Annual Report 2011

Centre for Image Analysis

Centrum för bildanalys

Cover: Illustrations from the five PhD theses presented at CBA during 2011. Further information in Section 4.2.

Top, left
Hamid Sarve — (Left) Rendered surface of a 3D image volume of a bone implant sample. The regions where the implant is in contact with bone tissue are superimposed on the surface. (Right) This surface is unfolded to a 2D image. Black dashed lines show the approximate location of the peaks of the threads. The vertical red line indicates the corresponding angles in the two images.

Top, right
Filip Malmberg — Surface rendering of the skeleton and a number of organs, segmented from a CT volume image using a semi-automatic method.

Middle
Milan Gavrilovic — Quantitative spectral decomposition in histopathology: removal of light scattering area is followed by automated identification of stained tissue components.

Bottom, left
Amin Allalou — (Back) Single cell analysis. (Front) Zebrafish tomography and jawbone segmentation.

Bottom, right
Khalid Niazi — (Left) Original image suffering from intensity inhomogeneity. (Right) Result of applying the proposed filtering method which is based on the grey-weighted distance transform of the magnitude spectrum.

Cover design:
Gustaf Kylberg

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Ewert Bengtsson, Vladimir Curic, Lena Nordström, Ida-Maria Sintorn, Robin Strand, Erik Wernersson

Centre for Image Analysis, Uppsala, Sweden

Printed in Sweden by the University Printers, Uppsala University, 2012

Contents

1 Introduction

1.1 General background

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

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 was a transitional year for CBA, since it was the first year in which we were no longer a department at UU, but one of six divisions within the Dept. of Information Technology. New significant changes in the organization will take place in 2012 as outlined in Section 2. So far, these reorganizations have not prevented us from continuing and expanding our research. We expect that the future changes will not negatively affect our possibilities either.

During 2011, a total of 38 persons were working at CBA: 17 researchers, 17 PhD students, 3 visiting researchers or technical staff and one administrator. Additionally, 13 Master thesis students have finished their thesis work with supervision from CBA. This does not mean, however, that we have had 50 full-time persons at CBA: many have split appointments, part time at CBA and part time elsewhere. Last year, CBA had a work volume corresponding to about 15 full-time, full-year employees at UU and 8 at SLU, not counting undergraduate teaching or Master thesis students. Most of us at CBA also do some undergraduate teaching, which so far has been organized by other divisions, mainly at the Dept. of Information Technology at UU. This will change next year, when our new division also will handle undergraduate education.

As a result of the changed organization, we were able to recruit two new associate professors, Carolina Wählby in quantitative microscopy, and Anders Hast in computer graphics and visualization. We were pleased that Cris Luengo qualified as docent at SLU, bringing the total number of CBA docents to ten; and that Ingela Nyström was promoted and installed as professor in visualization at UU.

On average, 3–4 PhD dissertations are produced each year. In 2011, five PhD theses were defended: Filip Malmberg at UU in May, Hamid Sarve at SLU in September, Muhammad Khalid Khan Niazi in October, Amin Allalou in November, and Milan Gavrilovic in December, the latter three all at UU.

Image processing is highly interdisciplinary, 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 49 national and 42 international collaborators see Section 5.6.

An important event this year was KOF11 – the evaluation of the quality of all research at Uppsala University carried out by international expert panels. It was a follow-up of the previous KoF07. The evaluators took part of our documented output, self evaluations and oral presentations. The result was summarized by the following statement under the heading *Quality of research*: “The works of the CBA in the discrete approach applied to microscopic medical images, and of 3D display is remarkable and clearly of internationally high standard. In the overall field of image analysis, the activities of CBA are internationally recognized. The development of techniques of visualization are among the best current output of CBA.” The full KoF11 report can be found at `http://uadm.uu.se/Research-funding/Standard-texts/?languageId=1`.

This year, results from a very exciting CBA-industry collaborative research project was presented in the Royal Swedish Society of Engineering Sciences (IVA) annual adress about progress in industrial and academic research and technology. The project concerns automatic imaging and identification of viruses in transmission electron microscopy images.

We have for many years had a clear focus on developing image analysis for medical applications. This

was recognized during 2011 by the Faculty of Medicine at UU with a direct permanent faculty grant of about 1.5 million SEK to support future research in that area, a very unusual measure. The large strategic program Science for Life Laboratory, SciLifeLab, also recognizes image analysis technology as essential for their fundamental biological research and supported the recruitment of Carolina Wählby, mentioned above, providing 3 million SEK per year for 3 years as a grant to strengthen the quantitative microscopy field.

A new multidisciplinary research area for CBA emerged towards the end of 2011. The Faculty of History and the Faculty of Languages with additional funds from the vice-Chancellor at UU will support this project concerning automatic reading of old handwritten documents.

Ingela Nyström, our deputy director, was appointed head of another major strategic research program in the e-science field, eSSENCE. As she assumed that position, she left the position as head of Uppsala Multidisciplinary Center for Advanced Computational Science, UPPMAX. She retains her position on the board of the Swedish University Computer Network, SUNET.

We are very active in international and national societies. Gunilla Borgefors was elected member of the Royal Swedish Society of Engineering Sciences (IVA) in 2011 and from 20110101, Borgefors is Editor in Chief for the journal Pattern Recognition Letters. Ingela Nyström served as secretary of the International Association of Pattern Recognition, IAPR. Ewert Bengtsson served as chair of the Evaluation Panel for Medical Engineering for the Swedish Research Council. At UU, he serves as senior advisor to the Vice-Chancellor on information technology and also as Chair of the University IT-council. 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 international research networks we were hosting workshops for delegations from Korea and India and in collaboration with SciLifeLab.

In addition to the more common ways of spreading information about our activites and work, such as seminars, publications, webpages 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/AR2011.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 in new ways. Our research is organized in a large number of projects (57) 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. A PhD thesis presented results on how spectral information can be handled in different kinds of microscopy images. Another PhD thesis analyzed mouse

embryo heart beats to detect adverse effects on embryo development of chemical compounds. During the year, we started a close collaboration with the strategic project SciLifeLab through which we formed a research platform in quantitative microscopy.

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. This year we became part of a project on light microscope tomography. Initial results from this work were presented in a PhD thesis. 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. The latter project was presented in a PhD thesis this year.

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. This work was presented in a PhD thesis.

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.

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 thirteen 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 Polacksbacken, building 2, south entrance, floor 1 Uppsala
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Fax:	+46 18 553447
E-mail:	`cb@cb.uu.se`

2 Organization

From an organizational point of view, 2011 was a transitional year 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 January 1st, 2011, the UU part of CBA became a division within the Dept. of Information Technology. At the same time, our research program at UU was widened to become "Computerized Image Analysis and Man–machine Interaction".

In April 2011, a new agreement was signed 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. Within the IT Department, there has been a review of the division structure, and on January 1st, 2012, CBA will become part of a new division, Visual Information and Interaction, Vi2. Ingela Nyström became head of that new division and thus also head of CBA. At the time of writing, it has not yet been decided to which department at SLU CBA will belong.

One component of the close integration between image analysis research at the two universities is that Gunilla Borgefors has been offered a full time position as guest professor in computerized image processing at UU, starting February 1st, 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 we see emerging 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

Our total expenditure was 22.1 million SEK for 2011, an increase of 18% from 2010. To cover this, 40% came from UU, 20% from SLU and 36% from external sources.

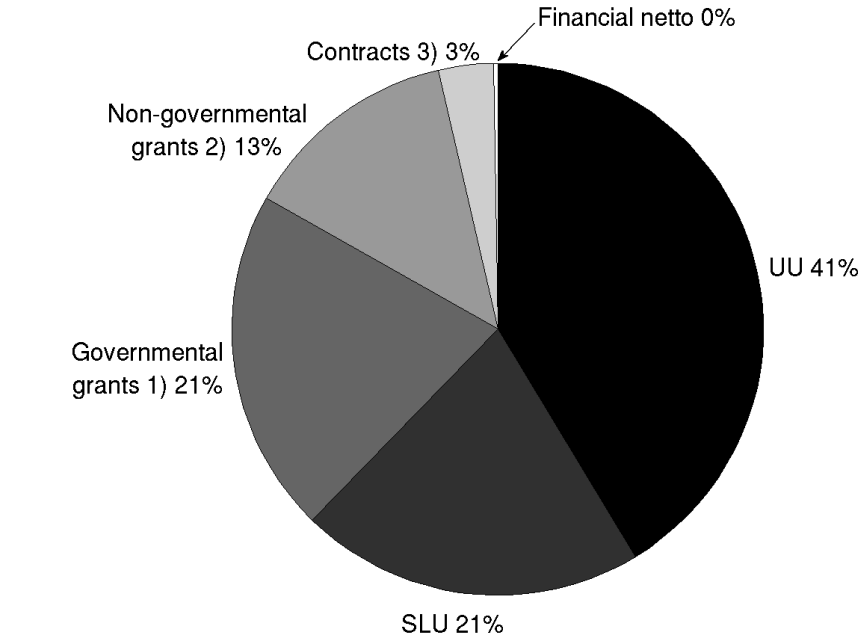
Over the years, the number of people working at CBA has varied considerably. During 2011, about 38 people were working at CBA, the same number as the previous year. About two thirds are employed by UU, the rest by SLU. The activity at CBA is similar to a department within a single university, but the administration is more complicated due to our dependence on two universities, and especially now during reorganizations.

Even though CBA itself does not organize undergraduate education, most of us teach 10–20%, more for some lecturers. The economy for that is not included in Table 1 below, which describes our overall economy for 2011. Since part of our economy is handled at UU and part at SLU, this summary is based on joining the two accounts and clearing internal transactions between the universities. The numbers are rounded to the nearest 1000 SEK. The same numbers for income and costs are also given as pie charts in Figure 1. 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: CBA income and costs for 2011 in kSEK.

Income		**Costs**	
UU	8752	Personnel	12894
SLU	4443	Equipment	614
Governmental grants[1]	4432	Operating exp.[4]	3093
Non-governmental grants[2]	2806	Rent	1300
Contracts[3]	702	University overhead	4194
Financial netto	53		
Total income	**21188**	**Total cost**	**22095**

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



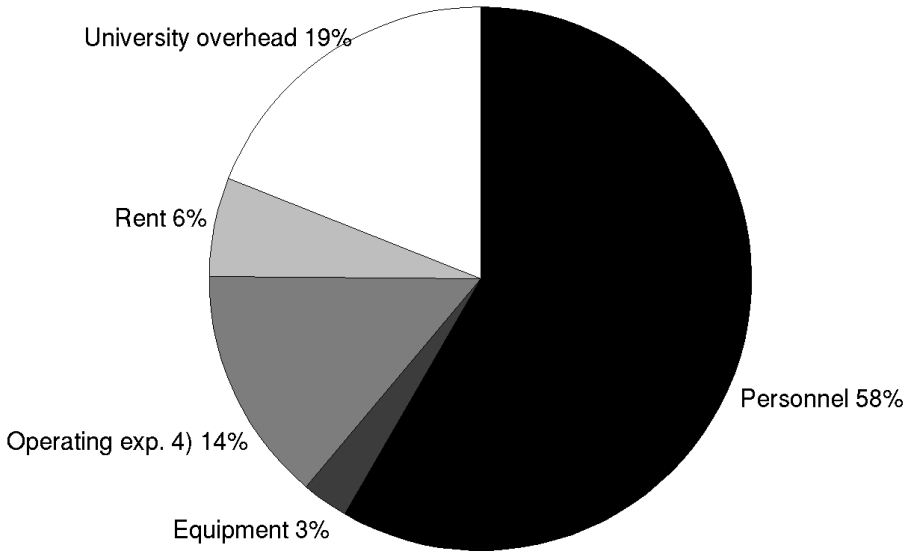


Figure 1: CBA income (top) and costs (below) for 2011.

2.2 Staff

Amin Allalou, Graduate Student, UU
Jimmy Azar, Graduate Student, UU
Ewert Bengtsson, Professor, PhD, Director, UU
Gunilla Borgefors, Professor, PhD, SLU
Anders Brun, Researcher, PhD, SLU
Ingrid Carlbom, Professor, PhD, UU
Vladimir Curic, Graduate Student, UU
Olle Eriksson, Lecturer, PhD, (part time) UU
Azadeh Fakhrzadeh, Graduate Student, SLU
Milan Gavrilovic, Graduate Student, UU
Gustaf Kylberg, Graduate Student, UU
Andreas Kårsnäs, Industrial Graduate Student, (part time) UU and Visiopharm, Hørsholm, Denmark
Joakim Lindblad, Researcher –110930, PhD, (part time) SLU
Tommy Lindell, Docent, PhD, (part time) UU
Elisabeth Linnér, Graduate Student, UU
Fei Liu, Graduate Student 111027–, University of Gävle
Cris Luengo, Researcher, PhD, Docent 111103–, SLU
Patrik Malm, Graduate Student, UU
Filip Malmberg, Graduate Student –110506, UU; Post Doc 110601–, UU
Khalid Niazi, Graduate Student, UU
Bo Nordin, Researcher/Lecturer, PhD, (part time) UU
Ingela Nyström, Docent/Professor, PhD, Deputy Director, (part time) UU
Fredrik Nysjö, Research Engineer, UU
Johan Nysjö, Graduate Student, 111001–, UU
Pontus Olsson, Graduate Student, UU
Hamid Sarve, Graduate Student –110902, SLU; Post Doc 110903–, UU
Stefan Seipel, Professor, PhD, (part time) UU and University of Gävle
Bettina Selig, Graduate Student, SLU
Martin Simonsson, Post Doc 111003–, UU
Ida-Maria Sintorn, Researcher, PhD, SLU
Robin Strand, Researcher, PhD, UU
Lennart Svensson, Graduate Student, SLU
Stina Svensson, Researcher –110331, Docent, PhD, (part time) SLU
Lena Wadelius/Nordström, Administration
Erik Wernersson, Graduate Student, SLU
Fredrik Wahlberg, Research Assistant, 110401–, UU
Carolina Wählby, Researcher, PhD, Docent, (part time) UU
Catherine Östlund, Researcher, PhD, (part time) SLU

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

3 Undergraduate education

Staff from CBA organizes and participates in many undergraduate courses. 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.

We offer a number of Master thesis projects (examensarbeten) each year. Thirteen were completed during 2011.

3.1 UU courses

1. **Computer Assisted Image Analysis I, 5 hp**
   Anders Brun, Gustaf Kylberg, Patrik Malm, Robin Strand, Cris Luengo, Bettina Selig, Azadeh Fakhrzadeh, Vladimir Curic
   Period: 110101–110308

2. **Scientific Computing I, 5 hp**
   Erik Wernersson
   Period: 110101–110401

3. **Scientific Computing III, 5 hp**
   Elisabeth Linnér
   Period: 110117–110310

4. **Computers and Programming, 10 hp**
   Bo Nordin
   Period: 110117–110531

5. **Object Oriented Programming Using C++, 10 hp**
   Bo Nordin
   Period: 110214–110531

6. **Computer Graphics, 10 hp**
   Gustaf Kylberg, Pontus Olsson
   Period: 110315–110531

7. **Bioimaging and Cell Analysis, 7.5 hp**
   Anders Brun, Ida-Maria Sintorn, Robin Strand, Carolina Wählby
   Period: 110829–110926

8. **Computers and Programming, 10 hp**
   Bo Nordin
   Period: 110829–111220

9. **Programming, Bridging Course, 10 hp**
   Olle Eriksson, Lennart Svensson
   Period: 110830–111220

10. **Scientific Visualization, 5 hp**
    Ingela Nyström, Filip Malmberg, Gustaf Kylberg, Stefan Seipel, Patrik Malm, Hamid Sarve
    Period: 110901–111021

11. **Methods for Cell Analysis, 3 hp**
    Carolina Wählby
    Period: 110929

12. **Computer Assisted Image Analysis 2, 10 hp**
    Cris Luengo, Anders Brun, Azadeh Fakhrzadeh, Ida-Maria Sintorn, Robin Strand, Patrik Malm, Carolina Wählby, Vladimir Curic
    Period: 111024–111220

13. **Medical Informatics, 5 hp**
    Ewert Bengtsson
    Period: 111114

14. **Workshop on using CellProfiler for PLA, 1 hp**
    Carolina Wählby
    Period: 111123

3.2 Master theses

1. **Visual Planning and Verification of Deep Brain Stimulation Interventions**
   Student: Elhassan M. Abdou
   Supervisor: Timo Ropinski, Dept. of Science and Technology, Linköping University
   Reviewer: Robin Strand
   Publisher: CBA Master Thesis No. 125 / IT nr 11 090
   Abstract: Deep Brain Stimulation (DBS) has resulted in a renaissance as an alternative way for treatment of Parkinson's disease and essential tremor. Deep brain stimulation employ the use of high electric field to stimulate some brain centers. The electric field in the brain is generated from chronic implanted electrodes in the brain. The final position of the electrodes in the brain is specified by the aid of CT and MR scans for the patient's head before and after the operation. A study of electric field distribution in the brain is required to interpret and improve the action of DBS. In this master thesis project, Voreen was extended to visualize a multimodal volume of the CT and MR images. The MR volume was segmented to extract the brain from the skull in T1 weighted images. Some image processing techniques were developed to enhance the contrast of CT and MR images. In order to stimulate electric field in the brain, the neurologists are allowed to design and position the electrodes in the reconstructed volume. The electrodes and some pre-modeled electric fields can be visualized in the reconstructed volume and the slice views. A mesh generator was developed using delaunay tetrahedralization. The generated mesh can be sent to PDE solver to solve Laplace equation describing the distribution of electric field.

2. **Digital Distance Functions Defined by Sequence of Weights**
   Student: Alexander Denev
   Supervisor: Robin Strand
   Reviewer: Gunilla Borgefors
   Publisher: CBA Master Thesis No. 126 / IT nr 11 082
   Abstract: In this paper, digital distance functions using sequences of weights are studied and used to approximate the Euclidian distance. Sequences of weights that guarantee a low maximum absolute error for path lengths of up to 10000 are calculated. A necessary condition and a sufficient condition for metricity of this kind of distance function are established.

3. **Efficient Implementation of Polyline Simplification for Large Datasets and Usability Evaluation**
   Student: Şadan Ekdemir
   Supervisor: Jörn Letnes
   Reviewer: Stefan Seipel
   Publisher: CBA Master Thesis No. 127 / IT nr 11 069
   Abstract: An in-depth analysis and survey of polyline simplification routines is performed within the project. The research is conducted using different simplification routines and performing evaluative tests on the outputs of each simplification routine. The project lies in between two major fields, namely Computer Graphics and Cartography, combining the needs of both sides and uses the algorithms that are developed for each field. After the implementation of the algorithms, a scientific survey is performed by comparing them according to the evaluation benchmarks, which are performance, reduction rate and visual similarity. Apart from the existing routines, one new simplification routine, triangular routine is developed and recursive Douglas-Peucker routine is converted into non-recursive. As a preprocessing part, Gaussian smoothing kernel is used to reduce noise and complexity of the polyline, and better performances are achieved. The end of research shows that there is no best model instead there are advantages and disadvantages of each simplification routine, depending on the prior need. It is also shown that usage of Gaussian smoothing as a filtering process improves the performance of each simplification routine.

4. **Image Analysis on Wood Fiber Cross-Section Images**
   Student: Sitao Feng
   Supervisor: Bettina Selig
   Reviewer: Cris Luengo
   Publisher: CBA Master Thesis No. 128 / IT nr 11 028
   Abstract: Lignification of wood fibers has a significant impact on wood properties. To measure the distribution of lignin in compression wood fiber cross-section images, a crisp segmentation method had been developed. It segments the lumen, the normally lignified cell wall and the highly lignified cell wall of each fiber. In order to refine this given segmentation the following two fuzzy segmentation methods were evaluated in this thesis: Iterative Relative Multi Objects Fuzzy Connectedness and Weighted Distance Transform on Curved Space. The crisp segmentation is used for the multi-seed selection.

   The crisp and the two fuzzy segmentations are then evaluated by comparing with the manual segmentation. It shows that Iterative Relative Multi Objects Fuzzy Connectedness has the best performance on segmenting the lumen, whereas Weighted Distance Transform on Curved Space outperforms the two other methods regarding the normally lignified cell wall and the highly lignified cell wall.

5. **Audio Editing in the Time-Frequency Domain Using the Gabor Wavelet Transform**
   Student: Ulf Hammarqvist
   Supervisor: Erik Wernersson
   Reviewer: Anders Brun
   Publisher: CBA Master Thesis No. 129 / UPTEC F nr F 11 022
   Abstract: Visualization, processing and editing of audio, directly on a time-frequency surface, is the scope of this thesis. More precisely the scalogram produced by a Gabor Wavelet transform is used, which is a powerful alternative to traditional techinques where the wave form is the main visual aid and editting is performed by parametric filters. Reconstruction properties, scalogram design and enhancements as well audio manipulation algorithms are investigated for this audio representation. The scalogram is designed to allow a flexible choice of time-frequency ratio, while maintaining high quality reconstruction. For this mean, the Loglet is used, which is observed to be the most suitable filter choice. Re-assignmentare tested, and a novel weighting function using partial derivatives of phase is proposed. An audio interpolation procedure is developed and shown to perform well in listening tests.The feasibility to use the transform coefficients directly for various purposes is investigated. It is concluded that Pitch shifts are hard to describe in the framework while noise thresh holding works well. A downsampling scheme is suggested that saves on operations and memory consumption as well as it speeds up real world implementations significantly. Finally, a Scalogram "compression" procedure is developed, allowing the caching of an approximate scalogram.

6. **Enriching Circuit Switched Mobile Phone Calls with Cooperative Web Applications**
   Student: Måns Hommerberg
   Supervisor: Johan Kristiansson
   Reviewer: Olle Eriksson
   Publisher: UPTEC F nr 11051
   Abstract: The thesis investigates the possibility to enrich standard mobile phone calls with cooperative web applications. Originating from the research field know as Computer Supported Cooperative Work (CSCW) this thesis report introduces and describes the implementation of several applications which can be used by the calling parties together during a phone call. Additionally, the report describes a proof-of-concept prototype for the Android platform, and discusses the performance of cooperative web application running on mobile devices in terms of network and CPU use.

   The conclusions of the thesis describe a prototype application addressing and implementing the requirements as described by the theory of computer supported collaborated work. The performance of the running application showed to be satisfactory, both regarding to network demand and processor use.

7. **Registration of 3D Volumetric CT Images**
   Student: Shuo Li
   Supervisor: Erik Wernersson
   Reviewer: Anders Brun
   Publisher: CBA Master Thesis No. 130 / IT nr 11 080
   Abstract: This master thesis aims to develop a system for analyzing transformation between two volumetric CT images. The volumetric image data we process is taken from a composite material. This composite

material combines wood fibre and plastic and can be used to make for instance hockey sticks or furniture. Because of the wood fibre embedded in this composite material, it absorbs water and sometimes deforms. By observing volumetric images generated by micro computed tomography (micro-CT), we know that the organization of fibre embedded in this material is very complicated. This makes it difficult to predict the deformation on beforehand. In our study, we have seen rigid transformations, non-rigid transformations and even discontinuities transformations (cracks). For a pair of very small sub volumes, in dry and wet condition, we have found that the transformation can approximated by a rigid transformation combined with a scaling value. To find this transformation, our system includes two key phases. In the first phase, we extract feature points in dry and wet condition. In the second phase, we register the feature points derived from dry and wet condition. In the feature point extraction phase, we have adapted different methods, for instance the Scale-Invariant Feature Transform (SIFT) method is used to extract features. In the registration phase, we have tested three different registration algorithms. The first algorithm is based on concepts from Random Sample Consensus (RANSAC). The second algorithm is inspired from the Iterative Closest Point (ICP) method. The third method is a novel algorithm that we call Spatial Invariant Registration. In the report, we compare the different methods in the feature extraction phase and in the registration phase. Finally, we discuss how our system can be extended to give better results with better accuracy.

8. **Evaluation of a Model-free Approach to Object Manipulation in Robotics**
   Student: Guoliang Luo
   Supervisors: Danica Kragic, Carl-Henric Ek, Royal Institute of Technology
   Reviewer: Anders Brun
   Publisher: CBA Master Thesis No. 131 / IT nr 11 035
   Abstract: Action Recognition is crucial for object manipulation in robotics. In recent years, Programming by Demonstration has been proposed as a way for a robot learning tasks from human demonstrations. Based on this concept, a model-free approach for object manipulation has recently been proposed in [1]. In this thesis, this model-free approach is evaluated for Action Recognition. In specific, the approach classifies actions by observing object-interaction changes from video.

   Image segmentation to videos presents various difficulties, such as motion blur, complex environment, Over- and Under- segmentation. This thesis investigates and simulates these image segmentation errors in a controllable manner. Based on the simulation, two different similarity measure methods are evaluated: The Substring Match (SSM) and Bhattacharyya Distance (B-Distance) method. The results show that the B-Distance method is more consistent and capable to classify actions with higher noise level compare to the SSM method.

   Further, we propose an action representation using kernel method. The evaluation shows that the novel representation improves Action Recognition rate significantly.

9. **Rendering Software for Multiple Projectors**
   Student: Fredrik Nysjö
   Supervisor: Robin Strand
   Reviewer: Ingrid Carlbom
   Publisher: CBA Master Thesis No. 132 / IT nr 11 081
   Abstract: CBA is currently developing a haptic glove that will be integrated with a new type of 3D holographic display. A prototype of this display has been developed at the Royal Institute of Technology and consists of standard off-the-shelf projectors and a special holographic optical element. The latter acts as a projection screen that creates a narrow viewing slit for each projector's image; this allows for autostereoscopic viewing from more than one viewing angle. The rendering software for the display prototype at the Centre for Image Analysis can render a fixed number of static perspective views of virtual 3D scenes. But the software's rendering pipeline was not properly calibrated for the intended application of the display: co-located haptics. Thus, the views are rendered without proper off-axis projection matrices, and they also exhibit keystone distortion from oblique projector angles when they are projected on the holographic optical element. In this master's thesis work, we develop a software library that extends the existing rendering software with support for keystone correction and arbitrary off-axis projections. We use this library to calibrate the rendering pipeline and the display. We also develop software tools that facilitate the calibration task. Furthermore, when views are rendered with static perspective, a viewer perceives a discrete transition between two distinct perspectives whenever he or she moves an eye from one viewing slit to an adjacent slit. To make these view transitions smooth and reduce other types of perspective errors, we couple the display

with an optical tracking system for head-tracking and experiment with adding dynamic perspective to the display. We conclude that while the addition of dynamic perspective helps reduce perspective errors, the display would need narrower viewing slits in order to allow smooth view transitions.

10. **Orbit Segmentation for Cranio-Maxillofacial Surgery Planning**
Student: Johan Nysjö
Supervisor: Ingela Nyström
Reviewer: Ewert Bengtsson
Publisher: CBA Master Thesis No. 124 / IT nr 11 010
Abstract: A central problem in cranio-maxillofacial (CMF) surgery is to restore the normal anatomy of the facial skeleton after defects, e.g., malformations, tumours, and trauma to the face. There is ample evidence that careful pre-operative surgery planning can significantly improve the precision and predictability of CMF surgery as well as reduce the post-operative morbidity. In addition, the time in the operating room can be reduced and thereby also costs. Of particular interest in CMF surgery planning is to measure the shape and volume of the orbit (eye socket), comparing an intact side with an injured side. These properties can be measured in 3D CT images of the skull, but in order to do this, we first need to separate the orbit from the rest of the image – a process called segmentation.

