshop)

National:

- Member of the Electorial Board ("elektorsförsamlingen") of the Faculty of Science and Technology, UU

Carolina Wählby
International:

- Program committee member, ISMB 2012: 20th Annual international conference on Intelligent Systems for Molecular Biology, July 15-17, Longbeach, California, USA, 20120715–20120717
- Programme committee member, ECCB 2012: The 11th European Conference on Computational Biology, September 9-12, 2012, Basel, Switzerland, 20120909–20120912
- Program committee member, ACM Conference on Bioinformatics, Computational Biology and Biomedicine, Orlando, Florida, October 7-10, 2012., 20121007–20121010

National:

- Expert evaluator of Emma Lundberg's application to become Assistant Associate Professor (Biträdande lektor) in Cellbiological proteomics at the Royal Institute of Technology, Stockholm, 20120101–20120315
- Thesis opponent at dissertation of Charlotte Stadler, Royal Institute of Technology, Stockholm., 20121109 *Comment:* Title: Towards subcellular localization of the human proteome using bioimaging