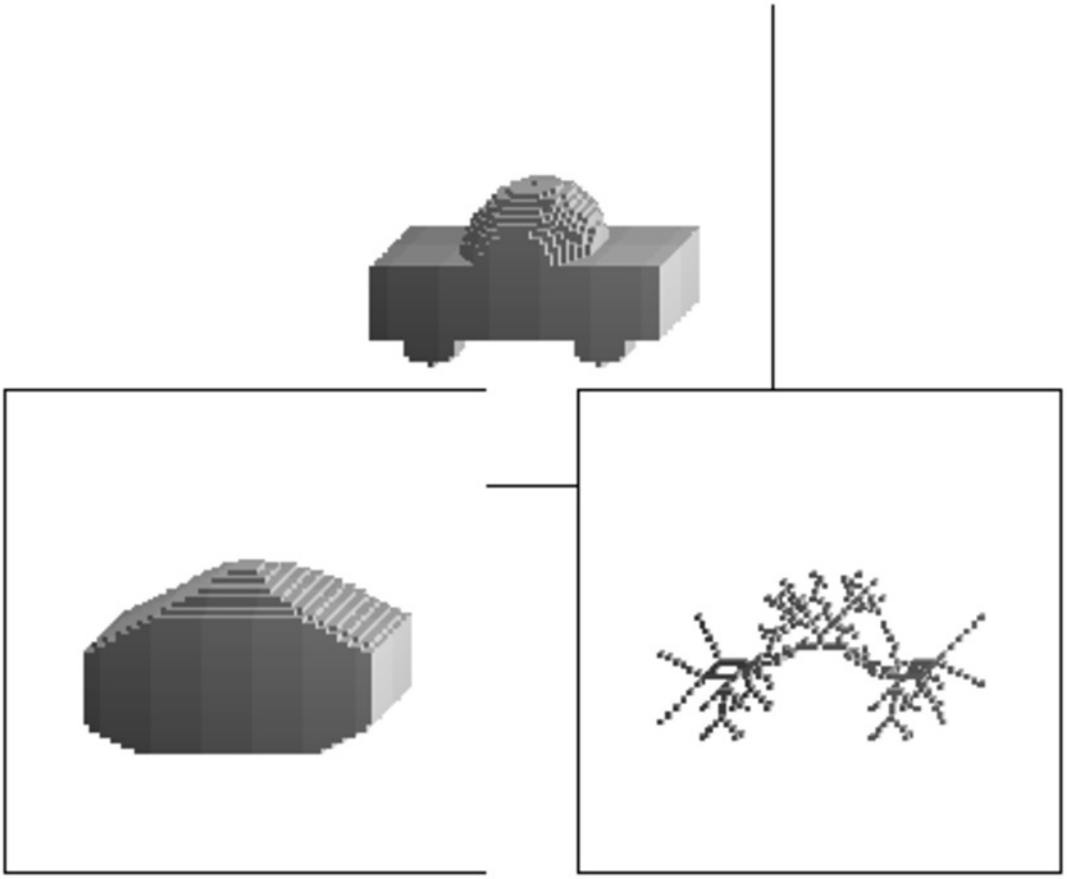
Centre for Image Analysis
Swedish University of Agricultural Sciences
Uppsala University

Annual Report 1997



Annual Report 1997

Centre for Image Analysis

Centrum för bildanalys

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1 Introduction and summaries

1.1 Background

Centre for Image Analysis (CBA) was founded in 1988 based on three small research groups, from Uppsala University (UU), the Swedish University for Agricultural Sciences (SLU) and the Swedish National Environmental Protection Agency (SNV). In 1995 a re-organisation of CBA took place, to reflect the actual situation of that time, and from 1 July, 1995, we are a pure university entity. The employees are formally employed at either university, and the Ph.D. students are admitted at any of the three faculties where we have a Ph.D. program (TN at UU, S and JLT at SLU), but CBA is administered by UU. A valuable consequence of the new constitution is the formation of the CBA reference group, consisting of (at present) seven organisations with an interest in the applications of image analysis.

The present fiscal year has again been one of strong expansion, as was the previous one. We have been successful in getting research grants from many different sources, not the least from the Swedish research foundations created a few years ago. The National image analysis research programme VISIT (VISual Information Technology) founded by SSF, is administered by CBA and its programme director is Lennart Thurfjell. Ewert Bengtsson and Gunilla Borgefors are both project leaders within VISIT. Tommy Lindell is co-ordinator of a big EU project on lake quality (SALMON). Gunilla Borgefors is project leader within the MISTRA founded programme REmote Sensing for the Environment (RESE).

When CBA was new, UU dominated, but now an even balance between the two universities has been reached, both regarding income from the universities and regarding external grants. The remaining difference is that there are more Ph.D. students at SLU and more senior personnel at UU. We now employ 31 persons, project workers and master thesis students uncounted, of which 21 are Ph.D. students. Ten of these started their studies this year (including Dec. 96 and Jan. 98). That only one new doctor earned her Ph.D. this year reflects the more meagre times five years ago.