    Today, orbit segmentation is usually performed by experts in CMF surgery planning who manually trace the orbit boundaries in a large number of CT image slices. This manual segmentation method is accurate but time-consuming, tedious, and sensitive to operator errors. Fully automatic orbit segmentation, on the other hand, is unreliable and difficult to achieve, mainly because of the high shape variability of the orbit, the thin nature of the orbital walls, the lack of an exact definition of the orbital opening, and the presence of CT imaging artifacts such as noise and the partial volume effect.

    The outcome of this master's thesis project is a prototype of a semi-automatic system for segmenting orbits in CT images. The system first extracts the boundaries of the orbital bone structures and then segments the orbit by fitting an interactive deformable simplex mesh to the extracted boundaries. A graphical user interface with volume visualization tools and haptic feedback allows the user to explore the input CT image, define anatomical landmarks, and guide the deformable simplex mesh through the segmentation.

    To evaluate the performance of our segmentation system, we let three test users independently segment 14 orbits twice (in a set of seven CT images) with the segmentation tools provided by the system. In order to assess segmentation accuracy, we construct crisp and fuzzy ground truth segmentations from manual orbit segmentations performed by the three test users. The results of this case study indicate that our segmentation system can be used to obtain fast and accurate orbit segmentations, with high intra-operator and inter-operator precision.

11. **Scalable Web Application using Node.JS and CouchDB**
Student: Umesh Paudyal
Supervisor: Claudijo Borovic
Reviewer: Olle Eriksson
Publisher: IT nr 11 066
Abstract: This report presents design and implementation of a protoype application using server side javascript programming language, node.JS and couchDB as backend database. It scales and evaluates the developed prototype application and the couchDB for their scalability and performance.

    The report concludes that node.JS is a suitable framework for development of scalable web servers and couchDB as a backend database, though natively not distributed and scalable, can be scaled and distributed across multiple nodes using clustering and replication mechanism.

12. **Mobile Application Development for Android - Solving Complex Debt Situations**
Students: Alexander Sjöberg and Emil Larsson
Supervisor: Tom Smedsaas
Reviewer: Olle Eriksson
Publisher: TVE nr 11 007
Abstract: The goal of the project has been to develop an Android application whose function is to calculate the necessary transactions, minimized in number, to resolve a complex debt situation within a group of individuals. These types of situations frequently occur in everyday life, for example when a group of friends cook dinner together and different people pay for various expenses such as food and beverages. The work

resulted in the application SplitIt, a stylish and easy-to-use application that meets the desired specifications. Uncertainties exist however, whether the algorithm thatcalculates the transactions is optimized regarding the minimum number oftransactions required. Some measures should be taken before the product is launched on the Android Market. The development of icons, for example, has been put to the side with the intention to spend more time on other parts of the user interface and algorithm development. Splitit has been developed by studying similar applications on the Android Market and by carefully considering usability. Before starting the implementation of the application, a user study was conducted in which sketches of the proposed user interface was designed and a test panel had the opportunity to navigate through the application. The study clarified unclear as well as appealing parts of the user interface.

13. **Image Analysis for Grain Quality Assessment**
Student: Fraz Ali
Supervisor: Jaan Luup, Maxx automation AB
Revierer: Cris Luengo
Publisher: IT nr 11 004 (confidential report)
Abstract: Assessing grain quality is a critical task to ensure that the grain-based products meet the food industry standards. Due to the complex texture-based symptoms, this process is carried out manually by quality assurance staff. To overcome the expense and inconsistencies of the process, an automated solution for grain quality is desirable.

For decades, researchers have been trying to improve the automated analysis of grains, and many image-based solutions for grain sorting have been proposed. However, none of these solutions is reliable and fast enough. Hence, the grain quality assessment is still performed manually. Recent advancement in computer vision systems and rapid progress in computer hardware industry demands that new efforts should be made to automate the complex task of grain quality assessment.

To develop an image-based solution for grain quality requires deep understanding of the symptoms as well as efficient image analysis techniques, to meet both the accuracy and performance requirements.

The purpose of this thesis is to investigate and develop efficient image analysis algorithms for grain quality assessment. An existing grain sorting system is used to acquire images. A set of image-based solutions is developed. In most of the algorithms high accuracy is achieved. A machine based on these solutions will be developed in future.

4 Graduate education

We had as many as five PhD exams in 2011. We gave seven PhD courses of interest to our own students that also enticed external students. At the end of 2011, we were main supervisors for twelve PhD students, eight at UU and four at SLU.

4.1 Graduate courses

1. **Parallel Image Analysis, 3 hp**
   Cris Luengo
   Period: 110321–110527

2. **Application Oriented Image Analysis, 7.5 hp**
   Robin Strand, Erik Wernersson, Vladimir Curic, Ida-Maria Sintorn, Bettina Selig, Gunilla Borgefors, Petra Philipsson, Carolina Wählby, Patrik Malm
   Period: 111019–111214
   Comment: Strand organized this course. The aim of this course is to give PhD students in the other areas sufficient knowledge to be able to use image analysis in their research. The course is application oriented in the meaning that it does not go too deeply into fundamental mathematics, but concentrates on basic concepts and general methodology.

3. **Pattern Recognition, 10 hp**
   Jimmy Azar
   Period: 111027–110112

4. **Applications of X-Ray Microtomography on Heterogeneous Materials, Jyväskylä International Summer School**
   Cris Luengo
   Period: 110815–110819
   Address: University of Jyväskylä, Finland
   Comment: Luengo gave nine hours of lectures and assisted the labs.

5. **Advanced Methods on Biomedical Image Analysis (AMBIA), Summer School of Masaryk University**
   Cris Luengo, Carolina Wählby
   Period: 110828–110910
   Address: Masaryk University, Brno, Czech Republic
   Comment: Luengo and Wählby gave lectures, participated in panel discussions, and assisted the labs.

6. **Classical and Modern Papers in Image Analysis**
   Seniors at CBA
   Period: 110916–
   Comment: The second Friday of every month, one student presents a paper. Afterwards this paper will be discussed by all present. One month the paper will be a classic. The next month it will be a modern paper (from the last 5 years, but established enough to have generated sufficient attention from the community).

7. **Morphological Techniques in Reproductive Biology, 1.5 hp**
   Cris Luengo
   Period: 111013–111019
   Comment: Luengo gave one lecture on image analysis.

4.2 Dissertations

1. *Date:* 110506
   Graph-based Methods for Interactive Image Segmentation
   Student: Filip Malmberg
   Supervisor: Ingela Nyström
   Assistant Supervisor: Ewert Bengtsson
   Opponent: Jayaram K. Udupa, Medical Image Processing Group, Dept. of Radiology, University of Pennsylvania, USA
   Committee: Carolina Wählby, Örjan Smedby, Dept. of Medical and Health Sciences, Linköping University, Ghassan Hamarneh, School of Computing Science, Simon Fraser University, Burnaby, BC, Canada, Magnus Borga, Dept. of Biomedical Engineering, Linköping University, Fredrik Kahl, Mathematical Imaging Group, Centre for Mathematical Sciences, Faculty of Engineering, Lund University
   Publisher: Acta Universitatis Upsaliensis, ISBN: 978-91-554-8037-0
   Abstract: The subject of digital image, analysis deals with extracting relevant information from image data, stored in digital form in a computer. A fundamental problem in image analysis is image segmentation, i.e., the identification and separation of relevant objects and structures in an image. 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, or semi-automatic, segmentation methods use human expert knowledge as additional input, thereby making the segmentation problem more tractable. The goal of interactive segmentation methods is to minimize the required user interaction time, while maintaining tight user control to guarantee the correctness of the results. Methods for interactive segmentation typically operate under one of two paradigms for user guidance: (1) Specification of pieces of the boundary of the desired object(s). (2) Specification of correct segmentation labels for a small subset of the image elements. These types of user input are referred to as boundary constraints and regional constraints, respectively.

   This thesis concerns the development of methods for interactive segmentation, using a graph-theoretic approach. We view an image as an edge weighted graph, whose vertex set is the set of image elements, and whose edges are given by an adjacency relation among the image elements. Due to its discrete nature and mathematical simplicity, this graph based image representation lends itself well to the development of efficient, and provably correct, methods.

   The contributions in this thesis may be summarized as follows:

   - Existing graph-based methods for interactive segmentation are modified to improve their performance on images with noisy or missing data, while maintaining a low computational cost.
   - Fuzzy techniques are utilized to obtain segmentations from which feature measurements can be made with increased precision.
   - A new paradigm for user guidance, that unifies and generalizes regional and boundary constraints, is proposed.

   The practical utility of the proposed methods is illustrated with examples from the medical field.

2. *Date:* 110923
   Evaluation of Osseointegration using Image Analysis and Visualization of 2D and 3D Image Data
   Student: Hamid Sarve
   Supervisor: Gunilla Borgefors
   Assistant Supervisors: Joakim Lindblad; Carina Johansson, Institute of Odontology, The Sahlgrenska Academy, Göteborg
   Opponent: Prof. em. Albert Vossepoel, Quantitative Imaging Group, Delft University of Technology, The Netherlands
   Committee: Christina Lindh, Dept. of Oral Radiology, Faculty of Odontology, Malmö University, Carolina Wählby, Andrew Mehnert, Signals and Systems, Chalmers University of Technology, Göteborg
   Publisher: Acta Universitatis agriculturae Sueciae, ISBN 978-91-576-7605-4
   Abstract: Computerized image analysis, the discipline of using computers to automatically extract information from digital images, is a powerful tool for automating time consuming analysis tasks. In this thesis, image analysis and visualization methods are developed to facilitate the evaluation of osseointegration, i.e., the biological integration of a load-carrying implant in living bone. Adequate osseointegration is essential

in patients who are in need of implant treatment. New implant types, with variations in bulk material and surface structural parameters, are continuously being developed. The main goal is to improve and speed up the osseointegration and thereby enhance patient well-being. The level of osseointegration can be evaluated by quantifying the bone tissue in proximity to the implant in e.g., light microscopy images of thin cross sections of bone implant samples extracted from humans or animals. This operator dependent quantitative analysis is cumbersome, time consuming and subjective. Furthermore, the thin sections represent only a small region of the whole sample. In this thesis work, computerized image analysis methods are developed to automate the quantification step. An image segmentation method is proposed for classifying the pixels of the images as bone tissue, non-bone tissue or implant. Subsequently, bone area and bone implant contact length in regions of interest are quantified. To achieve an accurate classification, the segmentation is based on both intensity and spatial information of the pixels. The automated method speeds up and facilitates the evaluation of osseointegration in the research laboratories. Another aim of this thesis is extending the 2D analysis to 3D and presenting methods for visualization of the 3D image volumes. To get a complete picture, information from the whole sample should be considered, rather than thin sections only. As a first step, 3D imaging of the implant samples is evaluated. 3D analysis methods, which follow the helix shaped implant thread and collects quantified features along the path, are presented. Additionally, methods for finding the position of the 2D section in the corresponding 3D image volume, i.e., image registration, are presented, enabling a direct comparison of the data from the two modalities. These novel and unique 3D quantification and visualization methods support the biomaterial researchers with improved tools for gaining a wider insight into the osseointegration process, with the ultimate goal of improved quality of life for the patients.

3. *Date:* 111025
Spectral Image Filtering Methods for Biomedical Applications
Student: Khalid Khan M. Niazi
Supervisor: Ingela Nyström
Assistant Supervisor: Ewert Bengtsson
Opponent: Lucas van Vliet, Delft University of Technology, The Netherlands
Committee: Josef Bigun, Intelligent Systems Laboratory, Halmstad University, Gunilla Borgefors, Ulf Eriksson, Dept. of Medical Cell Biology, UU, Michael Felsberg, Computer Vision Laboratory, Linköping University, Lennart Thurfjell, GE Healthcare, Uppsala
Publisher: Acta Universitatis Upsaliensis, ISBN:978-91-554-8155-1
Abstract: Filtering is a key step in digital image processing and analysis. It is mainly used for amplification or attenuation of some frequencies depending on the nature of the application. Filtering can either be performed in the spatial domain or in a transformed domain. The selection of the filtering method, filtering domain, and the filter parameters are often driven by the properties of the underlying image. This thesis presents three different kinds of biomedical image filtering applications, where the filter parameters are automatically determined from the underlying images.

Filtering can be used for image enhancement. We present a robust image dependent filtering method for intensity inhomogeneity correction of biomedical images. In the presented filtering method, the filter parameters are automatically determined from the grey-weighted distance transform of the magnitude spectrum. An evaluation shows that the filter provides an accurate estimate of intensity inhomogeneity.

Filtering can also be used for analysis. The thesis presents a filtering method for heart localization and robust signal detection from video recordings of rat embryos. It presents a strategy to decouple motion artifacts produced by the non-rigid embryonic boundary from the heart. The method also filters out noise and the trend term with the help of empirical mode decomposition. Again, all the filter parameters are determined automatically based on the underlying signal.

Transforming the geometry of one image to fit that of another one, so called image registration, can be seen as a filtering operation of the image geometry. To assess the progression of eye disorder, registration between temporal images is often required to determine the movement and development of the blood vessels in the eye. We present a robust method for retinal image registration. The method is based on particle swarm optimization, where the swarm searches for optimal registration parameters based on the direction of its cognitive and social components. An evaluation of the proposed method shows that the method is less susceptible to becoming trapped in local minima than previous methods.

With these thesis contributions, we have augmented the filter toolbox for image analysis with methods that adjust to the data at hand.

4. *Date:* 111111
Methods for 2D and 3D Quantitative Microscopy of Biological Samples
Student: Amin Allalou
Supervisor: Carolina Wählby
Assistant Supervisors: Ewert Bengtsson, Ida-Maria Sintorn
Opponent: Jens Rittscher, GE Global Research & Rensselaer Polytechnic Institute, USA
Committee: Hans Blom, Dept. of Biomolecular Physics, Royal Institute of Technology (KTH), Ola Friman, FOI, Swedish Defence Research Agency, Linköping, Reinald Fundele, Evolutionary Biology Centre, UU, Stina Svensson, Raysearch Labs, Stockholm, Rasmus Larsen, Dept. of Informatics and Mathematical Modelling, Technical University of Denmark, Denmark
Publisher: Acta Universitatis Upsaliensis, ISBN: 978-91-554-8167-4
Abstract: New microscopy techniques are continuously developed, resulting in more rapid acquisition of large amounts of data. Manual analysis of such data is extremely time-consuming and many features are difficult to quantify without the aid of a computer. But with automated image analysis biologists can extract quantitative measurements and increases throughput significantly, which becomes particularly important in high-throughput screening (HTS). This thesis addresses automation of traditional analysis of cell data as well as automation of both image capture and analysis in zebrafish high-throughput screening.

It is common in microscopy images to stain the nuclei in the cells, and to label the DNA and proteins in different ways. Padlock-probing and proximity ligation are highly specific detection methods that produce point-like signals within the cells. Accurate signal detection and segmentation is often a key step in analysis of these types of images. Cells in a sample will always show some degree of variation in DNA and protein expression and to quantify these variations each cell has to be analyzed individually. This thesis presents development and evaluation of single cell analysis on a range of different types of image data. In addition, we present a novel method for signal detection in three dimensions.

HTS systems often use a combination of microscopy and image analysis to analyze cell-based samples. However, many diseases and biological pathways can be better studied in whole animals, particularly those that involve organ systems and multi-cellular interactions. The zebrafish is a widely-used vertebrate model of human organ function and development. Our collaborators have developed a high-throughput platform for cellular-resolution in vivo chemical and genetic screens on zebrafish larvae. This thesis presents improvements to the system, including accurate positioning of the fish which incorporates methods for detecting regions of interest, making the system fully automatic. Furthermore, the thesis describes a novel high-throughput tomography system for screening live zebrafish in both fluorescence and bright field microscopy. This 3D imaging approach combined with automatic quantification of morphological changes enables previously intractable high-throughput screening of vertebrate model organisms.

5. *Date:* 111202
Spectral Image Processing with Applications in Biotechnology and Pathology
Student: Milan Gavrilovic,
Supervisor: Carolina Wählby
Assistant Supervisors: Ewert Bengtsson, Ingrid Carlbom
Opponent: Robert F. Murphy, Ray and Stephanie Lane Center for Computational Biology, Carnegie Mellon University, USA
Committee: Caroline Kampf, Dept. of Immunology, Genetics and Pathology, UU, Rachel Errington, School of Medicine, Cardiff University, UK, Reiner Lenz, Dept. of Science and Technology, Linköping University, Michal Kozubek, Faculty of Informatics, Masaryk University, Check Republic, Anders Liljeborg, Dept. of Biomedical and X-ray Physics, Royal Institute of Technology (KTH)
Publisher: Acta Universitatis Upsaliensis, ISBN: 978-91-554-8209-1
Abstract: Color theory was first formalized in the seventeenth century by Isaac Newton just a couple of decades after the first microscope was built. But it was not until the twentieth century that technological advances led to the integration of color theory, optical spectroscopy and light microscopy through spectral image processing. However, while the focus of image processing often concerns modeling of how images are perceived by humans, the goal of image processing in natural sciences and medicine is the objective analysis. This thesis is focused on color theory that promotes quantitative analysis rather than modeling how images are perceived by humans.

Color and fluorescent dyes are routinely added to biological specimens visualizing features of interest. By

applying spectral image processing to histopathology, subjectivity in diagnosis can be minimized, leading to a more objective basis for a course of treatment planning. Also, mathematical models for spectral image processing can be used in biotechnology research increasing accuracy and throughput, and decreasing bias.

This thesis presents a model for spectral image formation that applies to both fluorescence and transmission light microscopy. The inverse model provides estimates of the relative concentration of each individual component in the observed mixture of dyes. Parameter estimation for the model is based on decoupling light intensity and spectral information. This novel spectral decomposition method consists of three steps: (1) photon and semiconductor noise modeling providing smoothing parameters, (2) image data transformation to a chromaticity plane removing intensity variation while maintaining chromaticity differences, and (3) a piecewise linear decomposition combining advantages of spectral angle mapping and linear decomposition yielding relative dye concentrations.

The methods described herein were used for evaluation of molecular biology techniques as well as for quantification and interpretation of image-based measurements. Examples of successful applications comprise quantification of colocalization, autofluorescence removal, classification of multicolor rolling circle products, and color decomposition of histological images.

4.3 Docent degree

1. *Title:* From Images to Size Distributions
   Cris Luengo
   Date: 110929
   Abstract: In this lecture I will explain how one can obtain a size distribution, such as a pore size distribution or a fibre length distribution, from an image. Starting with very simple image analysis tools, namely the operations called dilation and erosion, I will build a complex tool capable of obtaining an accurate size distribution. Dilation and erosion are the two basic operations in a discipline called mathematical morphology. These operations transform an image using a probe. The interaction of the probe with the image gives information about the morphology (spatial arrangement) of the sample. A very specific combination of these basic operations, with carefully chosen probes, yields a granulometry, a curve that is directly proportional to a size distribution. I will show how such a granulometry can be precise enough to detect very small changes in the pore sizes of a milk gel, changes too small to see by eye. Next I will construct a probe such that the granulometry yields a length distribution, and I will show how this can be used to distinguish whole from broken rice kernels. I will also introduce a fairly new algorithm, the path closing, which can be used to make the computation of the length distribution much more efficient. I will then show the result of applying this efficient algorithm to a three-dimensional micro-tomographic image of a wood fibre composite material, and discuss a strategy to correct for the bias introduced by the limited field of view of the image.
   Comment: The docent lecture was held in English at SLU, Umeå. Luengo was promoted to docent 111103.

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

5 Research

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

In this Section, we list the 57 research projects that were active during 2011. Some are large projects that have been active for a long time, while others are smaller and short-lived. We started eleven new projects this year, while eight were completed since last year.

As is obvious from the descriptions, most of the projects are carried out in close cooperation with researchers from other universities and from other research areas. In Section 5.6, we list the groups with which we have had active cooperation in 2011.

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, Material Science, Dept. of Engineering Science, UU; Jonny Gustafsson and Lars Mattson, Industrial Metrology and Optics Group, KTH; Jan-Michaél Hirsch, Dept. of Surgical Sciences, Oral & Maxillofacial Surgery, 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)
   Period: 090810–
   Abstract: Our vision is a new interaction paradigm that gives the user an unprecedented experience to touch and manipulate high contrast, high resolution, three-dimensional (3D) virtual objects suspended in space, using a glove that gives such realistic haptic feedback that the interaction closely resembles interaction with real objects. The system has two main components: The first is a haptic system comprising a glove mounted on a robot arm that gives the user force feedback during manipulation of an object. The second component is a three-dimensional display based on a holographic optical element (HOE) that permits the user to interact with a virtual object by reaching into the object with the gloved hand.

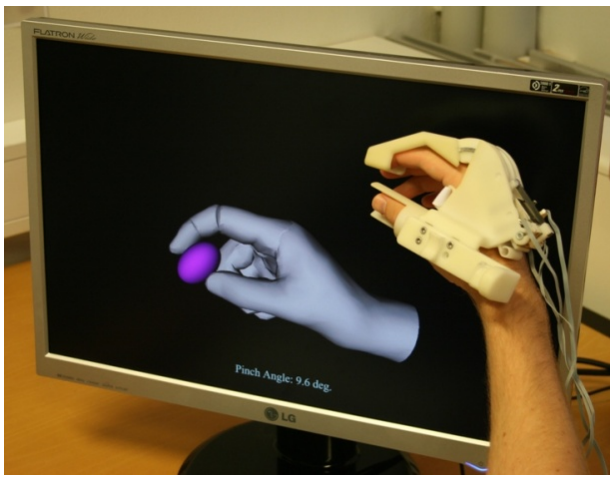
   Haptics Hardware. After experiments with the first generation glove built in 2010, we built a slimmer and lighter exoskeleton and moved the force sensor in front of the linkage to make the glove more sensitive to movements in the distal parts of the fingers. The exoskeleton prototype has six degrees of freedom (DOF) movement of the hand and one DOF gripping with the thumb and index finger. The six DOF movements are accomplished with a commercial haptic arm, the SensAble Phantom Premium, while the gripping exoskeleton "glove" is developed within this project.

   Haptics Software. One major goal of the Whole Hand Haptics Project is to allow the user to feel object stiffness. This is important to identify objects in the world around us, and it is particularly important in virtual surgery for manipulation of soft tissue. With this glove we are able to squeeze an object and feel different stiffness, something that has never to our knowledge been accomplished before with a compact glove! See Figure 2(a).

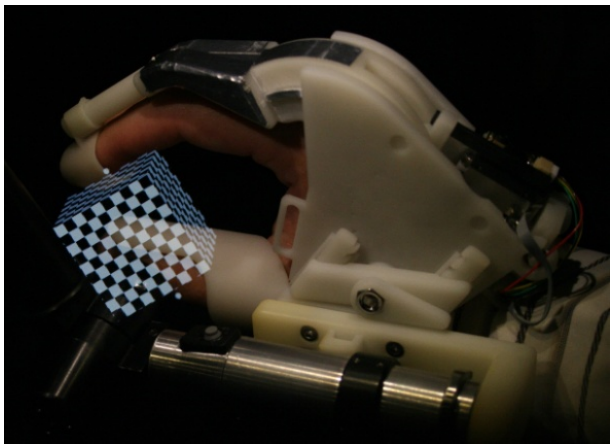
Another major goal of the Whole Hand Haptics project is to demonstrate that gripping an object with two (and later three) fingers allows object manipulation that is not feasible, or at least is very cumbersome, with one point of contact with an object. Using the haptic glove prototype, we have created software to simulate two finger interaction with a virtual object. The user may lift and manipulate the object in 3D, and a physics simulation which includes weight, inertia, and gravity adds to the realism (Figure 2(b)).

New Display Hardware. Since our goal is to develop haptics for cranio maxillo-facial surgery, we need a display system that allows relatively uncomplicated porting of WISH, our toolkit for interactive medical image analysis with volume visualization and haptics, from conventional workstations to a stereo display with co-located haptics. We chose a SenseGraphics Display 300, which is a desktop-sized stereo workstation with radio-frequency shutter glasses, a LCD-monitor, and a semi-transparent silvered mirror. Our tracking software and all our haptics now run on both the holographic display and the stereo display.

Perceptual Evaluation of Co-located and Non-co-located Haptics. We conducted a user study that investigates the pros and cons of physically co-located haptics on two different display types: the SenseGraphics half-transparent mirror 3D display and our prototype autostereoscopic display



(a)



(b)

Figure 2: (a) The user squeezes a virtual ball whose stiffness can vary. (b) The user may lift and manipulate the object in 3D: a physics simulation with weight, inertia, and gravity adds to the realism.

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, while co-location does not improve the accuracy in the spatial accuracy tasks.

Improvements to the 3D Holographic Display. This year we remade the hologram assuming a smaller interocular distance. This change enables a correct viewing experience for a larger number of people since there is now little risk that the slit width (the width of the viewing zone of one projector) is greater than the interocular distance of an adult person. At the same time the display was fine tuned to minimize some of the slit transition artifacts.

Software System. The software for both the display and the haptics is based on the H3DAPI from SenseGraphics. We extended H3DAPI with a software library that provides calibration of the graphics and all the hardware components, including (1) projector calibration with key stone correction for the HOE display; (2) haptics Phantom device calibration to find the zero position of all its sensors, which required that we manufacture a hardware jig, in addition to software development; (3) for each display, calibration of the visual and the haptic work volumes; and (4) for each display, registration of the tracking and the visual work volumes.

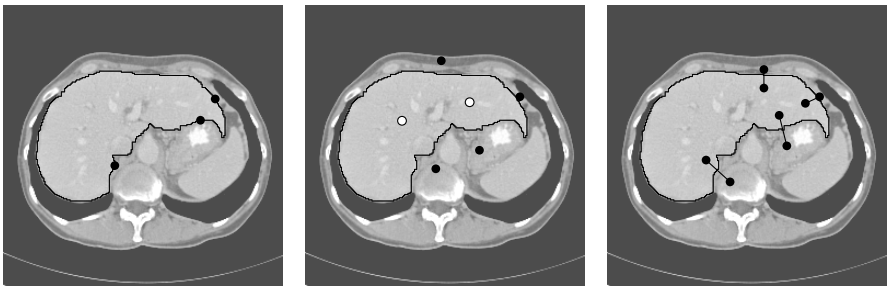
Matching and calibrating the visual work volume and the haptic work volume is essential, in particular when using co-located haptics, since humans easily become aware of discrepancies between the visual and the haptic work volumes. We acquired the OptiTrack system from Natural Point, which is an IR optical tracker with built in motion capture and image processing. We integrated the tracker camera software with our version of the H3DAPI from SenseGraphics AB.

2. **Improved Interactive Medical Image Analysis through Haptic Display Methods**
   Filip Malmberg, Ingela Nyström, Ewert Bengtsson, Stefan Seipel
   Partner: Gunnar Jansson[1], Dept. of Psychology, UU
   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 6 and 10.

   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`.

3. **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

[1]Professor Gunnar Jansson, our project partner and one of Europe's leading experts on haptic perception, sadly died on January 15, 2011.



(a) (b) (c)

Figure 3: 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.

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 labelling 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 3. 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.

This project was presented as part of the PhD thesis by Filip Malmberg that was defended in May 2011. In 2011, two papers related to this project were presented at the Scandinavian Conference on Image Analysis (SCIA) in Ystad, Sweden.

4. **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 lead 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 3). In this project, we seek to employ these methods for segmentation of medical

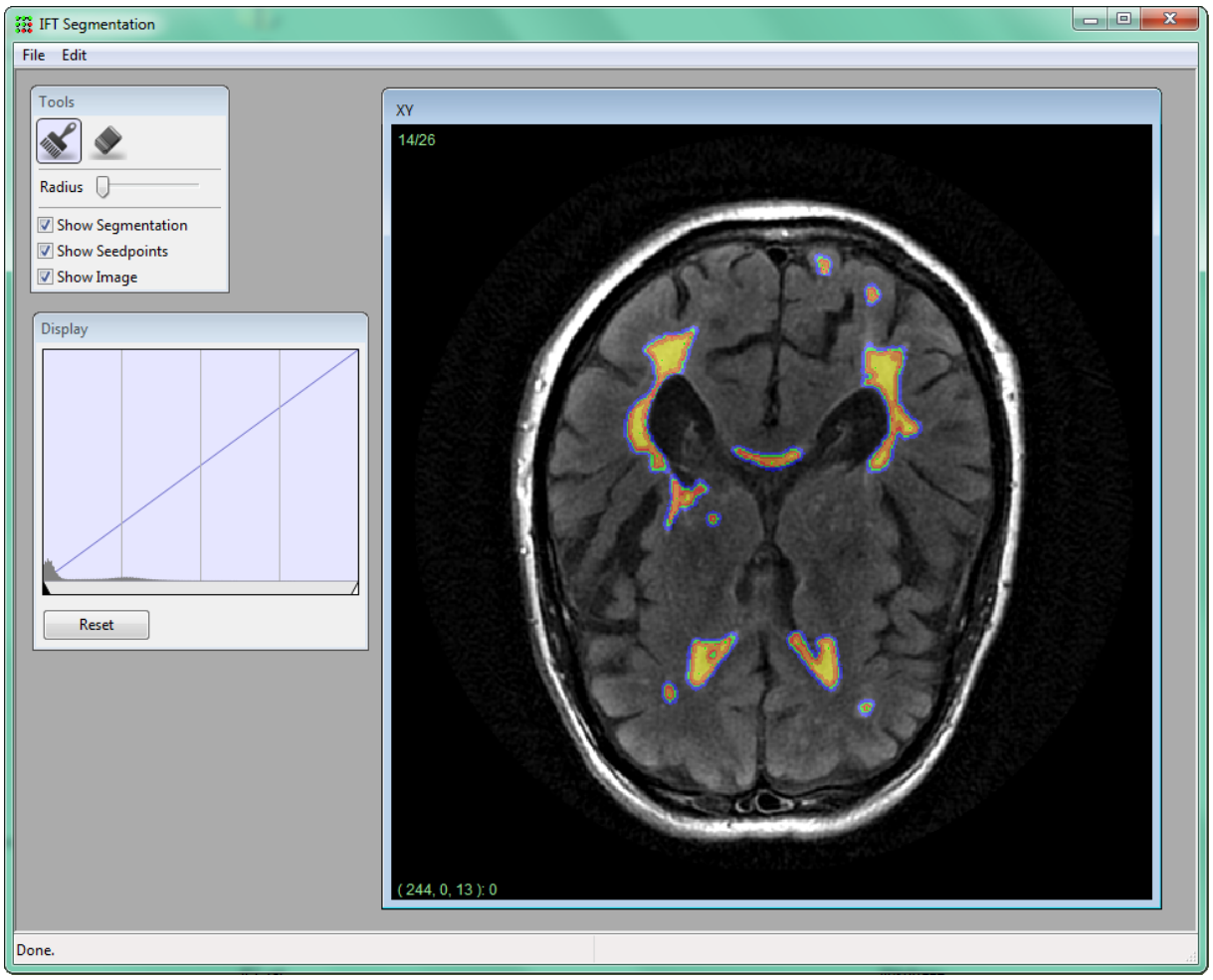


Figure 4: Screenshot from a software for interactive segmentation of volume images, developed at CBA. A radiologist segments white matter lesions in a MR image of the human brain by placing seed-points inside and outside the lesions. As the user provides additional seed-points, the segmentation is updated dynamically in real-time.

images, in collaboration with the Dept. of Radiology, Oncology and Radiation Science (ROS) at the UU Hospital.

During 2011, the software and methods developed in this project have been used in two clinical studies at the hospital: One study on measuring white matter lesions in MR images of the human brain, and one study on quantifying adipose tissue in whole-body MR images of rats. Publications describing the results of these studies are underway.

5. **ProViz – Interactive Visualization of 3D Protein Images**
   Lennart Svensson, Ida-Maria Sintorn, Johan Nysjö, Stina Svensson, 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: The traditional methods for solving the structure of proteins are X-ray crystallography and NMR spectroscopy. An alternative approach, Molecular Electron Tomography (MET), has

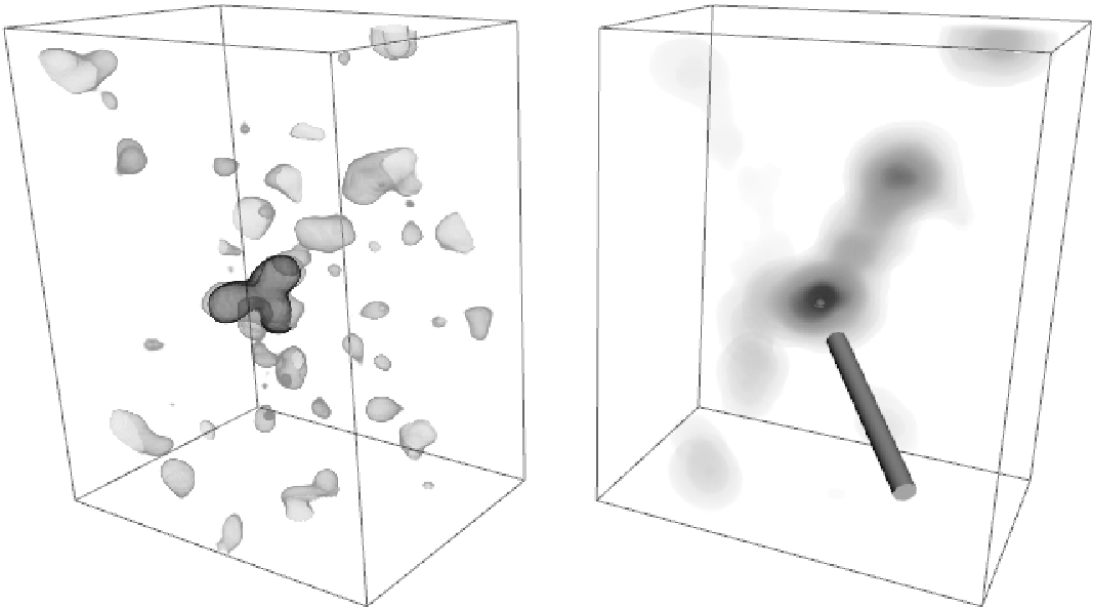


Figure 5: Interactive exploration of a MET volume (left) of the antibody IgG in solution and a *score volume* showing the fitness value of the best registration at each position. The user clicks on a point in the right volume and sees the corresponding registration in the left volume. Iso-surfaces are used to show a particular intensity level in the left volume, and dark regions show the highest scores in the right image. The IgG template appear in the middle of the MET volume in dark grey.

more recently gained interest within the field of structural biology as it enables studies of both the dynamics of proteins and individual macromolecular structures in tissue. However, MET results in images of low resolution, as compared with e.g., X-ray crystallography, and low signal-to-noise ratio. This creates a need for the new visualization and analysis methods developed in this project.

We have developed a method for automatic parameter estimation for proper visualization of MET volumes, as well as an interactive registration method where the fitness landscape is explored interactively, see example in Figure 5. A paper about the latter method was presented at the International Conference on Image Analysis and Processing (ICIAP 2011) in Italy in September. A continuation investigating different implementation techniques has been accepted to 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.

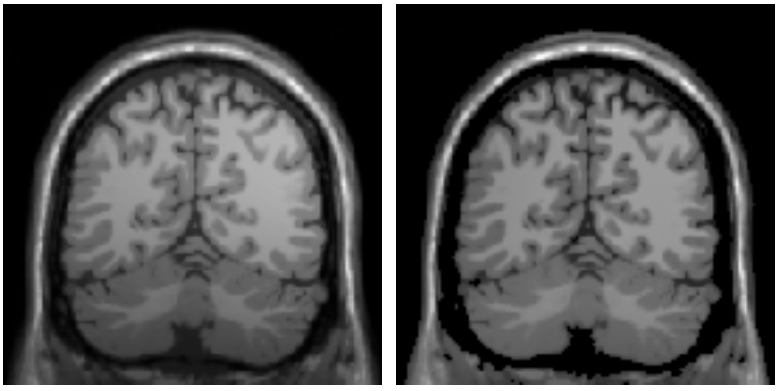
6. **Orbit Segmentation for Craniomaxillofacial Surgery Planning**
   Johan Nysjö, Filip Malmberg, Ewert Bengtsson, Ingela Nyström
   Partners: Jan Michael Hirsch, Elias Messo, Babett Williger, Dept. of Surgical Sciences, UU Hospital
   Funding: TN-faculty, UU; NovaMedTech
   Period: 0912–
   Abstract: 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.

In 2011, this project was presented at the International Visual Information Conference (IVIC) in Malaysia by Nystrm as invited speaker. We have also started investigating other applications for the system, e.g., volumetric measurements of the airway space in cone beam CT images.

7. **Illumination Correction in Medical Images**
Khalid Niazi, Ingela Nyström
Partners: M. Talal Ibrahim, Ling Guan, Ryerson Multimedia Lab, Ryerson University, Canada
Funding: COMSATS IIT, Islamabad
Period: 1003–
Abstract: Non-uniform illumination is considered as one of the major challenges in the field of medical imaging. It is often caused by the imperfections of the data acquisition device and the properties of the object under study. We have developed an iterative method which suppresses the magnitude of the frequencies that are responsible for non-uniformity in an image using the gray-weighted distance transform (GWDT). Moreover, the proposed method is not user dependent as all the parameters are automatically generated on the basis of the GWDT. It is tested on images acquired from several imaging modalities which makes it different and unique from most of the existing methods. See Figure 6.

This project was presented as part of the PhD thesis by Khalid Niazi that was defended in November 2011.



(a) (b)

Figure 6: a) A slice from an MRI suffering from non-uniform illumination. b) Result of the proposed method in Project 7.

8. **Analysis of Dynamic Breast MRI**
   Ewert Bengtsson, Ingela Nyström
   Partners: Stuart Crozier, Andrew Mehnert, School of Information Technology and Electrical Engineering, University of Queensland, Brisbane, Australia and MedTech West, Chalmers and Sahlgrenska University Hospital
   Funding: TN-faculty, UU; The Australian Research Council
   Period: 0503–
   Abstract: The pattern of change of signal intensity over time in dynamic contrast enhanced magnetic resonance images (DCE-MRI) of the breast is an important criterion for the differentiation of malignant from benign lesions. Malignant lesions release angiogenic factors which induce the growth and sprouting of existing blood vessels and the formation of new leaky vessels. This gives rise to increased inflow and an accelerated extra-vascularisation of contrast agent at the tumour site which is reflected as T1-weighted signal increase. However strong enhancement is not specific to malignant lesions. Contrariwise shallow or no enhancement is a feature of some malignant lesions. As a result the specificity of the technique is poor to moderate. This project is seeking to improve the specificity of breast MRI, and therefore its clinical utility mainly by means of computer visualization, image analysis, and statistical pattern recognition. This collaborative project started when Bengtsson was on sabbatical at the University of Queensland in 2004-2005 and has since then produced a number of results e.g. on parametric modelling of contrast enhancement, 3D colour-coding of 4D DCE-MRI data, hardware-accelerated volume visualization and haptic interaction/interrogation of the volumetric data. Due to Mehnert's move to Sweden the activity has been low during 2011, but we have plans to continue the collaboration on the project.

9. **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 reduces 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 aliasing errors on the fcc, bcc, and cubic grids was presented at 8th International Conference on Large-Scale Scientific Computations (LSSC), Sozopol, Bulgaria.

10. **Haptic-enabled 3D Angle Measurements in CT Wrist Images**
    Johan Nysjö, Filip Malmberg, Ingela Nyström, Ida-Maria Sintorn
    Partners: Albert Christersson, Dept. of Surgical Sciences, 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. Figure 7 shows a prototype of the system.

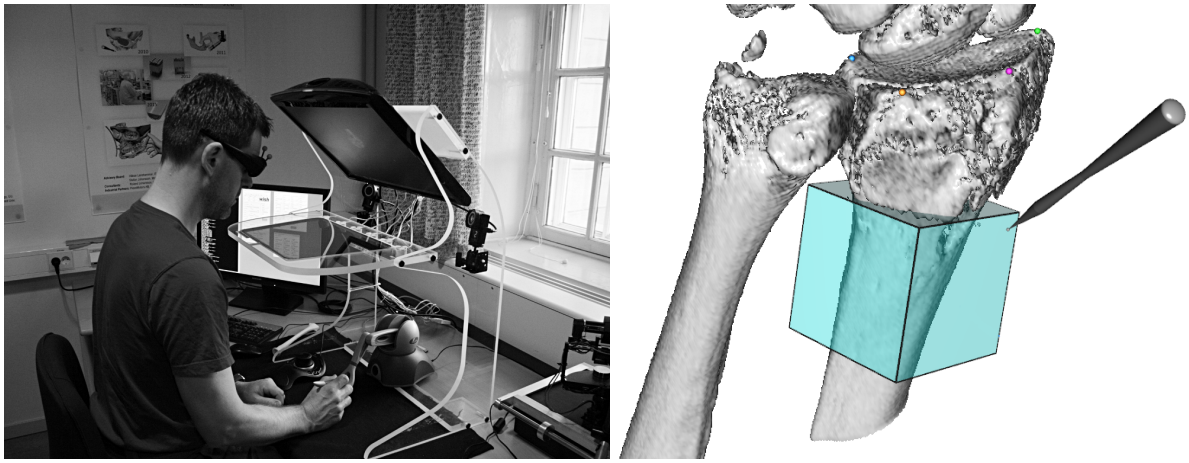


Figure 7: (Left) A user working at the visuo-haptic display. (Right) A volume selection tool used to estimate the central long axis of the radius bone.

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 2011 we did not produce any new publications mainly due to Anders Hast sabbatical in Italy but a number of new mathematical results were obtained that are expected to lead to publications in 2012.

12. **Ubiquitous Visualization in the Built Environment**
Stefan Seipel, Fei Liu
Funding: University of Gävle and 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.

5.2 Analysis of microscopic biomedical images

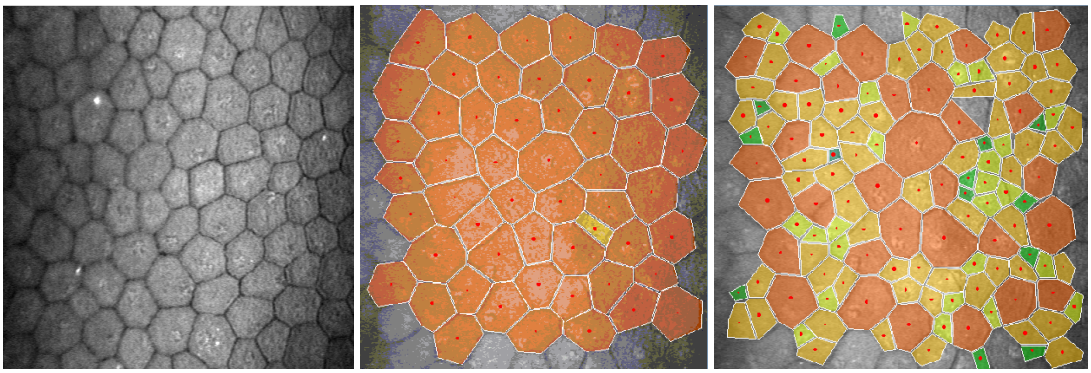
13. **CerviScan**
Ewert Bengtsson, Patrik Malm, Hyun-Ju Choi, Bo Nordin
Partners: Rajesh Kumar, CDAC, Centre for Development of Advanced Computing, Thiruvananthapuram, India and K Sujathan, Regional Cancer Centre, Thiruvananthapuram, India.
Funding: Swedish Governmental Agency for Innovation Systems (Vinnova) and Swedish Research Council
Period: 0801–
Abstract: Cervical cancer is killing a quarter million women every year. Screening based on so called PAP-smears have proven very effective to reduce cancer mortality but require much work of well trained cytotechnologist. For 50 years research to automate the screening has been in progress, Bengtsson was very active in this field 1973-1993. Since about 10 years, commercial automated systems have been in operation but unfortunately those systems have many limitations. In India there is no effective screening program in operation and around 70,000 women die from the disease each year. Now an effort to develop a screening system adapted to Indian situation is in progress at the research institute CDAC in Thiruvananthapuram, Kerala in cooperation with the RCC, Regional Cancer Centre there. Based on our earlier experience in the field we are cooperating with this project and we have received support from Vinnova and VR for this. At CDAC they have developed a program for data collection which so far has been used at RCC to collect image data from around 800 patients. They have also developed an overall framework for the screening including image segmentation, artifact rejection, feature extraction and cell and specimen classification. They are currently evaluating the performance and working on improving the various parts of the system as needed. We are in particular 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 are scanning the cells at 40 different focus levels creating stacks of data for each cell nucleus. Dr Sujathan spent two weeks in Uppsala in October 2010 and another two weeks in October 2011 to collect image stacks and annotate cell nuclei with labels indicating the biological "ground truth" to be used for training and testing our classifiers. Dr Hyun-Ju Choi from Korea who was a post-doc at CBA 2008-2010 has studied 3D nuclear texture for other applications and we are currently evaluating her approaches for this purpose. In November 2011 we started collaboration with Andrew Mehnert at MedTech West, Chalmers through which the texture approaches he developed in his PhD thesis will be applied and evaluated. We have also implemented several other feature extraction methods and adapted them for our data stacks. Bengtsson spent the first week of 2011 in Thiruvananthapuram discussing in detail how our approaches could be integrated. These discussions continued in October 2011 when a delegation from CDAC visited CBA.

14. **Tracking of Unstained Cells in Microfluidic Systems**
Martin Simonsson, Carolina Wählby
Partners: Johen Kreuger, Sara Thorslund, Gradientech AB, Uppsala
Funding: SciLife Lab Uppsala
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.

15. **Detection and Classification of Malaria Infected Cells by LED Specral Microscopy**
Carolina Wählby
Partners: Jeremie Zoueu, Olivier Bagui, Dept. Genie Electrique et Electronique, Institut National Polytechnique, Felix Houbhouet-Boigny, Cote d' Ivoire
Period: 1109–
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.

16. **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.

17. **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



(a) (b) (c)

Figure 8: (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).

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 8) 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.

18. **Spectral Image Analysis in Biomedical Applications**
Milan Gavrilovic, Carolina Wählby
Partners: Irene Weibrecht, Tim Conze, Ola Söderberg, Ulf Landegren, Dept. of Genetics and Pathology, UU
Funding: TN-faculty, UU
Period: 0807–
Abstract: Our previously published novel methods for quantification of colocalization are applied to a number of projects in collaboration with the Molecular Tools group at the Dept. of Genetics and Pathology. The aim is detection of multi-color rolling circle products representing DNA-protein interactions in wide-field fluorescence microscopy images, as recently published (Weibrwcht et al., New Biotechnology). In addition, we use the methods for evaluation of biochemical methods relevant in early stages of specimen preparation, e.g., estimating the quality of oligonucleotides, as presented in (Gavrilovic et al., Cytometry).

19. **Optical Computer Tomography and Automation of Animal Positioning and Brain Cell Counting in Zebrafish**
Amin Allalou, Carolina Wählby
Partners: Carlos Pardo, Mehmet F. Yanik, Research Laboratory of Electronics,
Massachusetts Institute of Technology, Cambridge, USA
Funding: TN-faculty, UU, The Swedish Research Council, Collaboration Grant, Medicine
Period: 1009–
Abstract: The research collaboration initiated during 2010 continued with more visits to MIT, Cambridge, USA, during 2011. A high-throughput platform for cellular resolution in vivo chemical and genetic screens on zebrafish has been developed at MIT, Cambridge, USA. The system automatically loads zebrafish larvae and positions and rotates them for high-speed confocal imaging. The number of neurons in the fish is of importance to different screens and therefore a method

has been tested to count the number of neurons in certain regions of the zebrafish brain. In addition, some methods have been developed to rotate and align the fish correctly before imaging, as published in (Chang et al., Lab. Chip). The automated rotational positioning also inspired the development of optical computer tomography methods for accurate and precise 3D volume rendering of zebrafish embryos, currently under development.

20. **Multicolor Read-Out Increases the Dynamic Range of in situ PLA**
Amin Allalou, Ida-Maria Sintorn, Carolina Wählby
Partners: Carl-Magnus Clausson, Ola Söderberg, Dept. of Genetics and Pathology, UU
Funding: TN-faculty, UU; VINNMER programme, Swedish Governmental Agency for Innovation Systems
Period: 1002–
Abstract: A novel approach to increase the dynamic range of in situ PLA has been developed at Dept. of Genetics and Pathology, UU. Using several probes with different concentrations the dynamic range can be extended significantly. Signal detection previously developed at CBA, UU, (3DSWD) is used to quantify the number of signals in the different concentrations (Clausson et. al. Nature Methods).

21. **Analysis of Rat Embryos**
Khalid Niazi, Ewert Bengtsson
Partners: Mats Nilsson, Lennart Dencker, Div. of Toxicology, Dept. of Pharmaceutical Biosciences, UU; Bill Webster, School of Medical Sciences, University of Sydney, Australia
Funding: Swedish Research Council with Lennart Dencker as PI, COMSATS IIT, Islamabad
Period: 0711–1111
Abstract: Embryo cultures of rodents is an established technique for monitoring adverse effects of chemicals on embryonic development. The cultures are assessed both morphologically looking for changes in the development of various organ structures and through analysis of the heart rate of the embryo where irregularities are a sign of adverse influences of the tested drug.

The heart rate was determined through fully automated image analysis of video sequences. After finding the heart location in the image through spatio-temporal image analysis we modeled the movement of the heart as a sinusoid which was analyzed using Emperical Mode Decomposition (EMD). We used EMD with slight modification along with Laplacian Eigenmaps to detect the periodic activity. The normal embryo's heart activity can easily be detected by local maxima detection but it becomes a challenging task once the heart activity becomes abnormal. The developed methods functions well and are being used by our pharmacological partners.

We also studied how the currently used subjective, semi-quantitative (categorical, score) assessment of the morphological development could be made more objective and quantitative. We initially created automatically extracted descriptors for the different organs that were to be related to the subjective assessments. The outcome of this needs to be evaluated further.

This project was presented as part of the PhD thesis by Khalid Niazi that was defended in November 2011.

22. **Parallax Error Correction in Retinal Image Registration**
Khalid Niazi, Bettina Selig, Ewert Bengtsson, Ingela Nyström
Partner: Albert Alm, Dept. of Neurosciences, UU
Funding: COMSATS IIT, Islamabad
Period: 0711–
Abstract: Retinal imaging is one of the main sources in ophthalmology to study the optical nerve head and the retina. Retinal images are often used for analyzing, diagnosing and treating a number

of diseases of the human retina. Image registration plays an important role in determining the progression of retinal illness. In the current project, we are developing a method which will help in evaluation of glaucoma progression. We are especially concentrating on correction of parallax error, which is normally produced due to a change in the angular position of the camera.

Retinal image registration can be performed between either the full images or within sub-regions. The movement of vessels makes it illogical to perform registration between full images. Using a sub-region which is least effected by vessel movement will present a true picture of the vessel movement. The vessels inside the optic disc, which lie close to the origin, move with time and often get over-exposed during imaging. It has also been reported that the end of the vessel gets detached from the surface of the retina due to loss of the nerve fibers, which leaves us to use the area around the border of the optic disc. We have used the conventional particle swarm optimization (PSO) algorithm which uses uniform distribution to update the velocity equation. Subsequently, we have modified the PSO algorithm which utilizes benefits from the Gaussian and the uniform distribution, when updating the velocity equation. Which one of the distributions is selected depends on the direction o f the cognitive and social components in the velocity equation. This direction checking and selection of the appropriate distribution provide the particles with an ability to jump out of local minima. The registration results achieved by this new version proves the robustness and its ability to find a global minimum.

This project was presented as part of the PhD thesis by Khalid Niazi that was defended in November 2011.

23. **Automatic, Quantitative Malignancy Grading of Prostate Cancer using Image Analysis**
Ingrid Carlbom, Milan Gavrilovic, Ewert Bengtsson, Jimmy Azar
Partners: Christer Busch, Marene Landström, Dept. of Genetics and Pathology, UU Hospital
Funding: Swedish Research Council
Period: 1001–
Abstract: Prostate cancer diagnosis is based on Gleason grading, which is the most widely used system for determining the severity of prostate cancer from tissue samples. However, Gleason grading is highly subjective with significant variation between experienced pathologists, which studies show may be as high as 30-40%. We propose to replace subjective diagnosis of prostate cancer with automatic severity grading using a combination of tissue staining and image analysis. The goal of this research is to identify and separate slow-growing cancer from more aggressive types, thereby helping to reduce needless radical treatment of the disease. Currently about 70% of patients with localized prostate cancer receive aggressive treatment that does not prolong life but often results in debilitating side effects.

We have developed an automatic (blind) method, referred to as the BCD (Blind Color Decomposition) method, for color decomposition of histological images acquired with a RGB camera. The method decouples intensity from color information and bases the decomposition only on the tissue absorption characteristics of a specific stain. When a stain does not absorb light but rather scatters light, we automatically remove the areas affected by that stain from the image prior to color decomposition. By modeling the CCD sensor noise with statistical techniques, we improve the method's accuracy. We extend current linear decomposition methods to include stained tissues where one of their spectral signatures cannot be separated from all combinations of the other tissues' spectral signatures. The result of the method is a set of density maps, one for each stained tissue type, which classifies portions of pixels into the correct stained tissue thereby reducing aliasing artifacts (See Figure 9). Comparisons with current color decomposition methods demonstrate that our method outperforms methods in the literature, giving a 92% median correlation with ground truth as compared to other published methods that give up to 81% median correlation. The BCD

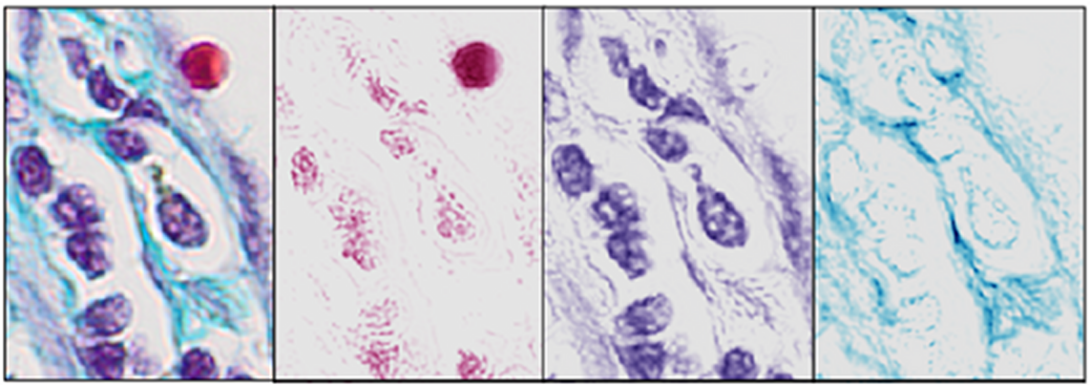


Figure 9: Color decomposition of stained prostate tissue (left), and three density maps (right).

method produces highly accurate density maps that can be used for identification of morphological features that are linked to cancer. This work resulted in a US provisional patent application.

During 2010, we developed a new staining method combining histochemical and immunohistochemical stains, making it possible to discriminate between normal glandular structures and infiltrating cancer. We have continued to develop stains that also give a color decomposition into density maps which enable highly accurate measurements of morphological features for determining the malignancy grade. We are in the process of evaluating several stains using methods for quantitative determination of the efficacy of stain/tissue combinations.

We developed a simple, computationally efficient, automated method for accurate detection and localization of cores in tissue microarray images (TMAs), which is based on geometric restoration of core shapes in microarray images without 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 present in the image wherefrom 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 the core regardless of the precise shape of the core. The method was tested on over 32 TMA images comprising over 2300 cores. The results show that the proposed method is able to reconstruct the location of the cores without any evidence of localization error even if only a partial core is included in the slide. Furthermore, an assessment of the computational efficiency of the algorithm shows it to be far more efficient than existing methods based on the Hough transform for circle detection.

24. **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
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.

25. **High Content Analysis (HCA) Method Development for Cellular Screening**
Ida-Maria Sintorn
Partners: Adrian Baddeley, Michael Buckley, Leanne Bischof, CSIRO Mathematical and Information Sciences, Australia; Stephen Haggarty, Broad Institute of Harvard and MIT, USA
Funding: S-faculty, SLU; VINNMER programme, Swedish Governmental Agency for Innovation Systems
Period: 0901–
Abstract: In biological research and in the drug development process when screening for new drugs, HCA systems are often used. Such a system is a fully automatized microscopy system that acquires hundreds or thousands of images in an experiment and automatically extracts information from the image data. In this project we have developed pre-processing tools to allow for improved comparison of image content within and across cellular screening experiments. We also develop methods and new statistical analysis tools for so called co-culture HCA experiments i.e., when more than one celltype are cultured together to allow for investigating their interaction in response to added substrates. During 2011 Sintorn spent three weeks at the Broad Institute as a guest researcher working on this project.

26. **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–
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.

27. **Identification of Highly Pathogenic Viruses in Transmission Electron Microscopy Images**
Gustaf Kylberg, Ida-Maria Sintorn, Ewert Bengtsson, Gunilla Borgefors
Partners: Vironova AB, Stockholm; Delong Instruments, Brno, Czech Republic; Ali Mirazimi, Kjell-Olof Höglund, Swedish Institute for Communicable Disease Control (SMI); Jan-Olof Strömberg and Joel Andersson, Dept. of Mathematics, KTH
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 28 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. 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 un-

derstanding of the discriminant power of the features under different conditions. Figure 10 shows the texture of 15 virus types.

A paper evaluating the segmentation method was accepted to Journal of Microscopy in 2011. Work on texture features was presented at the 16th Iberoamerican Congress on Pattern Recognition (CIARP) 2011 in Pucón, Chile.

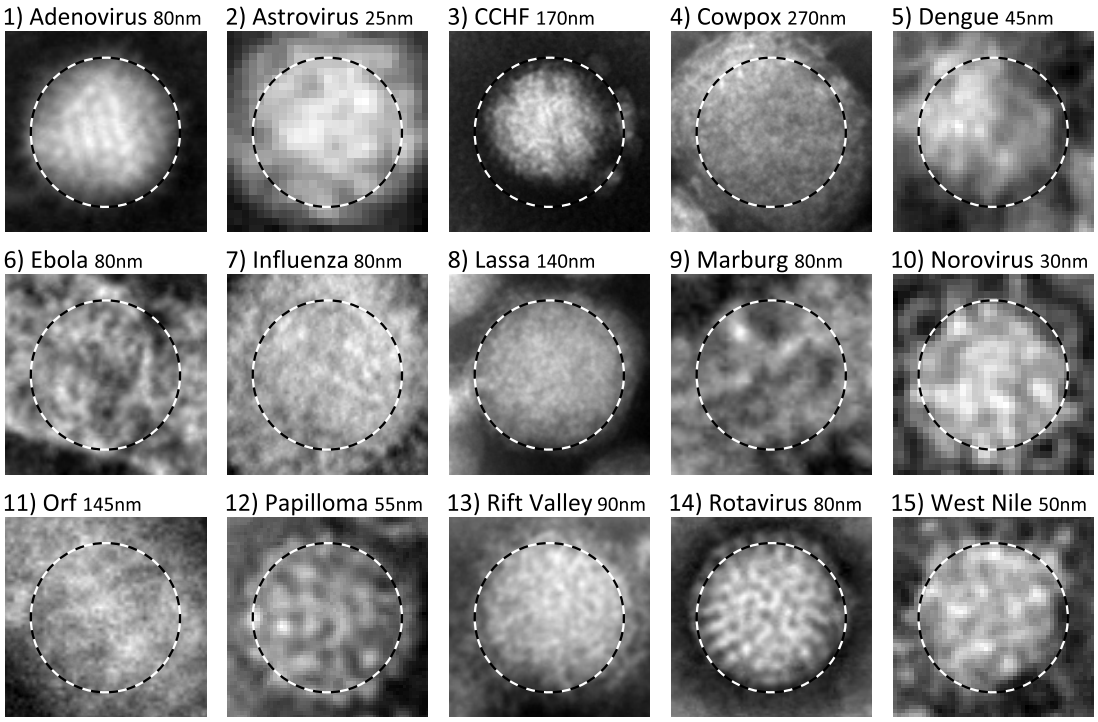


Figure 10: Examples of 15 virus textures. Texture features are computed from the area inside the dashed circles. The position of the circles are automatically selected from previously segmented objects.

28. **Detection of Regions of Interest for Automated Image Acquisition in Virus Identification**
Gustaf Kylberg, Ida-Maria Sintorn, Ewert Bengtsson, Gunilla Borgefors
Partners: Vironova AB, Stockholm; Delong Instruments, Brno, Czech Republic; Ali Mirazimi, Kjell-Olof Höglund, Swedish Institute for Infectious Communicable Control (SMI); Gun Frisk and Monika Hodik, Dept. of Immunology, Genetics and Pathology, UU
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 highly magnified 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 highly magnified images need to be acquired is estimated to be reduced with more than 99.99%.

As of mid 2011 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.

29. **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, see Figure 11. We use a level set based active contour method to delineate the lumen border and classical classification scheme to detect the seminiferous border.

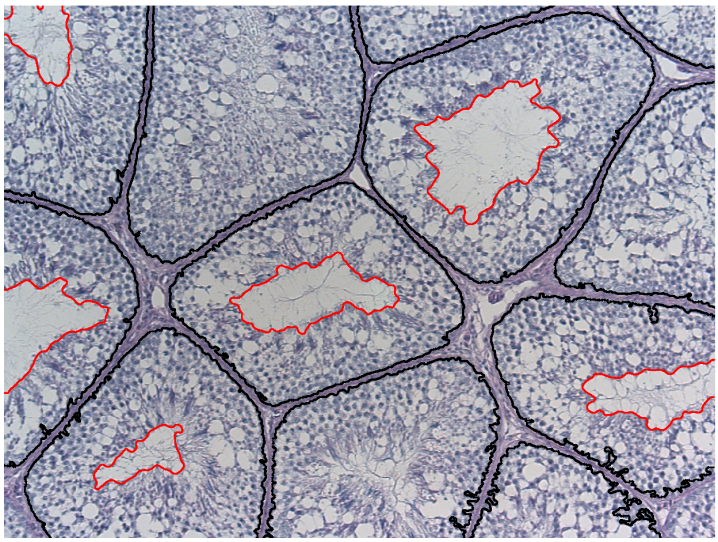


Figure 11: Cross section of the testis, H & E stained. Our algorithm delineates the seminiferous tubules border (in black) and lumen border (in red).

30. **New Objective Quantitative Analysis Techniques for Quantification of Tissue Regeneration Around Medical Devices**
Hamid Sarve, Joakim Lindblad, Vladimir Curic, Gunilla Borgefors
Partners: Carina Johansson, Dept. of Clinical Medicine, Örebro University/Institute of Odontology, The Sahlgrenska Academy, Gteborg; Nataša Sladoje, Faculty of Technical Sciences, University of Novi Sad, Serbia
Funding: Swedish Research Council; S-faculty, SLU
Period: 0503–
Abstract: With an aging and increasingly osteoporotic population, bone implants are becoming more important to ensure the quality of life. In order to evaluate how tissue reacts on implants, the

interface at the implant and tissue must be studied. Today, this is done manually in a microscope which is a costly and time-consuming procedure.

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

The project encompasses parallel development and comparison of methods for 2D analysis of histological sections as well as 3D analysis of SRμCT volumes. Within the project, methods for segmentation and feature extraction have been developed for both 2D histological sections, and 3D SRμCT volumes. To facilitate comparison of results from the two imaging modalities, a 2D-3D image registration method has also been developed. Furthermore, another significant contribution has been the development of methods for extraction of the 3D features from the 3D volume data. A thesis, titled Evaluation of Osseointegration using Image Analysis and Visualization of 2D and 3D Image Data, which was based on the methods described above were defended by Hamid Sarve in 2011.

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

We base the visualization on data from non-destructive 3D SRμCT imaging; this technique yields more accurate tomographic reconstruction at higher resolution compared to standard CT. Furthermore, SRμCT-imaging is more suitable for samples containing metal, as the artefacts caused by the metal is significantly lower compared to traditional CT. Existing visualization software are not really useful for this type of complex and highly detailed data, requiring the development of special purpose methods and software.

The combination of this project and project 30 will improve both quantitative and qualitative analysis of bone implant integration and thereby support the development of more effective implants and diminish the number of malfunctioning devices.Two new methods for visualizing SRμCT-scanned volume samples were presented at the International Conference on Computer Vision and Graphics (ICCVG'10); one being an animation that follows the implant thread and extracts information about the bone-implant integration over the whole sample and the other a 2D unfolding that displays a flattened version of the implant surface, with feature information projected onto it, providing a direct overview of the implant integration (see Figure 12). The methods were applied on real clinical data; they were applied in a case study involving retrieved human oral implants. As the case study showed, the use of 3D techniques highlighted the complexity of osseointegration and provided information other than the 2D analysis on histological images. The visualization

techniques were further discussed in Hamid Sarve's thesis, Evaluation of Osseointegration using Image Analysis and Visualization of 2D and 3D Image Data, defended in 2011.

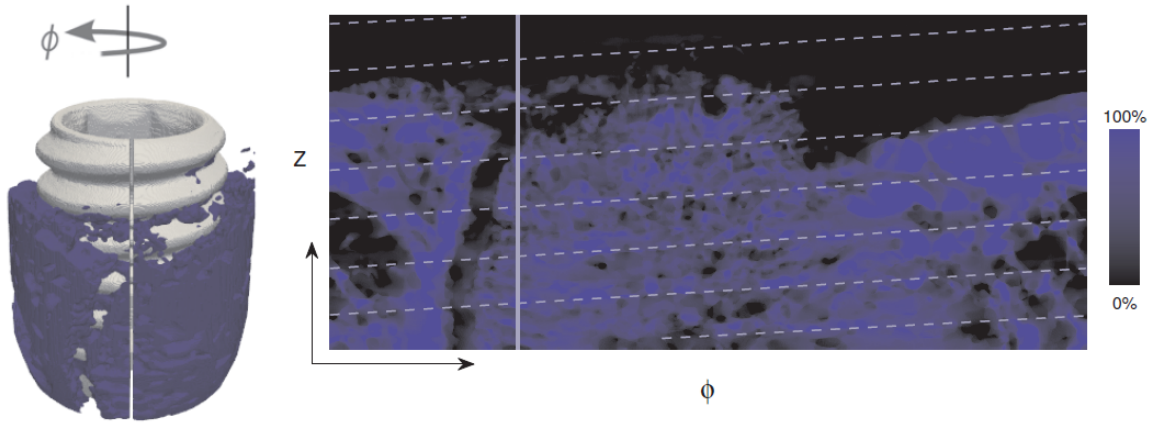


Figure 12: (Left) Rendered surface of the implant with bone tissue volume in the region of interest superimposed. (Right) The unfolded surface, where the blue regions indicate high concentration of bone tissue (see the bar to the right). White dashed lines show the peaks of the threads. The vertical line indicates the corresponding angles in the two images.

32. **Combating Breast Cancer by Digital Pathology**
Andreas Kårsnäs, Robin Strand, 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.

5.3 Theory: discrete geometry, volumes and fuzzy methods

33. **Adaptive Mathematical Morphology**
Vladimir Curic, Cris Luengo, Gunilla Borgefors
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.

An initial goal of this project is to develop a new method for spatially adaptive structuring elements and to further investigate adaptive morphological operators. 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. We intend to further develop new methods for adaptive structuring elements as well as to extend this work towards multi-valued images and sparse image representations. In addition, we plan to study the usefulness of salience adaptive structuring elements in granulometries.

34. **Anti-Aliased Euclidean Distance Transform**
Robin Strand
Partner: Stefan Gustavson, Media and Information Technology, Dept. of Science and Technology, Linköping University
Funding: TN-faculty, UU
Period: 0904–
Abstract: A binary image holds no information on the sub-pixel position of the edge of a sampled object since each sample is considered to be either fully inside or fully outside the object. Therefore, distance values for traditional distance transforms are constrained to values attained in an integer grid. In this project, a model where the intensity values represent the area coverage (the fraction of the pixel that meet the object) is used to approximate the position of the object contour. We assume that the area sampled object is binary and has a smooth contour. When the assumptions are met, we get a distance transform with higher accuracy compared to traditional methods.

35. **The Minimum Barrier Distance**
Robin Strand, Filip Malmberg
Partner: Punam K. Saha, Dept. of Electrical and Computer Engineering and the Dept. of Radiology, University of Iowa, IA, 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. 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.

36. **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).

37. **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 2011, we published two journal papers and two conference papers on this subject. For example, a survey paper on digital distance functions on three-dimensional grids and a paper on neighborhood sequences in a hexagonal grid.

38. **Image Processing and Analysis of 3D Images in the Face- and Body-Centered Cubic Grids**
Robin Strand, Gunilla Borgefors
Partner: Benedek Nagy, Dept. of Computer Science, Faculty of Informatics, University of Debrecen, Debrecen, Hungary
Funding: TN-faculty, UU; S-faculty, SLU
Period: 0308–
Abstract: The main goal of the project is to develop image analysis and processing methods for volume images digitized in non-standard 3D grids. Volume images are usually captured in one of two ways: either the object is sliced (mechanically or optically) and the slices put together into a volume or the image is computed from raw data, e.g., X-ray or magnetic tomography. In both cases, voxels are usually box-shaped, as the within slice resolution is higher than the between slice distance. Before applying image analysis algorithms, the images are usually interpolated to the cubic grid. However, the cubic grid might not be the best choice. In two dimensions, it has been demonstrated in many ways that the hexagonal grid is theoretically better than the square grid. The body-centered cubic (bcc) grid and the face-centered cubic (fcc) grid are the generalizations to 3D of the hexagonal grid. The fcc grid is a densest packing, meaning that the grid points are positioned in an optimally dense arrangement. The fcc and bcc grids are reciprocal, so the Fourier transform on an fcc grid results in a bcc grid. In some situations, the densest packing (fcc grid) is preferred in the frequency domain, resulting in a bcc grid in spatial domain.

In 2011, mainly papers on distance functions have been published in this project, see Project 37. See also Project 9.

39. **Skeletonization in 3D Discrete Binary Images**
Robin Strand, Ingela Nyström, Gunilla Borgefors
Partner: Gabriella Sanniti di Baja, Istituto di Cibernetica, CNR, Pozzuoli, Italy
Funding: TN-faculty, UU; S-faculty, SLU
Period: 9501–
Abstract: Skeletonization is a way to reduce dimensionality of digital objects. A skeleton should have the following properties: topologically correct, centred within the object, thin, and fully reversible. In general, the skeleton cannot be both thin and fully reversible. We have been working on 3D skeletonization based on distance transforms for the last decade.

By finding the set of centers of maximal balls (CMBs) and keeping these as anchor-points in the skeletonization process, the reversibility is guaranteed. In 2011, a paper by Strand on CMBs and some related concepts was presented at the international conference on discrete geometry for computer imagery (DGCI) in Nancy.

40. **Spel Coverage Representations**
Joakim Lindblad, Vladimir Curic, Filip Malmberg
Partners: Nataša Sladoje, Faculty of Technical Sciences, University of Novi Sad, Serbia; Attila Tanacs, Csaba Domokos, and Zoltan Kato, Dept. of Computer Science, Szeged University, Hungary
Funding: S-faculty, SLU; Graduate School in Mathematics and Computing (FMB)
Period: 0801–1112
Abstract: This project concerns the study and development of partial pixel/voxel coverage models for image object representation, where spatial image elements (spels) are allowed fractional coverage by the object. The project involves both development of methods for estimation of partial spel coverage (coverage segmentation) as well as development of methods for properly utilizing the information contained in such segmented images (feature extraction). The project builds on previous experience and knowledge from more general fuzzy representations, where the restriction to coverage representations enables derivation of strong theoretical results.

41. **Set Distances and their Application in Image Analysis**
Vladimir Curic, Joakim Lindblad, Hamid Sarve, Gunilla Borgefors
Partner: 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. Of particular interest are properties of monotonicity and continuity.

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. This work is submitted for a journal publication.

We extended the proposed set distance for crisp sets to a distance between fuzzy sets and observed the improved registration performance when utilizing fuzzy object representations, as compared to using a crisp object representation of the same resolution. Results of this study were presented at the 14th International Workshop on Combinatorial Image Analysis (IWCIA2011).

42. **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 microCT images of composite materials where curvature can be used as a descriptor of several local properties of wood fibres.

During 2011, some of the project findings were presented at the 3DIMPVT conference in Hangzhou, China.

5.4 Forestry related applications

43. **Three-dimensional Paper Sheet Structure Analysis Based on Image Analysis**
Catherine Östlund
Partner: Innventia, Stockholm
Funding: VINNMER programme, Swedish Governmental Agency for Innovation Systems
Period: 0901–
Abstract: Studies of paper sheet structure characterisation, e.g. the distribution of fibres, fibre flocs and the void areas between them, can be made using beta radiography or by splitting the paper in layers and study each layer, or by studying the cross-section of the paper. The three-dimensional (3D) structure of the sheet can from such data in some cases be estimated. The focus of this research project is to propose 3D paper structure analysis methods based on image analysis, and to compare the results from two-dimensional analysis methods to those achieved with a 3D method. An X-ray microtomograph is used for studying 3D images.

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
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 Radiation Synchrotron 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.

Two papers were submitted during 2011, one on measuring the fibre length distribution in composites from micro-CT images, and one on swelling of fibres in a composite due to moisture uptake. An overview article on characterization of nanofibrillated wood fibres appeared in the book Nanocomposites and Polymers with Analytical Methods.

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
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

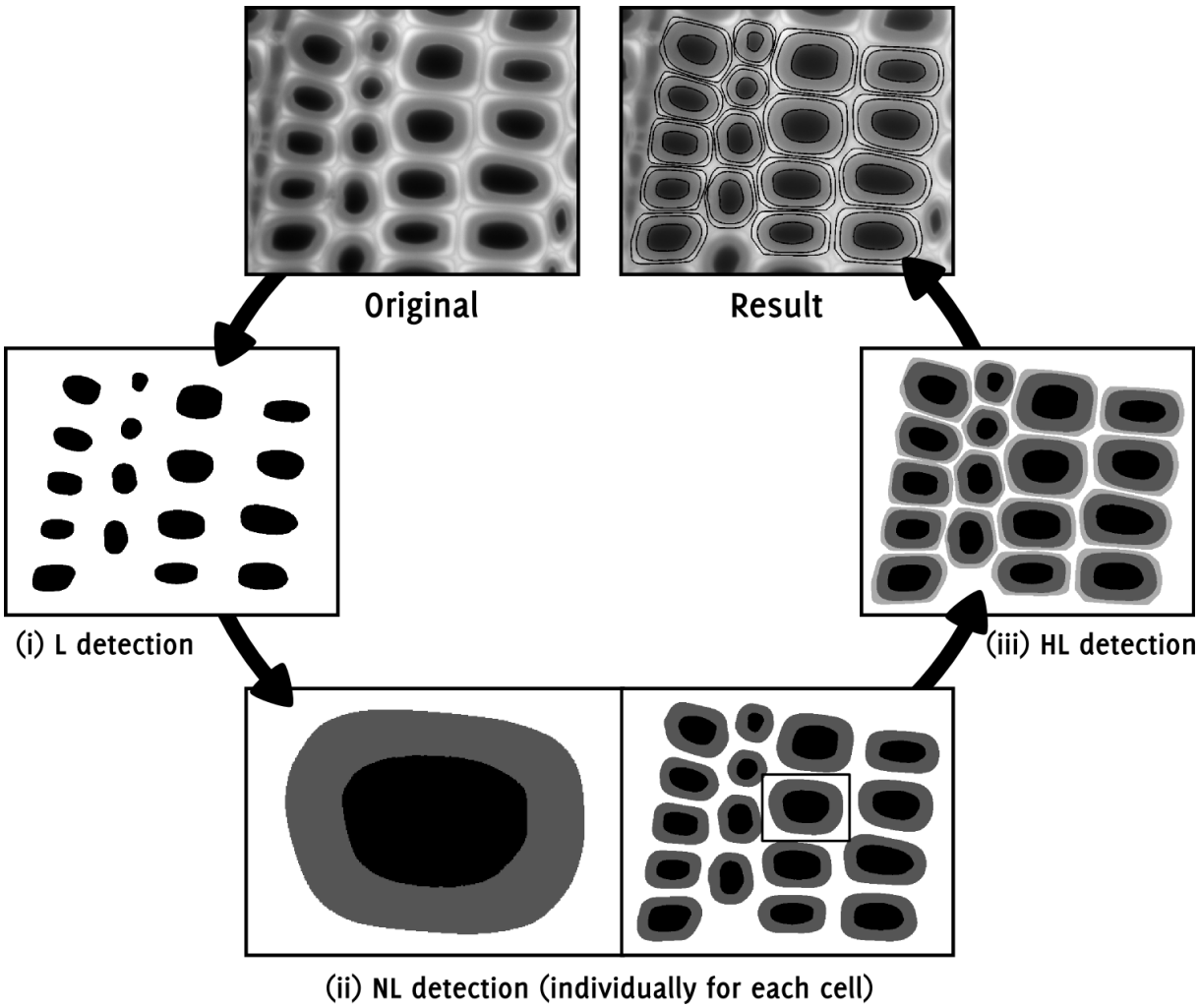


Figure 13: Flow chart: i) All cell lumens (L) are detected, and those not belonging to the fibers discarded; ii) normal lignified (NL) area is determined for each of the remaining fibers by extending L outwards, and iii) in the residual region the highly lignified (HL) area is detected.

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 develop an automatic method that detects and delineates softwood fibers. It divides the cells into lumen (L), normally lignified (NL) and highly lignified (HL) areas, see Figure 13. For this algorithm we use among others a two stage-snake described in our paper "Segmentation of Highly Lignified Zones on Wood Fibre Cross-Sections" that we presented at SCIA 2009 in Oslo. This year, we evaluated our method on both pine and spruce compression wood images and submitted our results to a journal for publication.

5.5 Other projects

48. **Surtsey and Capelinhos, Two Contemporary Submarine Volcanoes**
Tommy Lindell
Funding: TN-faculty, UU
Period: 0703–
Abstract: Capelinhos, close to the Island of Faial in the Azores in the middle of the Atlantic, began to erupt on the 27 of September 1957 from 4 submarine vents after a couple of days with seismic activities. The outbreak of magma started a violent eruption of ash, lapilli and steam when it interacted with the sea water. This continued until May 1958. The first two cones collapsed after a few months but the third cone still remains. is located most westerly of the island of Faial.

The island of Surtsey was formed in a volcanic eruption which began 130 meters below sea level, and reached the surface on 14 November 1963. The eruption lasted until 5 June 1967, when the island reached its maximum size of 2.7 km^2. Wind and wave erosion has diminished the island in size to about 1.4 km^2 today. Like as for the Capelinhos, eruptions created more islands from the vents, Jlnir and Syrtlingur but as in the case for Capelinhos those two islands disappeared soon.

Wind and waves are the main factors eroding these two volcanic features. They are now approximately half a century old, resting in two similar locations but within two rather different climatological systems as to their wave and wind climate. One intriguing question is then of course if the environment may have had any major differentiating effect on the present shape of the islands. This is under investigation in this project, based on satellite imagery and aerial photos and climatological data.

49. **Image Analysis for Landscape Analysis**
Anders Brun, Filip Malmberg
Partners: Bo Malmberg, Michael Nielsen, Dept. of Human Geography, Stockholms 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. During 2011 we have been active in both the assessment of forest damages and land cover in Ethiopia using remote sensing techniques. One EU grant application was submitted, for a project to deal with processing of data from the Sentinel-2 satellite, which is planned to be launched in 2013.

50. **Image Analysis for Studying Horse Behavior**
Anders Brun
Partners: Anna Byström, Lars Roepstorff, SLU
Funding: S-faculty, Dept. of Equine Studies, SLU
Period: 0901–
Abstract: In this project, we analyze signals from a pressure sensor on the horse saddle. The work of CBA is mainly to help the veterinary group to analyze these signals. During 2011 we have published a novel algorithm for the analysis of saddle pressure at SSBA.

51. **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 intend to set up a system in which we can observe a portion of a bee hive (containing several hundred individuals, each tagged with a number 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 provide them with an environment that is as natural as possible. The purpose is to observe the natural behaviour of the bees, and record the type and duration of interaction between individuals. In 2010 Olle Terenius was awarded a small grant from the Åke Wiberg foundation for materials and consumables, which we will use to create a setup and obtain preliminary data for a larger grant application.

52. **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 2011 the findings of this project were published in an international workshop on Handwritten Text Recognition, HIP, colocated with ICDAR 2011 in Beijing. A major grant application was sent to the Knut & Alice Wallenberg Foundation with a budget of about 50MKR.

53. **Size Distribution of Sand From a Fluidized Bed Boiler**
Cris Luengo
Partners: Mattias Moëll, Martin Petersen and Shariar Badiei, Vattenfall Research and Development AB, Stockholm
Funding: Vattenfall
Period: 1102–
Abstract: We are developing an on-line system to measure particle size distribution of sand from a fluidized bed boiler. We have written and validated an algorithm that works well on a series of test images obtained in a commercial fluidized bed boiler. During the coming year we will develop a test system to be installed at the same plant.

54. **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. In 2010 we improved the imaging capabilities of the robot, and adapted algorithms developed earlier in this project to the new setup.

55. **Drosophila Behaviour Analysis**
Cris Luengo
Partner: Michael Williams, Dept. of Neuroscience, UU
Funding: –
Period: 1106–
Abstract: We are developing software to automatically analyze video of fruit flies and quantify their behaviour. In particular, aggressive and sexual displays need to be counted. We are still in the initial phases of the project, in terms of image analysis.

56. **Face Recognition in Presence of Shadow Artifacts**
Khalid Niazi, Ingela Nyström
Partners: M. Talal Ibrahim, Ling Guan, Ryerson Multimedia Lab, Ryerson University, Canada
Funding: COMSATS IIT, Islamabad
Period: 1101-1112
Abstract: Face recognition in the presence of shadow artifacts is a challenging task.This project presents a novel filtering method for face recognition under varying illumination and shadow artifacts. The proposed method starts by normalizing the given input image by gamma transformation. Empirically, we have proven that most of the discriminating features in a human face are horizontal in nature and decimation-free directional filter bank provides a efficient mechanism to extract horizontal features from the facial images. The efficiency of the proposed method is evaluated on two public databases: Yale Face Database B, and the Extended Yale Face Database B. Experimental results demonstrate that the proposed method achieves higher recognition rate under varying illumination conditions and in presence of shadow artifacts in comparison with some other existing methods.

57. **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. 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.

5.6 Cooperation partners

International

CSIRO Mathematical and Information Sciences, Australia

School of Information Technology and Electrical Engineering, University of Queensland, Brisbane, Australia

School of Medical Sciences, University of Sydney, Australia

School of Physics, Monash University, Melbourne, Australia

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

Ryerson Multimedia Lab, Ryerson University, Canada

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

Dept. of Computer Science, University of Debrecen, Hungary

Dept. of Computer Science, Szeged University, Hungary

Centre for Development of Advanced Computing, Thiruvananthapuram, India

Regional Cancer Centre, Thiruvananthapuram, India

Istituto di Cibernetica, CNR, Pozzuoli, Italy

Eye Hospital Rotterdam, Netherlands

Quantitative Imaging Group, Delft University of Technology, Netherlands

Centre of Mathematics for Applications, University of Oslo, Norway

Norwegian Pulp and Paper Research Institute, Trondheim, Norway

Paper and Fibre Research Institute (PFI), Norway

SINTEF Materials and Chemistry, Norway

Faculty of Technical Sciences, University of Novi Sad, Serbia

Unilever Research and Development, Colworth House, Bedford, UK

Broad Institute of Harvard and MIT, USA

California Institute for Quantitative Biosciences, University of California Berkeley, CA, USA

Computer Science Department, St. Joseph's University, PA, USA

Dept. of Computer Science, University of California Irvine, CA, USA

Dept. of Ecology and Evolution, The University of Chicago, IL, USA

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

Dept. of Molecular and Cell Biology, University of California at Berkeley, MA, USA

Dept. of Neurobiology and Anatomy, Drexel University, PA, USA

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

Dept. of Radiology, University of Iowa, IA, USA

Dept. of Systems Biology, Harvard Medical School, Boston, MA, USA

GE Healthcare Systems, Molecular Imaging, Waukesha, WI, USA

Genomics and Life Sciences Division, Lawrence Berkeley National Laboratory, CA, USA

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

School of Engineering and Applied Sciences, Harvard University, Boston, MA, USA

SibTech, Inc., Brookfield, USA

National

Dept. of Biochemistry and Organic Chemistry, UU

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 Medical Sciences, Cancer Pharmacology and Computational Medicine, UU

Dept. of Neurosciences, UU

Dept. of Pharmaceutical Biosciences, UU

Dept. of Plastic- and Maxillofacial Surgery, UU Hospital

Dept. of Psychology, UU

Dept. of Radiology, Oncology and Radiation Science, UU

Dept. of Scandinavian Languages, UU

Dept. of Surgical Sciences, UU

Science for Life Laboratory, UU

Uppsala Applied Science Lab, UU

Dept. of Anatomy, Physiology and Biochemistry, SLU

Dept. of Ecology, SLU

Dept. of Economics, SLU

Dept. of Equine Studies, SLU

Dept. of Forest Products, SLU

SP Technical Research Institute of Sweden, Borås

Dept. of Industrial Development, IT and Land Management, University of Gävle

Faculty of Engineering and Sustainable Technology, University of Gävle

MedTech West, Chalmers and Sahlgrenska University Hospital, Göteborg

Institute of Odontology, The Sahlgrenska Academy, Göteborg

SenseGraphics AB, Kista

Lantmännen Lantbruk, Lidköping & Uppsala

Dept. of Science and Technology, 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 Mathematics, KTH, Stockholm

Dept. of Oncology-Pathology, Karolinska Institute, Stockholm

Dept. of Sociology, Stockholm University

Dept. of Solid Mechanics, KTH, Stockholm

Industrial Metrology and Optics Group, KTH, Stockholm

Innventia, Stockholm

Vattenfall Research and Development AB, Stockholm

Vironova AB, Stockholm

Dept. of Neurophysiology, Umeå University

Dept. of Risk-Benefit Assessment, National Food Administration, Uppsala

Gradientech AB, Uppsala

Maxx automation AB, Uppsala

PiezoMotors AB, Uppsala

Dept. of Clinical Medicine, School of Health and Medical Sciences, Örebro University

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 2011. We have published two book chapters, 17 journal articles and 19 articles in fully-reviewed international conference proceedings. In addition, we published eight papers in workshops, non-refereed or abstract refereed conference proceedings, and two other reports. The number of publications from CBA between 2000–2011 is shown in Figure 14.

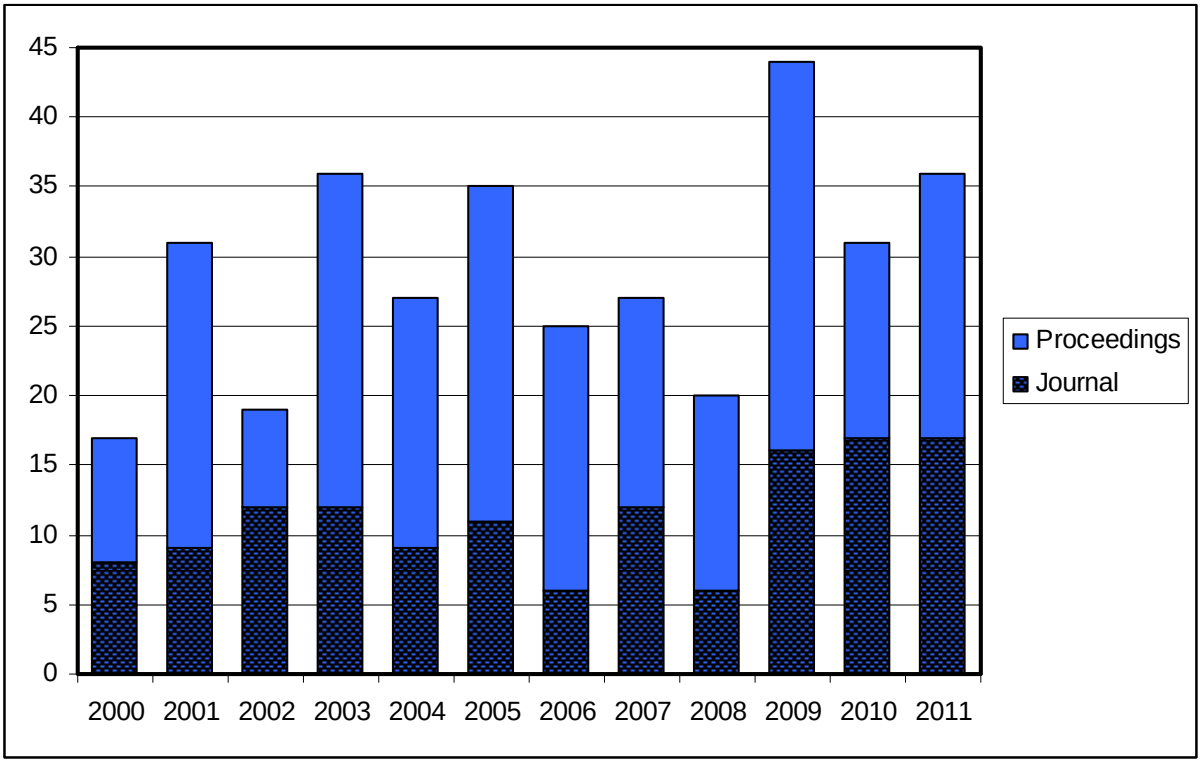


Figure 14: The number of publications from CBA.

6.1 Book chapters

1. **Structural Characterisation of Kraft Pulp Fibres and Their Nanofibrillated Materials for Biodegradable Composite Applications**
   Authors: Gary Chinga-Carrasco (1), Arttu Miettinen (2), **Cris L. Luengo Hendriks**, E. Kristofer Gamstedt (3), and Markku Kataja (2)
   (1) Paper and Fibre Research Institute (PFI), Norway
   (2) Dept. of Physics, University of Jyväskylä, Finland
   (3) Uppsala University, Disciplinary Domain of Science and Technology, Technology, Dept. of Engineering Sciences, Applied Mechanics
   Book: Nanocomposites and Polymers with Analytical Methods, pp 243-260
   Editor: John Cuppoletti
   Publisher: InTech, Rijeka, Croatia

2. **Rapid Prototyping of Image Analysis Applications**
   Authors: **Cris L. Luengo Hendriks**, **Patrik Malm**, and **Ewert Bengtsson**
   Book: Medical Image Processing: Techniques and Applications, Biological and Medical Physics, Biomedical Engineering Series, pp 5-25
   Editor: Geoff Dougherty
   Publisher: Springer, New York

6.2 Journal articles

1. **Synthesis and Characterization of scVEGF-PEG-[^{68}Ga]NOTA and scVEGF-PEG-[^{68}Ga]DOTA PET Tracers**
   Authors: Elisabeth Blom (1), Irina Velikyan (2,3), Azita Monazzam (2), **Pasha Razifar**, Manoj Nair (2), Payam Razifar (4), Jean-Luc Vanderheyden (5), Arcadius V. Krivoshein (6), Marina Backer (6), Joseph Backer (6), and Bengt Långström (1)
   (1) Dept. of Biochemistry and Organic Chemistry, UU
   (2) Uppsala Applied Science Lab, UU
   (3) Dept. of Radiology, Oncology and Radiation Science, UU
   (4) Dept. of Pharmaceutical Biosciences, UU
   (5) GE Healthcare Systems, Molecular Imaging, Waukesha, WI, USA
   (6) SibTech, Inc., Brookfield, USA
   Journal: Journal of Labelled Compounds and Radiopharmaceuticals, volume 54, number 11, pp 685-692
   Abstract: Vascular endothelial growth factor (VEGF) signaling via vascular endothelial growth factor receptor 2 (VEGFR-2) on tumor endothelial cells is a critical driver of tumor angiogenesis. Novel anti-angiogenic drugs target VEGF/VEGFR-2 signaling and induce changes in VEGFR-2 prevalence. To monitor VEGFR-2 prevalence in the course of treatment, we are evaluating ^{68}Ga positron emission tomography imaging agents based on macrocyclic chelators, site-specifically conjugated via polyethylene glycol (PEG) linkers to engineered VEGFR-2 ligand, single-chain (sc) VEGF. The ^{68}Ga-labeling was performed at room temperature with NOTA (2,2′, 2″-(1,4,7-triazonane-1,4,7-triyl) triacetic acid) conjugates or at 90 degrees C by using either conventional or microwave heating with NOTA and DOTA (2,2′, 2″, 2‴-(1,4,7,10-tetraazacyclododecane-1,4,7,10-tetrayl) tetraacetic acid) conjugates. The fastest (similar to 2min) and the highest incorporation ($>$90%) of ^{68}Ga into conjugate that resulted in the highest specific radioactivity (similar to 400MBq/nmol) was obtained with microwave heating of the conjugates. The bioactivity of the NOTA- and DOTA-containing tracers was validated in 3-D tissue culture model of 293/KDR cells engineered to express high levels of VEGFR-2. The NOTA-containing tracer also displayed a rapid accumulation (similar to 20s after intravenous injection) to steady-state level in xenograft tumor models. A combination of high specific radioactivity and maintenance of functional activity suggests that scVEGF-PEG-[^{68}Ga] NOTA and scVEGF-PEG-[^{68}Ga] DOTA might be promising tracers for monitoring VEGFR-2 prevalence and should be further explored.

2. **Increasing the Dynamic Range of *in situ* PLA**
Authors: Carl-Magnus Clausson (1,2), **Amin Allalou**, Irene Weibrecht (1,2), Salah Mahmoudi (3), Marianne Farnebo (4), Ulf Landegren (1,2), **Carolina Wählby**, and Ola Söderberg (1,2)
(1) Dept. of Immunology, Genetics and Pathology, UU
(2) Science for Life Laboratory, UU
(3) Dept. of Oncology-Pathology, Karolinska Institute, Stockholm
Journal: Nature Methods, volume 8, number 11, pp 892-893
Abstract: Molecular detection methods based on proximity ligation and padlock probes result in a localized signal with very high intensity, when imaged by fluorescence microscopy. The number of detection events is typically quantified by automated image analysis aimed at identifying each fluorescing signal. However, if the the number of signals is large they tend to form clusters that can not be resolved, limiting the dynamic range of the concentration of target molecules that can be quantified. To allow quantification of both abundant and scarce target molecules in the same reaction, we devised reagents that give rise to three variants of the reporter signal for any targeted molecule added in a concentration ratio of 1:10:100. It is therefore possible to visualize either 100, 10 or 1 out of 111 detected target molecules, enabling quantification at a concentration level without clustering. The ability to increase the dynamic range is of particular value for heterogeneous samples such as tissue sections, in which the amount of a specific protein may vary greatly between neighboring cells.

3. **A Conserved Developmental Patterning Network Produces Quantitatively Different Output in Multiple Species of Drosophila**
Authors: Charless C. Fowlkes (1), Kelly B. Eckenrode (2), Meghan D. Bragdon (2), Miriah Meyer (3), Zeba Wunderlich (2), Lisa Simirenko (4), **Cris L. Luengo Hendriks**, Soile V. E. Keränen (5), Clara Henriquez (5), David W. Knowles (5), Mark D. Biggin (5), Michael B. Eisen (4), and Angela H. DePace (2)
(1) Dept. of Computer Science, University of California Irvine, CA, USA
(2) Dept. of Systems Biology, Harvard Medical School, Boston, MA, USA
(3) School of Engineering and Applied Sciences, Harvard University, Boston, MA, USA
(4) California Institute for Quantitative Biosciences, University of California Berkeley, CA, USA
(5) Genomics and Life Sciences Division, Lawrence Berkeley National Laboratory, CA, USA
Journal: PLoS Genetics, volume 7, number 10, pp e1002346- (electronic publication)
Abstract: Differences in the level, timing, or location of gene expression can contribute to alternative phenotypes at the molecular and organismal level. Understanding the origins of expression differences is complicated by the fact that organismal morphology and gene regulatory networks could potentially vary even between closely related species. To assess the scope of such changes, we used high-resolution imaging methods to measure mRNA expression in blastoderm embryos of Drosophila yakuba and Drosophila pseudoobscura and assembled these data into cellular resolution atlases, where expression levels for 13 genes in the segmentation network are averaged into species-specific, cellular resolution morphological frameworks. We demonstrate that the blastoderm embryos of these species differ in their morphology in terms of size, shape, and number of nuclei. We present an approach to compare cellular gene expression patterns between species, while accounting for varying embryo morphology, and apply it to our data and an equivalent dataset for Drosophila melanogaster. Our analysis reveals that all individual genes differ quantitatively in their spatio-temporal expression patterns between these species, primarily in terms of their relative position and dynamics. Despite many small quantitative differences, cellular gene expression profiles for the whole set of genes examined are largely similar. This suggests that cell types at this stage of development are conserved, though they can differ in their relative position by up to 3-4 cell widths and in their relative proportion between species by as much as 5-fold. Quantitative differences in the dynamics and relative level of a subset of genes between corresponding cell types may reflect altered regulatory functions between species. Our results emphasize that transcriptional networks can diverge over short evolutionary timescales and that even small changes can lead to distinct output in terms of the placement and number of equivalent cells.

4. **Automated Classification of Multicolored Rolling Circle Products in Dual-Channel Wide-Field Fluorescence Microscopy**
Authors: **Milan Gavrilovic**, Irene Weibrecht (1), Tim Conze (1), Ola Söderberg (1), and **Carolina Wählby**
(1) Dept. of Immunology, Genetics and Pathology, UU
Journal: Cytometry Part A, volume 79A, number 7, pp 518-527
Abstract: Specific single-molecule detection opens new possibilities in genomics and proteomics, and automated image analysis is needed for accurate quantification. This work presents image analysis methods

for the detection and classification of single molecules and single-molecule interactions detected using padlock probes or proximity ligation. We use simple, widespread, and cost-efficient wide-field microscopy and increase detection multiplexity by labeling detection events with combinations of fluorescence dyes. The mathematical model presented herein can classify the resulting point-like signals in dual-channel images by spectral angles without discriminating between low and high intensity. We evaluate the methods on experiments with known signal classes and compare to classical classification algorithms based on intensity thresholding. We also demonstrate how the methods can be used as tools to evaluate biochemical protocols by measuring detection probe quality and accuracy. Finally, the method is used to evaluate single-molecule detection events in situ.

5. **Anti-Aliased Euclidean Distance Transform**
   Authors: Stefan Gustavson (1) and **Robin Strand**
   (1) Dept. of Science and Technology, Linköping University
   Journal: Pattern Recognition Letters, volume 32, number 2, pp 252-257
   Abstract: We present a modified distance measure for use with distance transforms of anti-aliased, area sampled grayscale images of arbitrary binary contours. The modified measure can be used in any vector-propagation Euclidean distance transform. Our test implementation in the traditional SSED8 algorithm shows a considerable improvement in accuracy and homogeneity of the distance field compared to a traditional binary image transform. At the expense of a $10\times$ slowdown for a particular image resolution, we achieve an accuracy comparable to a binary transform on a supersampled image with 16×16 higher resolution, which would require 256 times more computations and memory.

6. **Regularized Image Denoising Based on Spectral Gradient Optimization**
   Authors: Tibor Lukic (1), **Joakim Lindblad**, and Natasa Sladoje (1)
   (1) Faculty of Technical Sciences, University of Novi Sad, Serbia
   Journal: Inverse Problems, volume 27, number 8, pp 085010:1-17 (electronic publication)
   Abstract: Image restoration methods, such as denoising, deblurring, inpainting, etc, are often based on the minimization of an appropriately defined energy function. We consider energy functions for image denoising which combine a quadratic data-fidelity term and a regularization term, where the properties of the latter are determined by a used potential function. Many potential functions are suggested for different purposes in the literature. We compare the denoising performance achieved by ten different potential functions. Several methods for efficient minimization of regularized energy functions exist. Most are only applicable to particular choices of potential functions, however. To enable a comparison of all the observed potential functions, we propose to minimize the objective function using a spectral gradient approach; spectral gradient methods put very weak restrictions on the used potential function. We present and evaluate the performance of one spectral conjugate gradient and one cyclic spectral gradient algorithm, and conclude from experiments that both are well suited for the task. We compare the performance with three total variation-based state-of-the-art methods for image denoising. From the empirical evaluation, we conclude that denoising using the Huber potential (for images degraded by higher levels of noise; signal-to-noise ratio below 10 dB) and the Geman and McClure potential (for less noisy images), in combination with the spectral conjugate gradient minimization algorithm, shows the overall best performance.

7. **Interrogating Health-Related Public Databases from a Food Toxicology Perspective: Computational Analysis of Scoring Data**
   Authors: Farzaneh Maddah (1), Daniel Soeria-Atmadja (1), **Patrik Malm**, Mats G. Gustafsson (2), and Ulf Hammerling (1)
   (1) Dept. of Risk-Benefit Assessment, National Food Administration, Uppsala
   (2) Dept. of Medical Sciences, Cancer Pharmacology and Computational Medicine, UU
   Journal: Food and Chemical Toxicology, volume 49, number 11, pp 2830-2840
   Abstract: Over the last 15 years, an expanding number of databases with information on noxious effects of substances on mammalian organisms and the environment have been made available on the Internet. This set of databases is a key source of information for risk assessment within several areas of toxicology. Here we present features and relationships across a relatively wide set of publicly accessible databases broadly within toxicology, in part by clustering multi-score representations of such repositories, to support risk assessment within food toxicology. For this purpose 36 databases were each scrutinized, using 18 test substances from six different categories as probes. Results have been analyzed by means of various uni- and multi-variate statistical operations. The former included a special index devised to afford context-specific

rating of databases across a highly heterogeneous data matrix, whereas the latter involved cluster analysis, enabling the identification of database assemblies with overall shared characteristics. One database - HSDB - was outstanding due to rich and qualified information for most test substances, but an appreciable fraction of the interrogated repositories showed good to decent scoring. Among the six chosen substance groups, Food contact materials had the most comprehensive toxicological information, followed by the Pesticides category.

8. **A Graph-based Framework for Sub-pixel Image Segmentation**
   Authors: **Filip Malmberg**, **Joakim Lindblad**, Natasa Sladoje (1), and **Ingela Nyström**
   (1) Faculty of Technical Sciences, University of Novi Sad, Serbia
   Journal: Theoretical Computer Science, volume 412, number 15, pp 1338-1349
   Abstract: Many image segmentation methods utilize graph structures for representing images, where the flexibility and generality of the abstract structure is beneficial. By using a fuzzy object representation, i.e., allowing partial belongingness of elements to image objects, the unavoidable loss of information when representing continuous structures by finite sets is significantly reduced, enabling feature estimates with sub-pixel precision. This work presents a framework for object representation based on fuzzy segmented graphs. Interpreting the edges as one-dimensional paths between the vertices of a graph, we extend the notion of a graph cut to that of a located cut, i.e., a cut with sub-edge precision. We describe a method for computing a located cut from a fuzzy segmentation of graph vertices. Further, the notion of vertex coverage segmentation is proposed as a graph theoretic equivalent to pixel coverage segmentations and a method for computing such a segmentation from a located cut is given. Utilizing the proposed framework, we demonstrate improved precision of area measurements of synthetic two-dimensional objects. We emphasize that although the experiments presented here are performed on two-dimensional images, the proposed framework is defined for general graphs and thus applicable to images of any dimension.

9. **Measurement of Fibre-Fibre Contact in Three-Dimensional Images of Fibrous Materials Obtained from X-ray Synchrotron Microtomography**
   Authors: **Filip Malmberg**, **Joakim Lindblad**, **Catherine Östlund**, Karin Almgren (1), and Kristofer Gamstedt (1)
   (1) Dept. of Solid Mechanics, Royal Institute of Technology (KTH), Stockholm
   Journal: Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, volume 637, number 1, pp 143-148
   Abstract: A series of wood-fibre mats was investigated using high-resolution phase-contrast microtomography at the beamline ID 19 of the European Synchrotron Radiation Facility in Grenoble, France. A method fordata reduction to quantify the degree of fibre-fibre contact has been derived. The degree of fibre-fibre contact and bonding plays a fundamental role in the mechanical properties of cellulose-fibre mats, paper materials and cellulose-fibre composites. The proposed computerised automated method consists of two parts. First, fibre lumens are segmented using a watershed based method. This information is then used to identify fibre-fibre contacts in projections along the z-axis of the materia. The method is tested on microtomographic images of mats made of wood pulp fibres, and is shown to successfully detect differences in the amount of fibre-fibre contact between samples. The degree of fibre-fibre contact correlates well with measured out-of-plane strength of the fibrous material.

10. **Artificial Selection on Egg Size Perturbs Early Pattern Formation in Drosophila Melanogaster**
    Authors: Cecelia M. Miles (1), Susan E. Lott (2), **Cris L. Luengo Hendriks**, Michael Z. Ludwig (1), Manu (1), Calvin L. Williams (3), and Martin Kreitman (1)
    (1) Dept. of Ecology and Evolution, The University of Chicago, IL, USA
    (2) Dept. of Molecular and Cell Biology, University of California at Berkeley, MA, USA
    (3) Harvard Medical School, Boston, MA, USA
    Journal: Evolution, volume 65, number 1, pp 33-42
    Abstract: Pattern formation in Drosophila embryogenesis has been widely investigated as a developmental and evolutionary model of robustness. To ask whether genetic variation for pattern formation is suppressed in this system, artificial selection for divergent egg size was used to challenge the scaling of even-skipped (eve) pattern formation in mitotic cycle 14 (stage 5) embryos of Drosophila melanogaster. Three-dimensional confocal imaging revealed shifts in the allometry of eve pair-rule stripes along both anterior-posterior (A-P) and dorsoventral (D-V) axes as a correlated response to egg size selection, indicating the availability of genetic variation for this buffered trait. Environmental perturbation was not required

for the manifestation of this variation. The number of nuclei at the cellular blastoderm stage also changed in response to selection, with large-egg selected lines having more than 1000 additional nuclei relative to small-egg lines. This increase in nuclear number in larger eggs does not scale with egg size, however, as nuclear density is inversely correlated with egg length. Nuclear density varies along the A-P axis but does not correlate with the shift in eve stripe allometry between the selection treatments. Despite its macroevolutionary conservation, both eve stripe patterning and blastoderm cell number vary genetically both within and between closely related species.

11. **Approximating Euclidean Circles by Neighbourhood Sequences in a Hexagonal Grid**
Authors: Benedek Nagy (1) and **Robin Strand**
(1) Dept. of Computer Science, Faculty of Informatics, University of Debrecen, Hungary
Journal: Theoretical Computer Science, volume 412, number 15, pp 1364-1377
Abstract: In this paper the nodes of the hexagonal grid are used as points. There are three types of neighbours on this grid, therefore neighbourhood sequences contain values 1, 2, 3. The grid is coordinatized by three coordinates in a symmetric way. Digital circles are classified based on digital distances using neighbourhood sequences. They can be triangle, hexagon, enneagon and dodecagon. Their corners and side-lengths are computed, such as their perimeters and areas. The radius of a digital disk is usually not well-defined, i.e., the same disk can have various radii according to the neighbourhood sequence used. Therefore the non-compactness ratio is used to measure the quality of approximation of the Euclidean circles. The best approximating neighbourhood sequence is presented. It is shown that the approximation can be improved using two neighbourhood sequences in parallel. Comparisons to other approximations are also shown.

12. **Finite-Element Based Sparse Approximate Inverses for Block-Factorized Preconditioners**
Authors: Maya Neytcheva (1), Erik Bängtsson (1) and **Elisabeth Linnér**
(1) Dept. of Information Technology, UU
Journal: Advances in Computational Mathematics, volume 35, number 2-4, pp 323-355
Abstract: In this work we analyse a method to construct numerically efficient and computationally cheap sparse approximations of some of the matrix blocks arising in the block-factorized preconditioners for matrices with a two-by-two block structure. The matrices arise from finite element discretizations of partial differential equations. We consider scalar elliptic problems, however the approach is appropriate also for other types of problems such as parabolic problems or systems of equations. The technique is applicable for both selfadjoint and non-selfadjoint problems, in two as well as in three space dimensions. We analyse in detail the two-dimensional case and provide extensive numerical evidence for the efficiency of the proposed matrix approximations, both serial and parallel. Two- and three-dimensional tests are included.

13. **Automatic Counting of Annual Rings on Pinus Sylvestris End Faces in Sawmill Industry**
Author: **Kristin Norell**
Journal: Computers and Electronics in Agriculture, volume 75, number 2, pp 231-237
Abstract: The quality of wood can be analyzed using annual ring width. At Swedish sawmills, this is performed using manual inspection for grading purpose. Here a completely automatic method for counting the number of annual rings on log end faces is described and evaluated. The method is applied and tested using images from Pinus sylvestris end faces acquired in online sawmill production with a camera mounted above a conveyor belt. Completely untreated end faces were captured, as well as newly sawn ones. The proposed method includes preprocessing, pith detection and counting the number of rings in two regions of the end face. A new method to remove marks from uneven sawing is presented as a part of the preprocessing steps. The evaluation shows that the suggested automatic method performs as well as the manual measurements that are the method used for measuring today.

14. **Efficient Computation of Enclosed Volume and Surface Area from the Same Triangulated Surface Representation**
Authors: **Ingela Nyström**, George J. Grevera (1), Bruce E. Hirsch (2), and Jayaram K. Udupa (3)
(1) Computer Science Department, St. Joseph's University, PA, USA
(2) Dept. of Neurobiology and Anatomy, Drexel University, PA, USA
(3) Dept. of Radiology, University of Pennsylvania, PA, USA
Journal: Computerized Medical Imaging and Graphics, volume 35, number 6, pp 460-471
Abstract: We demonstrate that the volume enclosed by triangulated surfaces can be computed efficiently in the same elegant way the volume enclosed by digital surfaces can be computed by digital surface integration.

Although digital surfaces are effective and efficient for visualization and volume measurement, their drawback is that surface area measurements derived from them are inaccurate. On the other hand, triangulated surfaces give more accurate surface area measurements, but volume measurements and visualization are less efficient. Our data structure (called t-shell) for representing triangulated digital surfaces retains advantages and overcomes difficulties of both the digital and the triangulated surfaces. We create a lookup table with area and volume contributions for each of the 256 Marching Cubes configurations. When scanning the shell (e.g., while creating it), the surface area and volume are incrementally computed by using the lookup table and the current x co-ordinate, where the sign of the x component of the triangle normal indicates the sign of the volume contribution. We have computed surface area and volume for digitized mathematical phantoms, physical phantoms, and real objects. The experiments show that triangulated surface area is more accurate, triangulated volume follows digital volume closely, and that the values get closer to the true value with decreasing voxel size.

15. **Extracting 3D Information on Bone Remodeling in the Proximity of Titanium Implants in SRμCT Image Volumes**
Authors: **Hamid Sarve**, **Joakim Lindblad**, **Gunilla Borgefors**, and Carina B. Johansson (1)
(1) School of Health and Medical Sciences, Örebro University, Örebro
Journal: Computer Methods and Programs in Biomedicine, volume 102, number 1, pp 25-34
Abstract: Bone-implant integration is measured in several ways. Traditionally and routinely, 2D histological sections of samples, containing bone and the biomaterial, are stained and analyzed using a light microscope. Such histological section provides detailed cellular information about the bone regeneration in the proximity of the implant. However, this information reflects the integration in only a very small fraction, a 10 Î¼m thick slice, of the sample. In this study, we show that feature values quantified on 2D sections are highly dependent on the orientation and the placement of the section, suggesting that a 3D analysis of the whole sample is of importance for a more complete judgment of the bone structure in the proximity of the implant. We propose features describing the 3D data by extending the features traditionally used for 2D-analysis. We present a method for extracting these features from 3D image data and we measure them on five 3D SRμCT image volumes.

We also simulate cuts through the image volume positioned at all possible section positions. These simulations show that the measurement variations due to the orientation of the section around the center line of the implant are about 30%.

16. **Defuzzification of Spatial Fuzzy Sets by Feature Distance Minimization**
Authors: Natasa Sladoje (1), **Joakim Lindblad**, and **Ingela Nyström**
(1) Faculty of Technical Sciences, University of Novi Sad, Novi Sad, Serbia
Journal: Image and Vision Computing, volume 29, pp 127-141
Abstract: We present a novel defuzzification method, i.e., a mapping from the set of fuzzy sets to the set of crisp sets, and we suggest its application to image processing. Spatial fuzzy sets are, e.g., useful as information preserving representations of objects in images. Defuzzification of such a spatial fuzzy set can be seen as a crisp segmentation procedure. With the aim to provide preservation of selected quantitative features of the fuzzy set, we define the defuzzification of a fuzzy set to be a crisp set which is as close as possible to the fuzzy set, where the distance measure on the set of fuzzy sets, that we propose for defuzzification, incorporates selected local and global features of the fuzzy sets. The distance measure is based on the Minkowski distance between feature representations of the sets. The distance minimization, performed in the suggested defuzzification method, provides preservation of the selected quantitative features of the fuzzy set. The method utilizes the information contained in the fuzzy representation for defining a mapping from the set of fuzzy sets to the set of crisp sets. If the fuzzy set is a representation of an unknown crisp original set, such that the selected features of the original set are preserved in the fuzzy representation, then the defuzzified set may be seen as an approximate reconstruction of the crisp original. We present four optimization algorithms, exhibiting different properties, for finding the crisp set closest to a given discrete fuzzy set. A number of examples, using both synthetic and real images, illustrate the main properties of the proposed method. An evaluation of both theoretical aspects of the method, and its results, is given.

17. **Digital Distance Functions on Three-Dimensional Grids**
Authors: **Robin Strand**, Benedek Nagy (1), and **Gunilla Borgefors**
(1) Dept. of Computer Science, Faculty of Informatics, University of Debrecen, Hungary
Journal: Theoretical Computer Science, volume 412, number 15, pp 1350-1363

Abstract: In this paper, we examine five different three-dimensional grids suited for image processing. Digital distance functions are defined on the cubic, face-centered cubic, body-centered cubic, honeycomb, and diamond grids. We give the parameters that minimize an error function that favors distance functions with low rotational dependency. We also give an algorithm for computing the distance transform – the tool by which these distance functions can be applied in image processing applications.

6.3 Refereed conference proceedings

1. **Distance Measures Between Digital Fuzzy Objects and their Applicability in Image Processing**
   Authors: **Vladimir Curic**, **Joakim Lindblad**, and Natasa Sladoje (1)
   (1) Faculty of Technical Sciences, University of Novi Sad, Novi Sad, Serbia
   Conference: 14th International Workshop on Combinatorial Image Analysis (IWCIA), Madrid, Spain, volume 6636 of Lecture Notes in Computer Science, pp 385-397
   Publisher: Springer, Berlin/Heidelberg
   Editors: Jake Aggarwal, Reneta Barneva, Valentin Brimkov, Kostadin Koroutchev, and Elka Koroutcheva
   Abstract: We present two different extensions of the Sum of minimal distances and the Complement weighted sum of minimal distances to distances between fuzzy sets. We evaluate to what extent the proposed distances show monotonic behavior with respect to increasing translation and rotation of digital objects, in noise free, as well as in noisy conditions. Tests show that one of the extension approaches leads to distances exhibiting very good performance. Furthermore, we evaluate distance based classification of crisp and fuzzy representations of objects at a range of resolutions. We conclude that the proposed distances are able to utilize the additional information available in a fuzzy representation, thereby leading to improved performance of related image processing tasks.

2. **Precise Estimation of the Projection of a Shape from a Pixel Coverage Representation**
   Authors: Slobodan Drazic (1), **Joakim Lindblad**, and Natasa Sladoje (1)
   (1) Faculty of Technical Sciences, University of Novi Sad, Serbia
   Conference: 7th IEEE International Symposium on Image and Signal Processing and Analysis (ISPA), Dubrovnik, Croatia, pp 569-574
   Publisher: IEEE Computer Society, Piscataway, NJ
   Abstract: Measuring width and diameter of a shape are problems well studied in the literature. A pixel coverage representation is one specific type of digital fuzzy representation of a continuous image object, where the (membership) value of each pixel is (approximately) equal to the relative area of the pixel which is covered by the continuous object. Lately a number of methods for shape analysis use pixel coverage for reducing error of estimation. We introduce a novel method for estimating the projection of a shape in a given direction. The method is based on utilizing pixel coverage representation of a shape. Performance of the method is evaluated by a number of tests on synthetic objects, confirming high precision and applicability for calculation of diameter and elongation of a shape.

3. **Horizontal Features Based Illumination Normalization Method for Face Recognition**
   Authors: Muhammad Talal Ibrahim (1), **M. Khalid Khan Niazi**, and Ling Guan (1)
   (1) Ryerson Multimedia Lab, Toronto, Canada
   Conference: 7th IEEE International Symposium on Image and Signal Processing and Analysis (ISPA), Dubrovnik, Croatia, pp 684-689
   Publisher: IEEE Computer Society, Piscataway, NJ
   Abstract: This paper presents a novel filtering method for face recognition under varying illumination. The proposed method starts by normalizing the given input image by gamma transformation. The shadow artifacts in the normalized image are reduced with the decimation free directional filter banks (DDFB). We have used correlation coefficient as a similarity measure for face recognition. Empirically, we have proven that most of the discriminating features in a human face are horizontal in nature. The efficiency of the proposed method is evaluated on two public databases: Yale Face Database B, and the Extended Yale Face Database B. Experimental results demonstrate that the proposed method achieves higher recognition rate under varying illumination conditions in comparison with some other existing methods.

4. **Virus Texture Analysis Using Local Binary Patterns and Radial Density Profiles**
   Authors: **Gustaf Kylberg**, Mats Uppström (1), and **Ida-Maria Sintorn**
   (1) Vironova AB, Stockholm
   Conference: 16th Iberoamerican Congress on Pattern Recognition (CIARP), Pucón, Chile, volume 7042 of Lecture Notes in Computer Science, pp 573-580
   Publisher: Springer, Berlin/Heidelberg
   Editors: César San Martin and Sang-Woon Kim
   Abstract: We investigate the discriminant power of two local and two global texture measures on virus images. The viruses are imaged using negative stain transmission electron microscopy. Local binary patterns

and a multi scale extension are compared to radial density profiles in the spatial domain and in the Fourier domain. To assess the discriminant potential of the texture measures a Random Forest classifier is used. Our analysis shows that the multi scale extension performs better than the standard local binary patterns and that radial density profiles in comparison is a rather poor virus texture discriminating measure. Furthermore, we show that the multi scale extension and the profiles in Fourier domain are both good texture measures and that they complement each other well, that is, they seem to detect different texture properties. Combining the two, hence, improves the discrimination between virus textures.

5. **Generalized Hard Constraints for Graph Segmentation**
   Authors: **Filip Malmberg**, **Robin Strand**, and **Ingela Nyström**
   Conference: 17th Scandinavian Conference on Image Analysis (SCIA), Ystad Saltsjöbad, volume 6688 of Lecture Notes in Computer Science, pp 36-47
   Publisher: Springer, Berlin/Heidelberg
   Editors: Anders Heyden and Fredrik Kahl
   Abstract: Graph-based methods have become well-established tools for image segmentation. Viewing the image as a weighted graph, these methods seek to extract a graph cut that best matches the image content. Many of these methods are interactive, in that they allow a human operator to guide the segmentation process by specifying a set of hard constraints that the cut must satisfy. Typically, these constraints are given in one of two forms: regional constraints (a set of vertices that must be separated by the cut) or boundary constraints (a set of edges that must be included in the cut). Here, we propose a new type of hard constraints, that includes both regional constraints and boundary constraints as special cases. We also present an efficient method for computing cuts that satisfy a set of generalized constraints, while globally minimizing a graph cut measure.

6. **Image Foresting Transform: On-the-fly Computation of Segmentation Boundaries**
   Author: **Filip Malmberg**
   Conference: 17th Scandinavian Conference on Image Analysis (SCIA), Ystad Saltsjöbad, volume 6688 of Lecture Notes in Computer Science, pp 616-624
   Publisher: Springer, Berlin/Heidelberg
   Editors: Anders Heyden and Fredrik Kahl
   Abstract: The Image Foresting Transform (IFT) is a framework for seeded image segmentation, based on the computation of minimal cost paths in a discrete representation of an image. In two recent publications, we have shown that the segmentations obtained by the IFT may be improved by refining the segmentation locally around the boundaries between segmented regions. Since these methods operate on a small sub-set of the image elements only, they may be implemented efficiently if the set of boundary elements is known. Here, we show that this set may be obtained on-the-fly, at virtually no additional cost, as a by-product of the IFT algorithm.

7. **Bias Field Correction Using Grey-Weighted Distance Transform Applied on MR Volumes**
   Authors: **M. Khalid Khan Niazi**, **Ingela Nyström**, Muhammad Talal Ibrahim (1), and Ling Guan (1)
   (1) Ryerson Multimedia Lab, Toronto, Canada
   Conference: 8th International Symposium on Biomedical Imaging (ISBI), Barcelona, Spain, pp 357-360
   Publisher: IEEE Computer Society, Piscataway, NJ
   Abstract: We present a method that produces data-dependent high-pass filters that can be used in, e.g., image restoration. MR volumes often suffer from bias field artifacts produced due to unsteady magnetic field and spatial variations in reception of the RF magnetic eld emitted by the subject. To cope with these artifacts, we propose a method based on the grey-weighted distance transform (GWDT). It first computes the spectrum of the MR volume using Fast Fourier Transform, and then computes the GWDT of the magnitude spectrum. The power spectrum computed using GWDT helps in designing a high-pass filter which is later used to correct the bias artifacts. Experimental results on close to 100 datasets demonstrate the effectiveness of our method.

8. **Robust Signal Generation and Analysis of Rat Embryonic Heart Rate In Vitro using Laplacian Eigenmaps and Empirical Mode Decomposition**
   Authors: **M. Khalid Khan Niazi**, Muhammad Talal Ibrahim (1), Mats F. Nilsson, Anna-Carin Sköld, Ling Guan (1), and **Ingela Nyström**
   (1) Ryerson Multimedia Lab, Toronto, Canada
   Conference: 14th International Conference on Computer Analysis of Images and Patterns (CAIP), Seville,

Spain, volume 6855 of Lecture Notes in Computer Science, pp 523-530
Publisher: Springer, Berlin/Heidelberg
Editors: Pedro Real, Daniel Diaz-Pernil, Helena Molina-Abril, Ainhoa Berciano, and Walter Kropatsch
Abstract: To develop an accurate and suitable method for measuring the embryonic heart rate in vitro, a system combining Laplacian eigenmaps and empirical mode decomposition has been proposed. The proposed method assess the heart activity in two steps; signal generation and heart signal analysis. Signal generation is achieved by Laplacian eigenmaps (LEM) in conjunction with correlation co-efficient, while the signal analysis of the heart motion has been performed by the modified empirical mode decomposition (EMD). LEM helps to find the template for the atrium and the ventricle respectively, whereas EMD helps to find the non-linear trend term without defining any regression model. The proposed method also removes the motion artifacts produced due to the the non-rigid deformation in the shape of the embryo, the noise induced during the data acquisition, and the higher order harmonics. To check the authenticity of the proposed method, 151 videos have been investigated. Experimental results demonstrate the superiority of the proposed method in comparison to three recent methods.

9. **Path-Based Distance with Varying Weights and Neighborhood Sequences**
Authors: Nicolas Normand (1,2), **Robin Strand**, Pierre Evenou (1), and Aurore Arlicot (1)
(1) IRCCyN, University of Nantes, France
(2) School of Physics, Monash University, Melbourne, Australia
Conference: 16th International Conference on Discrete Geometry for Computer Imagery (DGCI), Nancy, France, volume 6607 of Lecture Notes in Computer Science, pp 199-210
Publisher: Springer, Berlin/Heidelberg
Editors: Isabelle Debled-Rennesson, Eric Domenjoud, Bertraud Kerautret, and Philippe Even
Abstract: This paper presents a path-based distance where local displacement costs vary both according to the displacement vector and with the travelled distance. The corresponding distance transform algorithm is similar in its form to classical propagation-based algorithms, but the more variable distance increments are either stored in look-up-tables or computed on-the-fly. These distances and distance transform extend neighborhood-sequence distances, chamfer distances and generalized distances based on Minkowski sums. We introduce algorithms to compute, in , a translated version of a neighborhood sequence distance map with a limited number of neighbors, both for periodic and aperiodic sequences. A method to recover the centered distance map from the translated one is also introduced. Overall, the distance transform can be computed with minimal delay, without the need to wait for the whole input image before beginning to provide the result image.

10. **Visualization and Haptics for Interactive Medical Image Analysis: Image Segmentation in Cranio-Maxillofacial Surgery Planning**
Authors: **Ingela Nyström**, **Johan Nysjö**, and **Filip Malmberg**
Conference: 2nd International Visual Informatics Conference (IVIC), Visual Informatics: Sustaining Research and Innovations, Selangor, Malaysia, volume 7066 of Lecture Notes in Computer Science, pp 1-12
Publisher: Springer, Berlin/Heidelberg
Editors: Halimah Badioze Zaman, Peter Robinson, Maria Petrou, Patrick Olivier, Timothy K. Shih, Sergio Velastin, and Ingela Nyström
Abstract: A central problem in cranio-maxillofacial (CMF) surgery is to restore the normal anatomy of the skeleton after defects, e.g., trauma to the face. With careful pre-operative planning, the precision and predictability of the craniofacial reconstruction can be significantly improved. In addition, morbidity can be reduced thanks to shorter operation time. An important component in surgery planning is to be able to accurately measure the extent of anatomical structures. Of particular interest are the shape and volume of the orbits (eye sockets). These properties can be measured in 3D CT images of the skull, provided that an accurate segmentation of the orbits is available. Here, we present a system for interactive segmentation of the orbit in CT images. The system utilizes 3D visualization and haptic feedback to facilitate efficient exploration and manipulation of 3D data.

11. **High-Throughput Cellular-Resolution *in vivo* Vertebrate Screening**
Authors: Carlos Pardo-Martin (1,2), Tsung-Yao Chang (1), **Amin Allalou**, **Carolina Wählby**, and Mehmet Fatih Yanik (1,3)
(1) Massachusetts Institute of Technology (MIT), MA, USA
(2) Harvard University, Moston, MA, USA
(3) Broad Institute, Boston, MA, USA
Conference: 15th International Conference on Miniaturized Systems for Chemistry and Life Sciences (μTAS), Seattle, WA, USA, pp 1557-1559
Publisher: Chemical and Biological Microsystems Society (CBMS)
Abstract: Due to its small size and optical transparency, zebrafish larvae are excellent vertebrate models to study human diseases in vivo. We previously developed a high throughput screening platform capable of handling, cellular-resolution imaging and optically manipulating zebrafish larvae. Here, we present new novel technologies to significantly increase the throughput of our screening platform by multi-threading the loading and imaging processes and high-speed algorithms to automatically manipulate the larvae.

12. **Quantification of Gaseous Structures with Volumetric Reconstruction from Visual Hulls**
Authors: **Stefan Seipel** and Peter Jenke (1)
(1) Faculty of Engineering and Sustainable Technology, University of Gävle
Conference: SIGRAD, Swedish Chapter of Eurographics, Stockholm, Sweden, pp 77-82
Publisher: Linköping University Electronic Press, Linköping University
Abstract: 3D reconstruction from visual hulls is a well established technique for camera based reconstruction of 3D objects in computer graphics. We propose in this paper to employ visual hull techniques to quantify the volume of diffusely defined gaseous structures. In our evaluation, visual quality of the 3D reconstructions is secondary. Instead, using synthetic ground truth data, we determine the number of independent silhouette images needed to achieve a stable volume estimate. We also estimate the influence of different segmentation results of the silhouette images on final volume estimates. Our results show that comparably few camera views yield to convergent volume estimates. For the type of 3D data studied, visual hull reconstructions overestimate actual volumes with about 50%. This proportion seems to be consistent for different data sets tested and may serve for re-calibration of volume estimation of gaseous structures.

13. **A Weighted Neighbourhood Sequence Distance Function with Three Local Steps**
Authors: **Robin Strand** and Benedek Nagy (1)
(1) Dept. of Computer Science, Faculty of Informatics, University of Debrecen, Hungary
Conference: 7th IEEE International Symposium on Image and Signal Processing and Analysis (ISPA), Dubrovnik, Croatia, pp 564-568
Publisher: IEEE Computer Society, Piscataway, NJ
Abstract: We present a combined weighted neighborhood sequence distance function on the square grid with three types of steps. For this general distance function, we compute parameters that optimize an error function for the asymptotic shape of digital disks. We also analyze approximations of the parameters that can be used in the digital grid used here. An algorithm that can be used for image processing applications is also presented.

14. **Sparse Object Representations by Digital Distance Functions**
Author: **Robin Strand**
Conference: 16th International Conference on Discrete Geometry for Computer Imagery (DGCI), Nancy, France, volume 6607 of Lecture Notes in Computer Science, pp 211-222
Publisher: Springer, Berlin/Heidelberg
Editors: Isabelle Debled-Rennesson, Eric Domenjoud, Bertraud Kerautret, and Philippe Even
Abstract: In this paper, some methods for representing objects using path-based distances are considered. The representations can be used as anchor points when extracting medial representations of the objects. The distance transform (DT) is obtained by labeling each object element with the distance to the background. By local operations on the DT, different sets of anchor points can be obtained. We present two different methods based on local operations and prove that the representations are reversible, when this is the case. The methods are defined for weighted distances based on neighborhood sequences, which includes for example the well known cityblock and chessboard distances.

15. **Investigating Measures for Transfer Function Generation for Visualization of MET Biomedical Data**
Authors: **Lennart Svensson**, **Ingela Nyström**, **Stina Svensson**, and **Ida-Maria Sintorn**
Conference: 19th International Conference on Computer Graphics, Visualization and Computer Vision (WSCG), Plzen, Czech Republic, Communication Papers Proceedings, pp 113-120
Publisher: Union Agency, Plzen
Editors: Gladimir Baranoski and Vaclav Skala
Abstract: In this paper, the question of automatically setting transfer functions for volume images is further explored. Morespecifically, the focus is automatic visualization of Molecular Electron Tomography (MET) volume images usingone-dimensional transfer functions. We investigate how well a few general measures based on density, gradient,curvature and connected component information are suited for generating these transfer functions. To assessthis, an expert has set suitable transfer function levels manually and we have studied how these levels relate todifferent characteristics of the selected measures for 29 data sets. We have found that the measures can be used toautomatically generate a transfer function used to visualize MET data, to give the user an approximate view of thecomponents in the image.

16. **Registration Parameter Spaces for Molecular Electron Tomography Images**
Authors: **Lennart Svensson**, **Anders Brun**, **Ingela Nyström**, and **Ida-Maria Sintorn**
Conference: 16th International Conference on Image Analysis and Processing (ICIAP), Ravenna, Italy, part I, volume 6978 of Lecture Notes in Computer Science, pp 403-412
Publisher: Springer, Berlin/Heidelberg
Editors: Giuseppe Maino and Gian Luca Foresti
Abstract: We describe a methodology for exploring the parameter spaces of rigid-body registrations in 3-D. It serves as a tool for guiding and assisting a user in an interactive registration process. An exhaustive search is performed over all positions and rotations of the template, resulting in a 6-D volume, or fitness landscape. This is explored by the user, who selects and views suitable 3-D projections of the data, visualized using volume rendering. The 3-D projections demonstrated here are the maximum and average intensity projections of the rotation parameters and a projection of the rotation parameter for fixed translation parameters. This allows the user to jointly visualize projections of the parameter space, the local behaviour of the similarity score, and the corresponding registration of the two volumes in 3-D space for a chosen point in the parameter space. The procedure is intended to be used with haptic exploration and interaction. We demonstrate the methodology on a synthetic test case and on real molecular electron tomography data using normalized cross correlation as similarity score.

17. **Data Mining Medieval Documents by Word Spotting**
Authors: **Fredrik Wahlberg**, Mats Dahllöf (1), Lasse Mårtensson (2), and **Anders Brun**
(1) Dept. of Linguistics and Philology, UU
(2) Dept. of Scandinavian Languages, UU
Conference: 1st International Workshop on Historical Document Imaging and Processing (HIP), Beijing, China, pp 75-82
Publisher: ACM, New York
Abstract: This paper presents novel results for word spotting based on dynamic time warping applied to medieval manuscripts in Latin and Old Swedish. A target word is marked by a user, and the method automatically finds similar word forms in the document by matching them against the target. The method automatically identifies pages and lines. We show that our method improves accuracy compared to earlier proposals for this kind of handwriting. An advantage of the new method is that it performs matching within a text line without presupposing that the difficult problem of segmenting the text line into individual words has been solved. We evaluate our word spotting implementation on two medieval manuscripts representing two script types. We also show that it can be useful by helping a user find words in a manuscript and present graphs of word statistics as a function of page number.

18. **Accurate Estimation of Gaussian and Mean Curvature in Volumetric Images**
Authors: **Erik L. G. Wernersson**, **Cris L. Luengo Hendriks**, and **Anders Brun**
Conference: International Conference on 3D Imaging, Modeling, Processing, Visualization, and Transmission (3DIMPVT), Hangzhou, China, pp 312-317
Publisher: IEEE Computer Society, Piscataway, NJ
Abstract: Curvature is a useful low level surface descriptor of wood fibres in 3D micro-CT images of paper and composite materials. It may for instance be used to differentiate between the outside and the inside

(lumen) of wood fibre. Since the image acquisition introduces noise, some kind of smoothing is required to obtain accurate estimates of curvature. However, in these materials, the fibres of interest are frequently both thin and densely packed. In this paper, we show how existing methods fail to accurately capture curvature information under these circumstances. Maintained resolution and smoothing of noise are two competing goals. In some situations, existing methods will even estimate the wrong signs of the principal curvatures. We also present a novel method, which is shown to have better performance in several experiments. This new method will generically produce better curvature estimates for thin objects and objects in close proximity.

19. **Indication of Methane Gas in IR-Imagery**
Authors: Julia Åhlén (1) and **Stefan Seipel**
(1) Dept. of Industrial Development, IT and Land Management, University of Gävle
Conference: IADIS International Conference on Computer Graphics, Visualization, Computer Vision and Image Processing (CGVCVIP), Rome, Italy, pp 187-182 (electronic publication)
Publisher: IADIS Press
Editor: Yingcay Xiao
Abstract: There are human produced sources of methane gas, such as waste storages, that contribute to the global warmth and other negative effects. There is not much research on the correlation of such leakage and greenhouse effect. Methane gas is not visible for humans and thus impossible to detect using commercial cameras. Specially designed IR-camera can detect this gas and thus is used in this study. Using digital video taken over a waste disposal place we create a detection algorithm that is sensitive to the spectral and morphological characteristics of methane gas. In case of small spot leakage there is a reason to assume failure in piping system and in case of widely spread leakage area we can state that it is caused by unsupervised storage of waste and this should be attended immediately. Background and target gas are distinguished using spectral and morphological classifiers, which are extracted from the analyzed IR-imagery. It is shown that methane gas detection can be carried out efficiently using image processing techniques and the definition of turbulence of the image.

6.4 Non-refereed conferences and workshops

1. **Approaches for Increasing Throughput and Information Content of Image-Based Zebrafish Screens**
   Authors: **Amin Allalou**, **Vladimir Curic**, Carlos Pardo Martin (1), Mehmet Fatih Yanik (1), and **Carolina Wählby**
   (1) Dept. of Electrical Engineering and Computer Science, Massachusetts Institute of Technology (MIT), MA, USA
   Conference: Swedish Symposium on Image Analysis, Linköping (SSBA) (electronic publication)

2. **Image Analysis of Saddle Pressure Data**
   Authors: Anna Byström (1), Lars Roepstorff (1), and **Anders Brun**
   (1) Dept. of Anatomy, Physiology and Biochemistry, SLU
   Conference: Swedish Symposium on Image Analysis, Linköping (SSBA) (electronic publication)

3. **Refinement of Segmented Virus Particle Candidates in TEM images**
   Authors: **Gustaf Kylberg** and **Ida-Maria Sintorn**
   Conference: Swedish Symposium on Image Analysis, Linköping (SSBA) (electronic publication)

4. **The Cerviscan Project – Project Description and Current Progress**
   Authors: **Patrik Malm** and **Ewert Bengtsson**
   Conference: Swedish Symposium on Image Analysis, Linköping (SSBA) (electronic publication)

5. **Cuanto: A Tool for Quantification of Bone Tissue in the Proximity of Implants**
   Authors: **Hamid Sarve**, **Amin Allalou**, and Carina Johansson (1)
   (1) School of Health and Medical Sciences, Örebro University, Örebro
   Conference: Swedish Symposium on Image Analysis, Linköping (SSBA) (electronic publication)

6. **Calculating Curvature from Orientation Fields in Volumetric Images**
   Authors: **Erik L. G. Wernersson**, **Cris L. Luengo Hendriks**, and **Anders Brun**
   Conference: Swedish Symposium on Image Analysis, Linköping (SSBA) (electronic publication)

7. **Tissue Separation for Quantitative Malignancy Grading of Prostate Cancer**
   Authors: **Milan Gavrilovic**, **Jimmy Azar**, Christer Busch (1), and **Ingrid Carlbom**
   (1) Dept. of. Immunology, Genetics and Pathoglogy, UU
   Conference: Swedish Medical Engineering Conference (Medicinteknikdagarna), Linköping (abstract)

8. **Whole Hand Haptics**
   Authors: **Pontus Olsson**, **Ingrid Carlbom**, Stefan Johansson (1), and **Fredrik Nysjö**
   (1) Dept. of. Engineering Sciences, UU
   Conference: Swedish Medical Engineering Conference (Medicinteknikdagarna), Linköping (abstract)

6.5 Other publications

See also Section 3.2 for Master theses finished during 2011.

1. **CBA Annual Report 2010**
   Editors: **Ewert Bengtsson**, **Vladimir Curic**, **Erik Wernersson**, **Ingela Nyström**, **Ida-Maria Sintorn**, **Robin Strand**, **Lena Wadelius**
   Publisher: Centre for Image Analysis, 93 pages

2. **Kylberg Texture Dataset v. 1.0**
   Author: **Gustaf Kylberg**
   Publisher: Centre for Image Analysis, external report no. 35, 4 pages

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 2011. 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.

An important event during the year was the external evaluation of research at UU conducted through the so called KoF11. The international expert panel that evaluated the research at CBA visited us on May 10.

Professor Stefan Seipel has served as Vice-chair of the Swedish Society for Computer Graphics (SIGRAD). Professor Ewert Bengtsson continued to serve as advisor to the Rector of UU on information technology and also as Chair of the UU IT-council, together with many other related appointments. Professor Gunilla Borgefors is 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 as many as 11 seminars outside CBA, mostly in the Uppsala area, but also in The Netherlands, Denmark and USA. We had 15 invited seminars at CBA, from the USA, France, India, Canada and Sweden. In addition, we held 37 seminars in our "Monday seminar series", of which nine were Master Thesis presentations. We gave one special invited talks as well as nine oral and four poster presentations at international fully reviewed conferences, and twelve other oral conference presentations. We had long-term visitors from Canada, India and Cote d'Ivoire. In addition, Erik Wernersson paid a long visit to Fachhochschule, Salzburg, and Dept. of Forest and Water Management, Ghent, Belgium; Bettina Selig to the Quantitative Imaging Group at Delft University of Technology and the Eye Hospital Rotterdam, The Netherlands; Amin Allalou Massachusetts Institute of Technology, Cambridge, USA; and Ida-Maria Sintorn BROAD Institute, Boston, USA. 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 44 international and 43 national "committees" of the most varying types in which we have served.

7.1 Professor installation

1. **Ingela Nyström**
   Date: 111118
   Comment: The professor installations are preceded by public lectures, *inaugural speeches*. Nyström gave her lecture *En bild säger mer än tusen siffror* (An image says more than a thousand numbers), in Swedish, on November 14 in the UU main building.

7.2 Organised conferences and workshops

1. **CBA Internal Planning**
   Organisers: CBA AU and others
   Address: A conference center in Knivsta, Noors slott
   Date: 110207–110208
   Comment: A two day workshop to discuss CBA identity and activity in our new organisation as a division within the IT Department. All CBA staff participated in the workshop.

2. **Uppsala-Inje Workshop**
   Organiser: Ewert Bengtsson
   Address: CBA
   Date: 110718–110724
   Comment: Hosting Heung-Kook Choi and four students for a week long joint workshop with seminars, demonstrations and excursions.

3. **Workshop on Cerviscan project**
   Organiser: Ewert Bengtsson
   Address: CBA
   Date: 111014–111020
   Comment: A full week of sessions to discuss our joint project and make detailed plans for the steps ahead.

4. **Centre for Image Analysis and BioVis, SciLifeLab Uppsala joint symposium: Quantifying and modeling cellular processes using image analysis**
   Organisers: Carolina Wählby and Jan Grawe
   Address: Uppsala Biomedical Center (BMC), Uppsala University
   Date: 111201
   Comment: Among the speakers were Robert Murphy, Carnegie Mellon University, PA, USA, Rachel Errington, Cardiff Medical School, Cardiff, UK, Ida-Maria Sintorn, Cris Luengo, and Ingela Nyström.

7.3 Seminars held outside CBA

1. **Ewert Bengtsson**
   Date: 110404
   Address: Uppsala university administration seminar room
   Title: Self Assessment of IT Board
   Comment: Presented our work to evaluate the IT Board and asked about input from university rector and vice-rector.

2. **Cris Luengo**
   Date: 110407
   Address: Ångström Laboratory, UU
   Title: Accurately Quantifying Bone Properties Through Imaging
   Comment: Luengo also moderated a discussion group. The meeting (Frontiers in Biomaterials Imaging) was organized by ÅMA (UU Innovation) to bring image analysis and biomaterial sciences together.

3. **Hamid Sarve**
   Date: 110407
   Address: Ångström Laboratory, UU
   Title: Evaluation of Osseointegration using Image Analysis
   Comment: Sarve also moderated a discussion group. The meeting (Frontiers in Biomaterials Imaging) was organized by ÅMA (UU Innovation) to bring image analysis and biomaterial sciences together.

4. **Bettina Selig**
   Date: 110412
   Address: Quantitative Imaging Group at Delft University of Technology, The Netherlands
   Title: What Do I Usually Do? - A German in Sweden

5. **Andreas Kårsnäs**
   Date: 110512
   Address: Technical University of Denmark (DTU), Copenhagen
   Title: TissueMorph: Analysing Complex Structures in Histological Images
   Comment: Kårsnäs gave a presentation on Visionday 2011.

6. **Ida-Maria Sintorn**
   Date: 110526
   Address: Imaging Platform, BROAD Institute, Boston, MA
   Title: Analysis of Neuron/Astrocyte Co-Cultures - Image Normalization and Morphology Measurements

7. **Ida-Maria Sintorn**
   Date: 110608
   Address: Swedish Institute of Communicable Disease Control, Solna, Sweden
   Title: PanViruShield Project Report – Final Results
   Comment: Swedish Defense Materiel Administration, Swedish Civil Contingencies Agency representatives present at this final project presentation meeting including a tour of the security lab and a demonstration of the sample preparation procedure and analysis.

8. **Carolina Wählby**
   Date: 110824
   Address: The Karolinska Institute, Stockholm
   Title: Image Based, High-Throughput Screening of Gene Function in Cells and Model Organisms
   Comment: Wählby gave a presentation on the meeting Putting proteins under the microscope; future PROSPECTS for biological imaging

9. **Carolina Wählby**
   Date: 110824
   Address: UU Hospital
   Title: Image based, High-Throughput Screening of Gene Function in Cells and Model Organisms
   Comment: Wählby gave a presentation on the SciLifeLab day, Uppsala

10. **Filip Malmberg**
    Date: 111031
    Address: Dept. of Radiology, Oncology and Radiation Science, UU Hospital
    Title: Interaktiv Bildsegmentering i Medicinska Tillämpningar (Interactive image segmentation in medical applications), in Swedish

11. **Ewert Bengtsson**
    Date: 111122
    Address: Sahlgrenska University Hospital, Göteborg
    Title: Molecules to Organs - Challenges in Biomedical Image Analysis
    Comment: A one hour invited seminar.

7.4 Seminars at CBA with invited guest lecturers

1. **Jeremy Adler**
   Address: Vascular Biology group, Dept. of Genetics and Pathology, UU
   Date: 110117
   Title: A Random Walk in Image Analysis

2. **Ghassan Hamarneh**
   Address: School of Computing Science, Simon Fraser University, Burnaby, BC, Canada
   Date: 110120
   Title: Perspectives and Challenges of Optimization in Medical Image Analysis

3. **Rafeef Abugharbieh**
   Address: Dept. of Electrical and Computer Engineering, University of British Columbia, Vancouver, Canada
   Date: 110125
   Title: New Directions for fMRI Data Analysis

4. **Johan Henriksson**
   Address: Dept. of Biosciences and Nutrition, Karolinska Institute, Stockholm
   Date: 110131
   Title: Endrov – an Open Source Framework for Image Processing and Analysis

5. **Roland S. Johansson**
   Address: Dept. of Integrative Medical Biology, Umeå University
   Date: 110311
   Title: Coding and Use of Sensory Signals during Dexterous Object Manipulation in Humans

6. **Jayaram K. Udupa**
   Address: Medical Image Processing Group, Dept. of Radiology, University of Pennsylvania, USA
   Date: 110509
   Title: Fuzzy Object Modeling

7. **Tony Barrera**
   Date: 110513
   Title: Fast Algorithms for Digital Circles

8. **Stéphanie Robert**
   Address: Dept. of Forest Genetics and Plant Physiology, SLU
   Date: 110609
   Title: Using Chemical Genetics to Investigate the Involvement of Vesicular Trafficking in Plant Development

9. **Elton Rexhepaj**
   Address: SciLifeLab Stockholm
   Date: 110613
   Title: Knowledge Discovery in Medical Imaging Data using Image Analysis and Machine Learning Methods and Application to Drug Development

10. **Daniel G. Aliaga**
    Address: Dept. of Computer Science, Purdue University, West Lafayette, IN, USA
    Date: 110912
    Title: Computational Cities: Geometrical Modeling for Urban Design and Simulation

11. **Seidon Alsaody**
    Address: Dept. of Mathematics, UU
    Date: 110926
    Title: Generalizing Connective Segmentation to Arbitrary Complete Lattices

12. **Alexandra Pacureanu**
    Address: CREATIS, INSA de Lyon & European Synchrotron Radiation Facility, Grenoble, France
    Date: 111004
    Title: Imaging and Analysis of the Bone Cell Network with Synchrotron Radiation CT

13. **Carl Sjöberg**
    Address: Dept. of Radiology, Oncology and Radiation Science, UU
    Date: 111017
    Title: Probabilistic Weighting - a Segmentation Fusion Method

14. **Andrew Mehnert**
    Address: Chalmers University of Technology, Göteborg
    Date: 111018
    Title: Image Analysis for the Study of Chromatin Distribution in Cell Nuclei

15. **Rittscher Jens**
    Address: GE Global Research
    Date: 111110
    Title: Using Algorithms to Produce High Content Information from Cell and Tissue Images

7.5 Seminars at CBA

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

1. **Hamid Sarve**
   Date: 110110
   Title: How to Write a Thesis

2. **Jim Björk**
   Date: 110124
   Title: Evaluation of a 3D Holographic Display
   Comment: Master thesis presentation

3. **Ulf Hammarqvist**
   Date: 110209
   Title: Audio Editing it the Time-Frequency Domain using the Gabor Wavelet Transform
   Comment: Master thesis presentation

4. **Amin Allalou**
   Date: 110214
   Title: A Visit at MIT, Cambridge

5. **Cris Luengo**
   Date: 110221
   Title: The Generalized Radon Transform: Sampling, Accuracy and Memory Considerations

6. **Bettina Selig**
   Date: 110228
   Title: Endothelial Cell Segmentation

7. **Patrik Malm**
   Date: 110307
   Title: Updating the CBA Web Presence

8. **Ewert Bengtsson**
   Date: 110314
   Title: Recognizing Signs of Malignancy - The Quest for Computer Assisted Cancer Screening and Diagnosis Systems

9. **Anders Brun**
   Date: 110321
   Title: Particle Methods for Image Processing

10. **Gustaf Kylberg**
    Date: 110328
    Title: Local Binary Patterns for Texture Analysis of Virus Images

11. **Vladimir Curic**
    Date: 110404
    Title: An Introduction to Morphological Amoebas

12. **Erik Wernersson**
    Date: 110411
    Title: Localization and Description of Feature Points in scalar images

13. **Lennart Svensson**
    Date: 110418
    Title: Visualizing Registration Parameter Spaces for MET Images

14. **Filip Malmberg**
    Date: 110429
    Title: Rehearsal Before the Public Defense of the Thesis

15. **Andreas Kårsnäs**
    Date: 110502
    Title: Using Sparse Label Dictionaries for Segmentation of Nuclei in Digital Histopathology

16. **Robin Strand**
    Date: 110516
    Title: High-Accuracy Distance Transform

17. **Feng Sitao**
    Date: 110520
    Title: Image Analysis on Wood Fiber Cross-Section Images
    Comment: Master thesis presentation

18. **Cai Tengjiao**
    Date: 110520
    Title: Recognizing Art Pieces in Subway Using Computer Vision
    Comment: Master thesis presentation

19. **Guoliang Luo**
    Date: 110523
    Title: Evaluation of a Model Free Approach to Object Manipulation in Robotics
    Comment: Master thesis presentation

20. **Catherine Östlund**
    Date: 110523
    Title: How to Add Water and Remove it

21. **Khalid Niazi**
    Date: 110530
    Title: Non-Uniform Illumination Correction in Medical Images

22. **Ida-Maria Sintorn**
    Date: 110905
    Title: Project Wrap up for "Rapid Detection and Identification of Highly Pathogenic Viruses"

23. **Alexander Denev**
    Date: 110909
    Title: Digital Distance Functions Defined by Sequences of Weights
    Comment: Master thesis presentation

24. **Hamid Sarve**
    Date: 110919
    Title: Rehearsal Before the Public Defense of the Thesis

25. **Stefan Seipel**
    Date: 111003
    Title: Evaluating 2D and 3D Map Representations for Basic Geo-Spatial Assessment

26. **Ingela Nyström**
    Date: 111010
    Title: eSSENCE - a Strategic Effort for Many Researchers Including us at CBA

27. **Khalid Niazi**
    Date: 111020
    Title: Rehearsal Before the Public Defense of the Thesis

28. **Fredrik Nysjö**
    Date: 111024
    Title: Rendering Software for Multiple Projectors
    Comment: Master thesis presentation

29. **Shuo Li**
    Date: 111024
    Title: Registration of 3D Volumetric CT Images
    Comment: Master thesis presentation

30. **Amin Allalou**
    Date: 111031
    Title: Rehearsal Before the Public Defense of the Thesis

31. **Cris Luengo**
Date: 111107
Title: From Images to Size Distributions

32. **Azadeh Fakhrzadeh**
Date: 111114
Title: Automated Analysis of Histological Images of Testicular Tissue

33. **Elisabeth Linnér**
Date: 111121
Title: Properties of the Face- and Body-Centered Cubic Grids

34. **Milan Gavrilovic**
Date: 111128
Title: Rehearsal Before the Public Defense of the Thesis

35. **Pontus Olsson**
Date: 111205
Title: Physically Co-Located Haptic Interaction with 3D Displays

36. **Martin Simonsson**
Date: 111212
Title: Quantification of DNA Damage Response – From the Bottom to the Plot

37. **Elhassan Mohamed Abdou**
Date: 111219
Title: Visual Planning and Verification of Deep Brain Stimulation Interventions
Comment: Master thesis presentation

7.6 Conference participation

7.6.1 Special invited speaker

1. *Conference:* 2nd International Conference on Visual Informatics (IVIC 2011)
Ingela Nyström
Date: 111109
Address: Selangor, Malaysia
Title: Visualization and Haptics for Interactive Medical Image Analysis — Image Segmentation in Cranio-Maxillofacial Surgery Planning

7.6.2 Oral presentations – refereed conferences

1. *Conference:* International Conference on Computer Graphics, Visualization and Computer Vision 2011 (WSCG 2011)
Lennart Svensson
Date: 110131–110203
Address: University of West Bohemia, Campus-Bory, Plzen, Czech Republic
Title: Investigating Measures for Transfer Function Generation for Visualization of MET Biomedical Data

2. *Conference:* 16th IAPR International Conference on Discrete Geometry for Computer Imagery (DGCI 2011)
Robin Strand
Date: 110406–110408
Address: Nancy, France
Title: Sparse Object Representations by Digital Distance Functions

3. *Conference:* The First Joint 3DIM/3DPVT Conference on 3D Imaging, Modeling, Processing, Visualization and Transmission (3DIMPVT 2011)
Erik Wernersson
Date: 110516–110519

Address: Hangzhou, China
Title: Calculating Curvature in Volumetric Images using Orientation Fields

4. *Conference:* Scandinavian Conference on Image Analysis (SCIA 2011)
Filip Malmberg
Date: 110523–110527
Address: Ystad Saltsjöbad
Title: Generalized Hard Constraints for Graph Segmentation

5. *Conference:* Large Scale Scientific Computations
Elisabeth Linnér
Date: 110605–110610
Address: Sozopol, Bulgaria
Title: Aliasing Properties of Voxels in 3D Sampling Lattices

6. *Conference:* 7th International Symposium on Image and Signal Processing and Analysis (ISPA 2011)
Robin Strand
Date: 110904–110906
Address: Dubrovnik, Croatia
Title: A Weighted Neighbourhood Sequence Distance Function with Three Local Steps

7. *Conference:* International Conference on Image Analysis and Processing (ICIAP 2011)
Lennart Svensson
Date: 110913–110916
Address: Ravenna, Italy
Title: Registration Parameter Spaces for Molecular Electron Tomography Images

8. *Conference:* ICDAR and HIP (International Workshop on Historical Document Imaging and Processing)
Anders Brun
Date: 110916–110921
Address: Beijing, China
Title: Data Mining Medieval Documents by Word Spotting

9. *Conference:* 16th Iberoamerican Congress on Pattern Recognition (CIARP 2011)
Gustaf Kylberg
Date: 111115–111118
Address: Pucón, Chile
Title: Virus Texture Analysis Using Local Binary Patterns and Radial Density Profiles

7.6.3 Poster presentations – refereed conferences

1. *Conference:* International Workshop on Combinatorial Image Analysis (IWCIA 2011)
Vladimir Curic
Date: 110523–110525
Address: Madrid, Spain
Title: Distance Measures Between Digital Fuzzy Objects and their Applicability in Image Processing

2. *Conference:* Scandinavian Conference on Image Analysis (SCIA 2011)
Filip Malmberg
Date: 110523–110527
Address: Ystad Saltsjöbad
Title: Image Foresting Transform: On-the-fly Computation of Segmentation Boundaries

3. *Conference:* Bioimage Informatics II
Carolina Wählby
Date: 110918–110921
Address: Janelia Farm, MD, USA
Title: Quantifying Phenotypic Variation in Image-Based C. Elegans Screens

4. *Conference:* Medical Image Computing and Computer Assisted Intervention (MICCAI 2011)
   Andreas Kårsnäs
   Date: 110918–110922
   Address: Toronto, Canada
   Title: Learning Histopathological Patterns

7.6.4 Oral presentations – non-refereed conferences

1. *Conference:* Swedish Symposium on Image Analysis (SSBA 2011)
   Amin Allalou
   Date: 110316–110318
   Address: Linköping University
   Title: Approaches for Increasing Throughput and Information Content of Image-Based Zebrafish Screens

2. *Conference:* Swedish Symposium on Image Analysis (SSBA 2011)
   Gustaf Kylberg
   Date: 110316–110318
   Address: Linköping University
   Title: Refinement of Segmented Virus Particle Candidates in TEM Images

3. *Conference:* Swedish Symposium on Image Analysis (SSBA 2011)
   Erik Wernersson
   Date: 110316–110318
   Address: Linköping
   Title: Calculating Curvature in Volumetric Images using Orientation Fields

4. *Conference:* Visual Forum
   Ida-Maria Sintorn
   Date: 110403
   Address: Lindholmen science park, Göteborg
   Title: ProViz – Interactive Visualization of 3D Protein Images
   Comment: Sintorn and Svensson also demonstrated the ProViz-software in the exhibition.

5. *Conference:* Inje Workshop, Uppsala
   Robin Strand
   Date: 110718–110722
   Address: CBA
   Title: Segmentation with Grey Weighted Distance Transforms

6. *Conference:* Quantifying and modeling cellular processes using image analysis
   Ingela Nyström
   Date: 111201
   Address: Uppsala Biomedical Center (BMC), UU
   Title: 3D Biomedical Visualization
   Comment: Centre for Image Analysis and BioVis, SciLifeLab Uppsala Joint Symposium.

7. *Conference:* Quantifying and modeling cellular processes using image analysis
   Cris Luengo
   Date: 111201
   Address: Uppsala Biomedical Center (BMC), UU
   Title: The Three-Dimensional Fruit Fly Embryo
   Comment: Centre for Image Analysis and BioVis, SciLifeLab Uppsala Joint Symposium.

8. *Conference:* Quantifying and modeling cellular processes using image analysis
   Ida-Maria Sintorn
   Date: 111201
   Address: Uppsala Biomedical Center (BMC), UU
   Title: TEM for Automatic Virus Recognition and In Situ Protein Analysis
   Comment: Centre for Image Analysis and BioVis, SciLifeLab Uppsala Joint Symposium.

7.6.5 Poster presentations – non-refereed conferences

1. *Conference:* Swedish Symposium on Image Analysis (SSBA 2011)
   Hamid Sarve
   Date: 110316–110318
   Address: Linköping University
   Title: Visualization Methods for 3D Bone Implant Samples

2. *Conference:* Swedish Symposium on Image Analysis (SSBA 2011)
   Patrik Malm
   Date: 110316–110318
   Address: Linköping University
   Title: CerviScan Project Overview

3. *Conference:* IST (Imaging Science and Technology) Day
   Bettina Selig
   Date: 110406–110406
   Address: Quantitative Imaging Group at Delft University of Technology, The Netherlands
   Title: Lumen and Ray Detection in Compression Wood Cross-Sections

4. *Conference:* Medicinteknikdagarna
   Ingrid Carlbom, Pontus Olsson
   Date: 111011–111012
   Address: Linköping
   Title: Whole Hand Haptics

5. *Conference:* Internal workshop, Stockholm University
   Anders Brun
   Date: 111211
   Address: Stockholm University
   Title: Image Segmentation using Context Based Estimation of Spectral Class Presence

7.6.6 Attended conferences

1. *Conference:* Origin-of-Life Day
   Gunilla Borgefors
   Date: 110225
   Address: Uppsala Biomedical Center (BMC), UU
   Comment: A cross-disciplinary symposium on the conditions for the emergence of biomolecules and basic forms of life (following the Celsius-Linné lectures).

2. *Conference:* Swedish Bioimaging Network
   Ewert Bengtsson
   Date: 110309
   Address: Linköping University Hospital
   Comment: A meeting to consolidate the national collaboration network in Bioimaging (including image analysis), around 40 attendees.

3. *Conference:* SSBA strategy day
   Ewert Bengtsson, Anders Brun, Cris Luengo, Ingela Nyström, Ida-Maria Sintorn
   Date: 110316
   Address: Linköping University Hospital
   Comment: A meeting to discuss the current funding situation in image analysis and try to find ways of increase recognition and support organised in conjunction with SSBA symposium. Bengtsson and Anders Brun co-organized the SSBA strategy panel (“seniordagen”).

4. *Conference:* Swedish Symposium on Image Analysis (SSBA 2011)
   Ewert Bengtsson, Gunilla Borgefors, Anders Brun, Ingrid Carlbom, Vladimir Curic, Azadeh Fakhrzadeh, Elisabeth Linnér, Cris Luengo, Ingela Nystöm, Ida-Maria Sintorn, Lennart Svensson

Date: 110316–110318
Address: Linköping University
Comment: Sintorn and Nystöm on the SSBA board at the Annual meeting.

5. *Conference:* 16th International Conference on Discrete Geometry for Computer Imagery (DGCI 2011)
Gunilla Borgefors
Date: 110406–110408
Address: INRIA, Nancy, France
Comment: Borgefors was Session Chair.

6. *Conference:* 17th Scandinavian Conference on Image Analysis (SCIA 2011)
Ingela Nyström, Elisabeth Linnér, Ewert Bengtsson, Gunilla Borgefors, Cris Luengo
Date: 110523–110526
Address: Ystad Saltsjöbad
Comment: SSBA board meeting during the conference.

7. *Conference:* AIM-day Cancer
Ewert Bengtsson, Gunilla Borgefors
Date: 110614
Address: Rudbeck Laboratory, UU
Comment: Bengtsson participated in two sessions on image analysis for cancer applications, Ingrid Carlbom was one of the organizers.

8. *Conference:* World Haptics
Ingrid Carlbom, Pontus Olsson
Date: 110621–110624
Address: Istanbul, Turkey

9. *Conference:* 10th International Symposium on Mathematical Morphology (ISMM 2011)
Cris Luengo, Vladimir Curic
Date: 110706–110708
Address: Intra, Lake Maggiore, Italy

10. *Conference:* AMC SIGGRAPH 2011
Ingrid Carlbom
Date: 110808–110811
Address: Vancouver, Canada

11. *Conference:* Putting proteins under the microscope: future PROSPECS for biological imaging
Ida-Maria Sintorn
Date: 110824
Address: Karolinska Institute, Solna
Comment: One-day seminar.

12. *Conference:* 16th International Conference on Image Analysis and Processing (ICIAP 2011)
Gunilla Borgefors
Date: 110914–110916
Address: Ravenna, Italy
Comment: Borgefors was Session Chair.

13. *Conference:* Medical Image Computing and Computer Assisted Intervention (MICCAI)
Azadeh Fakhrzadeh
Date: 110918–110922
Address: Toronto, Canada

14. *Conference:* Swedish Medical Engineering Conference
Ewert Bengtsson
Date: 111011–111012
Address: Linköping Conference Centre

15. *Conference:* Bob Duin Farewell Symposium
    Cris Luengo
    Date: 111028
    Address: Delft, The Netherlands

16. *Conference:* 16th Iberoamerican Congress on Pattern Recognition (CIARP 2011)
    Ida-Maria Sintorn
    Date: 111115–111118
    Address: Pucon, Chile

7.6.7 Other conferences

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

1. *Conference:* VINNMER fellowship day
   Ida-Maria Sintorn
   Date: 110127
   Address: Piperska Muren, Scheelegatan 14, Stockholm

2. *Conference:* Ledardagen 2011
   Cris Luengo
   Date: 110127
   Address: Aulan, Ultuna Campus, SLU

3. *Conference:* LADOK 3 planning
   Ewert Bengtsson
   Date: 110210
   Address: KTH, Stockholm
   Comment: Discussed the plans for a completely new administrative system for higher education in Sweden to replace the current Ladok system.

4. *Conference:* Deans conference UU
   Ewert Bengtsson
   Date: 110426–110427
   Address: Gimo Conference Centre
   Comment: Discussion of various strategic management issues for UU.

5. *Conference:* Nordic eScience Conference
   Ingela Nyström
   Date: 110929–110930
   Address: Helsini, Finland
   Comment: Representing the strategic initiative eSSENCE and UU

6. *Conference:* SLU - Forest Faculty Day
   Ida-Maria Sintorn, Cris Luengo
   Date: 111130
   Address: Faculty of Forestry, SLU, Umeå

7. *Conference:* 7th IEEE International Conference on e-Science
   Ingela Nyström
   Date: 111205–111208
   Address: Stockholm
   Comment: Panel member: International e-Science Coordination. Session chair: Bioinformatics and Health/Tools.

7.7 Visiting scientists (staying at least 2 weeks)

1. **Ghassan Hamarneh, Rafeef Abugharbieh**
   Address: School of Computing Science, Simon Fraser University; and Dept. of Electrical and Computer Engineering, University of British Columbia; Vancouver, Canada
   Hosts: Ingela Nyström, Cris Luengo, Ewert Bengtsson, Gunilla Borgefors
   Date: 110110–110130
   Comment: Hamarneh and Abugharbieh were at CBA for 3 weeks to explore possible future collaborations between Uppsala and Vancouver.

2. **Dr K Sujathan**
   Address: Regional Cancer Centre, Thiruvanantahpuram, India
   Host: Ewert Bengtsson
   Date: 110927–111009
   Topic: Collecting identified cell images for training annd testing classifiers
   Comment: A two week visit as part of our joint project.

3. **Olivier Kossan Bagui**
   Address: Institute National Polytechnique Dept. Genie Electrique et Electronique, Institut National, Polytechnique Felix Houbhouet-Boigny, Cote d' Ivoire
   Host: Carolina Wählby
   Date: 111031–120110
   Topic: Joint project on malaria detection using LED spectral microscopy
   Comment: Zoueu came for a short visit 110927 while Kossan Bagui stayed and worked with us at CBA on blood cell segmentation for about 3 months.

4. **S. Issac Niwaas**
   Address: National Institute of Technology (NIT), Tiruchirappalli, Tamil, Nadu, India
   Host: Ewert Bengtsson
   Date: 111208–
   Topic: Visiting PhD student
   Comment: Niwas is a visiting PhD student doing research on breast cancer image analysis for at least 6 months, probably until end of May 2012.

7.8 Other visitors

1. **Tomas Lundmark**
   Address: Faculty of Forestry, SLU, Umeå
   Host: Ewert Bengtsson
   Date: 110118
   Topic: The future organisation of CBA

2. **Bengt Sandblad**
   Address: HCI division, IT Department, UU
   Host: Ewert Bengtsson
   Date: 110124
   Topic: The need of a review of IT-systems at UU from usability perspective

3. **Johan Henriksson**
   Address: Karolinska Institute
   Host: Anders Brun
   Date: 110131
   Topic: Cell Image Analysis

4. **Ingemar Kaj**
   Address: Dept. of Mathematics, UU
   Hosts: Ingrid Carlbom, Ewert Bengtsson
   Date: 110214
   Comment: Demonstrated our haptic research for our division dean to get his support for applications.

5. **Olle Terenius, Antoine Lecocq**
   Address: Dept. of Ecology, SLU
   Host: Cris Luengo
   Date: 110303
   Topic: Discussion future project

6. **Roland Johansson**
   Address: Umeå University
   Host: Ingrid Carlbom
   Date: 110311
   Topic: Human Touch
   Comment: Johansson gave a talk on Human touch and met with the haptics group.

7. **Thomas Storsjö, Marcus Edvinsson**
   Address: Eurocon Analyzer AB, Timrå
   Host: Cris Luengo
   Date: 110325
   Topic: Start of exjobb
   Comment: Storsjö introduced the project requirements, and we discussed how the project will proceed. Edvinsson started his exjobb at CBA the following Monday.

8. **Ingrid Melinder**
   Address: Former head of Nada, KTH
   Host: Ingrid Carlbom
   Date: 110406
   Topic: Women's Role in IT
   Comment: Melinder gave a talk on how she has achieved such success in hiring women and also visited CBA for a haptics demo.

9. **Andrew Mehnert, Mikael Persson**
   Address: Chalmers, Göteborg
   Host: Ewert Bengtsson
   Date: 110421
   Topic: Possible future collaboration

10. **Tomas Ulvcrona**
    Address: Vindeln Experimental Forests, Vindeln, SLU
    Host: Ida-Maria Sintorn
    Date: 110429
    Topic: Discussion about potential collaborative projects

11. **De Leidsche Flesch**
    Address: Leiden, The Netherlands
    Host: Cris Luengo
    Date: 110503
    Comment: About 30 undergraduate students from Leiden University visited CBA and heard about image analysis and the various projects we are running. Selig, Kylberg, Malm, Malmberg, Sarve and Olsson showed their work.

12. **Jayaram K. Udupa**
    Address: Medical Image Processing Group, Dept. of Radiology, University of Pennsylvania, Philadelphia, USA
    Host: Ingela Nyström
    Date: 110504–110509
    Topic: Discussions on various projects of common interest, in particular the haptics project
    Comment: A visit in connection with Malmberg's dissertation, where Udupa served as faculty opponent.

13. **KOF evaluation panel**
    Address: Various international universities
    Hosts: Seniors at CBA

Date: 110511
Number of visitors: 10
Topic: Evaluation of research in applied mathematics
Comment: Lunch and one hour visit to present all our research for the evaluation panel.

14. **Jan Carlsson**
Address: Dept. of Physical Chemistry, UU
Host: Ewert Bengtsson
Date: 110512
Topic: Possible collaboration

15. **Gabriella Sanniti di Baja**
Address: Istituto di Cibernetica "E. Caianiello", C.N.R., Pozzuoli, Italy
Hosts: Gunilla Borgefors, Ingela Nyström
Date: 110513–110520
Topic: Sanniti di Baja gave a CoSy seminar and ongoing cooperation
Comment: During the visit it was announced that Sanniti di Baja had been elected as a foreign member of the Royal Society of Sciences in Uppsala. Sanniti di Baja was invited to give a seminar at the Centre for Interdisciplinary Mathematics, UU.

16. **Tomas Lundmark**
Address: Faculty of Forestry, SLU, Umeå
Host: Ewert Bengtsson
Date: 110513
Topic: The future organisation of CBA
Comment: Meeting with Håkan Lanshammar, Ingemar Kaj on organisation.

17. **Stephanie Robert**
Address: Umeå Plant Science Centre, Dept. of Forest Genetics and Plant Physiology, SLU
Host: Ida-Maria Sintorn
Date: 110609
Topic: Image analysis of plant cell fluorescence images
Comment: Robert also gave a seminar about her research.

18. **Pasha Razifar, Rune Sundset, Samuel Kuttner**
Address: Pasha Razifar, GE PET Research Uppsala and Rune Sundset and Samuel Kuttner, Kompetansesenter for diagnostisk fysikk Røntgenavdelingen, Pb. 103 Universitetssykehuset Nord-Norge HF, Tromsø, Norway
Host: Ewert Bengtsson
Date: 110616
Topic: Planning a joint application for PET research

19. **Per Lötstedt, Gustaf Ullman**
Address: Scientific Computing, IT Department, UU
Host: Ewert Bengtsson
Date: 110616
Topic: Collaboration on cell tracking project

20. **Aurelie Laloeuf**
Address: Karolinska Institute
Host: Lennart Svensson
Date: 110623
Topic: Collaboration discussions

21. **Gabriella Sanniti di Baja**
Address: Istituto di Cibernetica "E. Caianiello", C.N.R., Pozzuoli, Italy
Host: Gunilla Borgefors
Date: 110901–110904
Topic: Ongoing cooperation

22. **Daniel Aliaga**
Address: Computer Science, Purdue University, West Lafayette, IN, USA
Host: Ingrid Carlbom
Date: 110912
Topic: UrbanVision
Comment: Aliaga gave seminar on UrbanVision is a system for modeling and simulating urban enviroments.

23. **Mikael Jonsson**
Address: Dept. of Engineering, UU
Host: Ewert Bengtsson
Date: 110921
Topic: Interview about UU IT organisation
Comment: Jonsson is preparing a proposal for how UU should organize the central strategic management and development of IT systems.

24. **Pasha Razifar**
Address: GE Uppsala
Host: Ewert Bengtsson
Date: 110921
Topic: Future collaboration possibilities

25. **International Science Program guests**
Address: ISP, Uppsala
Hosts: Ewert Bengtsson, Carolina Wählby
Date: 110928
Number of visitors: 3
Topic: Discussing possible project collaboration on Malaria parasite detection though image analysis

26. **Rajesh Kumar, Salam Sibi, Pundluvalu Nataraju Sharathkumar**
Address: Thiruvananthapuram, India
Host: Ewert Bengtsson
Date: 111014–111021
Topic: Joint workshop
Comment: Several others from CBA participated in the meetings during the week.

27. **Andrew Mehnert**
Address: Chalmers, Göthenburg
Host: Ewert Bengtsson
Date: 111017–111019
Topic: Joint workshop
Comment: Mehnert took part in the workshop in the Cerviscan project.

28. **Olivier Kossan Bagui, Jeremie Zoueu**
Address: Institute National Polytechnique Dept. Genie Electrique et Electronique, Institut National, Polytechnique Felix Houbhouet-Boigny, Cote d' Ivoire
Host: Carolina Wählby
Date: 111031
Topic: Joint project on malaria detection using LED spectral microscopy
Comment: Zoueu came for a short visit while Kossan Bagui stayed and worked with us at CBA on blood cell segmentation for about 3 months.

29. **Markku Hauta-Kasari, Joni Orava**
Address: School of Computing, SIB-labs, University of Eastern Finland, Joensuu, Finland
Host: Ewert Bengtsson
Date: 111118
Topic: Plans for a joint EU application
Comment: Will write a joint application on real time spectral image analysis in brain surgery.

30. **Tomas Lundmark, Håkan Lindkvist**
Address: SLU Faculty of Forestry, Umeå
Host: Ewert Bengtsson
Date: 111125
Topic: Future organisation of SLU part of CBA
Comment: Håkan Lanshammar, Sverker Holmgren and Irene Kolare also participated.

31. **Roland Johansson, Benoni Edin**
Address: Professors of Physiology, Umeå University
Host: Ingrid Carlbom
Date: 111216
Topic: Human Somatosensory System
Comment: Prof. Johansson and Edin met with the Haptics Group.

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

1. **Bettina Selig**
Hosts: Bernd Rieger (Quantitative Imaging Group, Delft University of Technology, Netherlands), Koen Vermeer (Eye Hospital Rotterdam, Netherlands)
Address: Delft University of Technology and Eye Hospital Rotterdam, The Netherlands
Date: 110319–110425
Topic: Endothelial Cell Segmentation of the Cornea of Human Eyes
Comment: Cooperative project between the Quantitative Imaging Group at Delft University of Technology and the Eye Hospital Rotterdam.

2. **Amin Allalou**
Host: Mehmet F. Yanik
Address: MIT – Massachusetts Institute of Technology, Cambridge, USA
Date: 110328–110504
Topic: Research Visit

3. **Ida-Maria Sintorn**
Host: Anne Carpenter
Address: Imaging Platform, BROAD Institute, Boston, USA
Date: 110513–110527
Topic: Research Visit
Comment: The purpose of the visit was to strengthen an established collaboration with neuroscientists in Boston but also to exchange experiences with the researchers at the Imaging Platform.

4. **Erik Wernersson**
Hosts: Karl Entacher, Alexander Petutschingg
Address: Fachhochschule Salzburg, Forschungsgesellschaft mbH, Urstein Süd 1, A-5412 Puch/Salzburg, Austria
Date: 110912–111007
Topic: Research visit
Comment: Two visits 110912–111007 and 111114–111129.

7.10 Short visits to other research groups and meetings outside CBA

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

1. **Lennart Svensson, Ida-Maria Sintorn**
Hosts: Lars Norlén, Aurelie Laloeuf, Lianne den Hollander
Address: Dermatology and Venereology Unit, Karolinska Institute, Stockholm
Date: 110111
Topic: Collaboration discussions

2. **Cris Luengo**
   Host: Olle Terenius
   Address: Dept. of Ecology, Ultuna Campus, SLU
   Date: 110202
   Topic: Discussion future research project
   Comment: Lead to the VR grant "Understanding the transmission route of infectious human diseases via social contact networks in honey bees".

3. **Ida-Maria Sintorn, Robin Strand**
   Host: Jeremy Adler
   Address: Rudbeck laboratory, Uppsala
   Date: 110202
   Topic: Particle diffusion on surface
   Comment: Met with Adler and Parmryd to discuss a potential collaboration project.

4. **Cris Luengo, Hamid Sarve**
   Host: Ångström Materials Academy, UU Innovation
   Address: Faculty room at Ångström
   Date: 110218
   Topic: Meeting/Polymer, CBA, PET, ÅMA, Life Science
   Comment: Purpose of the meeting: Present each others fields and interests and see if we can find activities that are of common interest.

5. **Hamid Sarve, Amin Allalou, Patrik Malm**
   Host: Heung-Kook Choi
   Address: Pusan, Korea
   Date: 110219–110226
   Topic: Swedish-Korean Workshop

6. **Ewert Bengtsson**
   Host: Uppsala City Council
   Address: Uppsala Municipal Office
   Date: 110330
   Topic: Reception to thank Bengt Rinde
   Comment: Bengt Rinde was retiring, Bengtsson had worked together with him on promoting IT business-university collaboration for many years.

7. **Björn Holmberg**
   Host: Anders Brun
   Address: Polacksbacken
   Date: 110426
   Topic: Combitech business, future Master thesis projects
   Comment: Lunch meeting with Holmberg from Combitech.

8. **Ewert Bengtsson, Ingela Nyström**
   Host: Conference Centre Representative
   Address: Stockholm Waterfront Conference Centre
   Date: 110503
   Topic: Planning for ICPR 2014
   Comment: Bengtsson, NystrÃ¶m, Anders Heyden, and Magnus Borga visited the conference Centre where we are planning to organize ICPR 2014 to see what facilities they can offer.

9. **Ida-Maria Sintorn, Carolina Wählby**
   Hosts: Sofia Mellgren, Elise Langenkamp, Anna Dimberg
   Address: Dept. of Immunology, Genetics, and Pathology, UU
   Date: 110510
   Topic: Tissue microarray analysis

10. **Stefan Seipel**
    Host: GeomaticsNorway

Address: GeomaticsNorway, Fornebu
Date: 110524
Topic: Discussion of project proposal

11. **Ida-Maria Sintorn**
Host: Stephen Haggarty
Address: The Centre for Human Genetic Research, Massachusetts General Hospital, Boston, USA
Date: 110526
Topic: Collaboration regarding neuronal co-culture analysis

12. **Ingela Nyström**
Host: Freddy Ståhlberg
Address: Dept. of Medical Radiation Physics, Lund University
Date: 110531
Topic: Data storage for the national 7T MR camera initiative
Comment: A meeting with participating key players in this national initiative. Representatives from Swedish Bioimaging, CMIV, CBA, eSSENCE, Lunarc, UPPMAX, UCAN, and more.

13. **Gunilla Borgefors, Ewert Bengtsson, Ida-Maria Sintorn, Gustaf Kylberg**
Hosts: Ali Mirazimi, Kjell-Olof Höglund
Address: Swedish Institute for Communicable Disease Control (SMI), Solna
Date: 110608
Topic: Presentation and demonstration of the PANVIRUSSHIELD project
Comment: This presentation celebrated the end of the project.

14. **Ewert Bengtsson**
Host: Anders Magnusson
Address: Dept. of Radiology, Oncology and Radiation Science, UU Hospital
Date: 110609
Topic: Possible new collaboration
Comment: New project ideas on accurate 3D measurements in X-ray images discussed.

15. **Stefan Seipel**
Host: University of Trondheim
Address: University of Trondheim, Norway
Date: 110615
Topic: Discussion of possible collaboration

16. **Ida-Maria Sintorn, Gustaf Kylberg**
Host: Mohammed Homman
Address: Vironova AB, Stockholm
Date: 110726–110727
Topic: miniTEM project kickoff
Comment: First meeting in the Eurostar mini-TEM project with partner representatives from Vironova, CBA and Delong Instruments in the Czech Republic.

17. **Ingela Nyström**
Host: Brian C. Lovell
Address: School of ITEE, University of Queensland, Brisbane, Australia
Date: 110808–110809
Topic: IAPR Executive Committee Meeting

18. **Ingela Nyström**
Host: Andrew P. Bradley
Address: School of ITEE, University of Queensland, Brisbane, Australia
Date: 110810
Topic: Discussing common interests in biomedical image analysis

19. **Carolina Wählby, Martin Simonsson**
Hosts: Johan Kreuger and Sara Thorslund

Address: Gradientech AB, Uppsala Science Park, Uppsala
Date: 110812–111231
Topic: Cell tracking
Comment: We initiated a collaboration in August 2011 and have visited each other several times during the fall exchanging data and results on cell tracking.

20. **Catherine Östlund**
Hosts: Tuomas Turpeinen, Jussi Timonen
Address: University of Jyväskylä, Finland
Date: 110817–110826
Topic: Microtomography

21. **Ingela Nyström**
Hosts: Stig Skelboe, Francois Fluckiger
Address: Niels Bohr Institute, Copenhagen University, Denmark
Date: 110818–110819
Topic: Study of CERN School of Computing 2011
Comment: In preparation for CERN School of Computing 2012 to be held in Uppsala.

22. **Hamid Sarve**
Host: Carina Johansson
Address: Carina Johansson, Institute of Odontology, The Sahlgrenska Academy, Göteborg
Date: 110826
Topic: Project discussion
Comment: Visited the lab.

23. **Ewert Bengtsson**
Host: Radio reporter
Address: Uppsala
Date: 110906
Topic: Swedish Radio Uppland
Comment: Interviewed with live broadcast about history and trends on internet.

24. **Gunilla Borgefors**
Host: Gabriella Sanniti di Baja
Address: Istituto di Cibernetica "E. Caianiello", C.N.R., Pozzouli, Italy
Date: 110908–110913
Topic: Ongoing cooperation

25. **Ida-Maria Sintorn, Gustaf Kylberg**
Host: Klaus Leifer
Address: Dept. of Engineering Sciences, Ångström Laboratory, UU
Date: 110916
Topic: Electron microscopes at Ångström
Comment: Talked to Leifer about the electron microscopy equipment research projects at Ångström.

26. **Ida-Maria Sintorn, Lennart Svensson, Johan Nysjö**
Hosts: Bertil Daneholt, Sergej Masich
Address: Dept. of Cell and Molecular Biology, Karolinska Institute
Date: 110921
Topic: Segmentation of molecular electron tomography images
Comment: Discussion about how to collaborate regarding segmentation of molecular electron tomography images. While at Karolinska Institute, collaborators in Lars Norlen's group were also visited.

27. **Ewert Bengtsson, Filip Malmberg**
Host: Anders Magnusson
Address: Dept. of Radiology, Oncology and Radiation Science, UU Hospital
Date: 110922
Topic: Collaboration on measurements in X-rays

28. **Ewert Bengtsson**
Host: Olof Nilsson
Address: Academic Hospital, UU
Date: 110929
Topic: Lunch Meeting for "Rektorsråd"
Comment: The group of senior advisors to the vice chancellor of UU met informally to discuss our tasks and duties. Marianne Carlsson and Lars Burman also participated.

29. **Cris Luengo**
Host: Gerie van der Heijden
Address: Biometris, Wageningen University, The Netherlands
Date: 111031
Topic: Possible future collaboration

30. **Ingela Nyström**
Host: Francois Fluckiger
Address: CERN, Geneva, Switzerland
Date: 111103–111104
Topic: Planning of CERN School of Computing 2012

31. **Ewert Bengtsson**
Host: Andrew Mehnert
Address: MedTechWest, Chalmers and Sahlgrenska University Hospital
Date: 111121–111123
Topic: Possible collaboration on biomedical image analysis
Comment: Paid a three day visit to learn about the ongoing activities and plans for expansion in biomedical image analysis at MedTechWest.

32. **Ida-Maria Sintorn**
Host: Lyuba Belova
Address: Dept. of Materials Science and Engineering, Royal Institute of Technology
Date: 111121
Topic: STEM imaging of viruses
Comment: Visit to try Scanning transmission electron microscopy (STEM) on virus samples and also to discuss normalization issues in FIB-SEM microscopy.

33. **Gunilla Borgefors**
Host: Hans Olofsson
Address: Onsala Space Observatory (OSO), Råö
Date: 111124
Topic: Board meeting
Comment: First meeting of the new Board/Steering Committee for OSO. Included extensive presentation of OSO.

34. **Ida-Maria Sintorn, Gustaf Kylberg**
Host: Gustaf Ullman
Address: Dept. of Molecular Biology, Uppsala Biomedical Centre (BMC), UU
Date: 111214
Topic: Segmentation of bacteria in microscopy images

35. **Erik Wernersson**
Host: Jan Van den Bulcke
Address: Dept. of Forest and Water Management Coupure Links 653, 9000 Ghent, Belgium
Date: 111103–111104
Topic: Research visit

7.11 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–
- Member of the European Research Council Advanced Grants Panel (ERC) 2008–
  Comment: During 2011, Bengtsson did only a few reviews. More extensive panel work again in 2012
- Member of the Labex-jury for the French research council
  Comment: Taking part in the evaluation of a large number of large research proposals, Nov 2010-Feb 2011.
- Member of the Planning committee for International Conference on Pattern Recognition 2014
  Comment: (3 meetings)

National:

- Member of the Royal Swedish Academy of Engineering Sciences, Section VII: Basic and Interdisciplinary Engineering Sciences. 2006–
  Comment: (3 section meetings, 3 academy meetings)
- Vice Chair of Section VII of the Royal Swedish Academy of Engineering Sciences, 091119 –
  Comment: (7 planning meetings)
- Member of the Royal Society of Sciences in Uppsala (Kungliga Vetenskapssocieteten), 1998–
  Comment: Elected member of the oldest scientific society in Sweden. (4 meetings)
- Chair of Uppsala University IT Council, 2008–
  Comment: The IT Council is responsible for coordinating all aspects of IT usage and development at UU. The board has about 15 members. 6 meetings and additionally 7 preparatory and follow up meetings.
- Advisor to the Rector on Information Technology at UU, 1998–
  Comment: One of five advisor appointed to lead the strategic planning of UU and give advice to the Rector, taking part in the Deans-conference (2 meetings each 2 days).
- Member of the Board of UpGIS, the network for Geographical Information Systems at UU, 1999–
  Comment: (4 meetings.)

- Member of the Science Council for the Swedish Society of Medical Engineering
  Comment: (2 telephone meetings.)

- Member of the UU student cooperation group, 2000–
  Comment: A group where the leadership of the university and the student unions and nations meets to discuss matters of common interest. (3 meetings)

- Member of the scientific board of Hillevi Fries Research Scholarship Foundation
  Comment: A Swedish foundation that accepts applications and gives out research grants for urology research. The board has three members. (1 meeting)

- Non-voting member of the UU Library Board 2007–
  Comment: (4 meetings)

- Member of the Management Group at IT Department, "Ledningsgruppen"
  Comment: (32 meetings)

- On the IT Department new division structure planning group
  Comment: (7 meetings)

- On a reference group for Uppsala Learning Lab
  Comment: (2 meetings)

- Auditor for Swedish Society for Image Analysis (SSBA), 2004–

- Chair of the Evaluation Panel for grant applications to the Swedish Research Council (VR): Natural and Engineering Sciences-Biomedical Engineering, 2009–
  Comment: Four full day meetings, about two weeks of full time work reading applications, more than 200 emails.

- Planning group for SSBA senior strategy day
  Comment: 2 telephone meetings to plan the new senior strategy day at SSBA conference March 16, 2011

- On the steering committee of the interdisciplinary project to develop systems for handwritten text recognition.
  Comment: (5 meetings)

- Mentoring young reseachers writing VR applications.
  Comment: (2 meetings)

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–
  Comment: DGCI 2011 took place in Nancy, France, April 2011
- Steering committee for International Symposium on Mathematical Morphology (ISMM), 20111015–

- Programme committee for 11th International Conference on Pattern Recognition and Image Processing (PRIP2011), Minsk, Belarus, 20110101–20110520
- Programme committee for 14th International Conference on Computer Analysis of Images and Patterns (CAIP2011), Sevilla, Spain, 20110101–20110831
- Programme committee for Iberian Conference on Pattern Recognition and Image Analysis (IbPRIA2011), Spain, 20110101–20110610
- Programme committee for International Conference on Discrete Geometry for Computer Imagery, DGCI2011, Nancy, France, 20110101–20110408
- Programme committee for International Conference on Image Analysis and Processing, (ICIAP2011), Ravenna, Italy, 20110101–20110916
- Programme committee for International Symposium on Mathematical Morphology (ISMM2011), Intra, Italy, 20110101–20110708
- Expert committe for a Professor with special responsibilites in Computer Vision at Aalborg University, Denmark, 20110601–20111130

National:

- Royal Society of Sciences in Uppsala (Kungliga Vetenskapssocieteten), Member No. 19, 2000–
  Comment: Elected member of the oldest scientific society in Sweden (founded 1710), (5 meetings).
- Member of the Royal Swedish Academy of Engineering Sciences (IVA), 20110323–
  Comment: Member of Division VII: Basic and Interdisciplinary Engineering Sciences (3 meetings).
- Swedish Parliamentarians and Scientists, 1987–
  Comment: Members are elected. Only one scientist per field admitted.
- Board/Steering Committee for Onsala Space Observatory, 20110927–
  Comment: (1 meeting)

- 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–
  Comment: Representing TN-faculty, UU.
- Expert for Post-doc position at Swedish Research Council, 20110930–20111031

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:

- Member, KK Stiftelsen's workshops on Future of Perceptualization, 2010–2011

Joakim Lindblad
International:

- Reviewing and Program Committee of the International Workshop on Combinatorial Image Analysis (IWCIA) 2011, Madrid, Spain
- Reviewing Committee of the International Conference on Discrete Geometry for Computer Imagery (DGCI) 2011, Nancy, France

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–
- Associate editor for Pattern Recognition Letters, 20110606–
- Program committee, 10th International Symposium on Mathematical Morphology (ISMM 2011), Intra, Italy, July 6-8, 2011

Ingela Nyström
International:

- Member of the Executive Committee, International Association for Pattern Recognition (IAPR)
  - 2nd Vice President 2008–2010
  - Secretary 2010–
- Program Committee for 17th Scandinavian Conference on Image Analysis (SCIA 2011), Ystad Saltsjöbad, Sweden, May 2011
- Co-chair of 2nd International Conference on Visual Informatics (IVIC 2011), Selangor, Malaysia, Nov 2011

- Advisory Committee of CERN School of Computing, 2011-

National:

- Board Member of Swedish Society for Automated Image Analysis (SSBA), 2000–
  Comment: President 2002–2006
- Board Member of the Swedish University computer NETwork (SUNET), 2008–
- Board Member of the 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-
- 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, 20110101
- Member of the Electorial Board (”hörandeförsamlingen”) for the new Vice-chancellor of Uppsala University
- Dissertation committee of Erik Zeitler, Dept. of Information Technology, Div. of Computing Science, UU, 20110920
  Comment: Title: Scalable Parallelization of Expensive Continuous Queries over Massive Data Streams
- Dissertation committee of Frida Gyllensvärd, Center for Medical Image Science and Visualization (CMIV), Linköping University, 20111125
  Comment: Title: Efficient Methods for Volumetric Illumination

Stefan Seipel
International:

- Board member of SIGRAD - the Swedish Computer Graphics Association, 20110101–20111231
- Evaluation panel for applications to the Sweden-America Foundation, 20110501–20110531
- Scientific program committee of IV2011, 13-15 July 2011, London, 20110713–20110715

National:

- Program Committee Member for the Annual Computer Graphics Conference SIGRAD 2010
- Board Member of the SIGRAD organisation, Svenska föreningen för grafisk databehandling, 2004–
- Dissertation committee, Norrköping, 20111111–20111111
  Comment: Dissertation of Sara Johansson Fernstad, Title: Algorithmically Guided Information Visualization
- Scientific program committee of the Sigrad 2011 Conference, KTH, 20111117–20111118

Ida-Maria Sintorn
National:

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

Robin Strand
International:

- Program Committee, DGCI 2011, 20110101–20110408
  Comment: Strand was PC member in charge of the topic "Geometric Transforms"

National:

- Member of the Electorial Board ("elektorsförsamlingen") of the Faculty of Science and Technology, UU, 20110101

Carolina Wählby
National:

- Dissertation committee, Uppsala, 20110506
  Comment: Dissertation of Filip Malmberg, Title: Graph-based Methods for Interactive Image Segmentation

- Dissertation committee, Uppsala, 20110923
  Comment: Dissertation of Hamid Sarve, Title: Evaluation of Osseointegration using Image Analysis and Visualization of 2D and 3D Image Data