CBA assembles an annual report describing the various activities that have taken place during the year. This annual report is intended for anyone interested in our work, e.g., the founding bodies, sponsors, co-operation partners and our research colleagues.

In the next two subsections the research at CBA is briefly summarised in English and Swedish, respectively. A more detailed description of each research project can be found in Section 5. Section 2 describes the organisational and financial aspects of CBA. The other aspects of our work are briefly summarised in the introduction to each section which is printed in a larger font than the following detailed material.

1.2 Summary

According to the founding documents, the objective of the Centre for Image Analysis is "to create the know-how needed for an operative and sensible use of digital image analysis in society, particularly in the fields of environment and medicine." The research work is organised in three groups: The image analysis group at UU, which works mainly with medical applications and is headed by Ewert Bengtsson; the image analysis and remote sensing group at SLU headed by Gunilla Borgefors, which concentrates on forestry, agriculture, environment, and industry applications; and the aquatic remote sensing group at UU, headed by Tommy Lindell. All groups also conducts some basic research.

The UU image analysis group has had its main focus on the medical application field where tomographic volume images from different sensors and light microscopic images of cancerous tissues and cells have been analysed.

Lennart Thurfjell has continued his work on the 3D computerised brain atlas. Funding has been received from VISIT and from NUTEK. Two graduate students are involved in this project.

In collaboration with other groups, we have a project to develop methods for evaluating biopsy strategies in prostate cancer diagnosis, based on 3D modelling.

The work on computer assisted analysis of light microscopic cell images has a long tradition in our group, dating back to 1973. We are presently involved in developing computer support for screening specimens from gyneacological health control in cooperation with Chicago based AccuMed International, Inc.

A new project starting this year investigates the possibilities of telepathology in a new context, "the virtual microscope." A detailed image of the entire specimen is transmitted at reduced bandwidth and low cost times, in colour and at multiple focal levels. When evaluation is done by the pathologist, a software "microscope" manipulates this digital representation to display what would have been seen in the real microscope.

Methods for applying colour classification algorithms to the analysis of histological tissues has been developed further and is currently being tested on routine clinical material. Both supervised and unsupervised quantitative analysis is considered. This year, a new combination approach was tested, using cultured cell stained in the same batch as the tissue being analysed. These cultured cells are easy to analyse, and are used to train the classifiers for the real sample.

Methods for quantitatively evaluating and describing structures in 3D volume images has also been studied in another more basic methodological project supported by TFR. This project involves both universities, as well as Istituto di Cibernetica in Italy. Ingela Nyström defended her thesis in this area in June this year.

The group has also carried out a project for CERN this year. The task was to construct an inspection system for the 6000 km superconducting cable needed for the new elementary particle research accelerator LHC. The cable has to be perfect in all its length, otherwise the devise will explode in the very high magnetic fields. The system works in real time, uses a MAPP camera, MSDOS, and was installed at CERN in the Autumn.

In support of the different projects at CBA, as well as in order to provide an improved platform for the education in image analysis, we have continued work on our general platform for image analysis, the IMP system.

The SLU Image Analysis and Remote Sensing group is headed by Professor Gunilla Borgefors. The group and its activities has steadily grown since 1993, and was significantly extended this year. It now consists of twelve Ph.D. students, working on a very wide variety of applications. The aim of the group is three-fold:

- to do applied image analysis research in co-operation with groups outside CBA
- to do basic image analysis research
- to be a central SLU source for image analysis knowledge.

Several projects are aimed at forestry applications. SJFR finances a project were high resolution colour infrared images are used for forest inventory. Image variables to be extracted are, for example, horizontal tree crown area, tree species, and tree positions in the image. Another project has essentially the same goal, but using a radically different sensor, the new CARABAS radar, developed at the National Defence Research Establishment in Linköping. This sensor

is, in contrast to conventional SAR radar, well adapted to vegetation analysis. This year an improved version was tested, yielding better quality images than the first version.

There are also two forestry projects at a completely different scale. The graduate school in Wood and Fibre Science finances a project were the aim is to develop objective and, as far as possible, automatic methods for description and analysis of wood fibres in all their dimensions. In VISIT one project is aimed at analysing the internal structure of paper, building volume images of the fibre structure to understand the relations between this structure and mechanical and optical properties.

In agriculture the EU financed project involving both Statistics Sweden, crop experts and meteorologists aim at predicting crop production using existing European models but adapting them to Swedish conditions. In contrast to this a new project aims at detecting within-field variations in satellite images and investigating if this can be used for gathering historic information to generate recommendations for precision agriculture. We also have mere basic research going, analysing remote sensed images for agricultural uses, in particular methods using pixel neighbourhoods rather than single pixels.

The national RESE project, financed by MISTRA, is organised in thematic projects treating explicit environmental problems, and technical projects, generating methods and methodological knowledge to be used in the thematic projects. We are responsible for one of the technical projects, and this year started the activities in two main areas: using multispectral texture for segmentation and classification and analysis and display of high dimensional remote sensed data.

We have started a project on quantitative food quality analysis within the MISTRA financed FOOD21 programme. The aim is to develop automatic methods for analysing microscopic images of muscle fibre and grain kernels.

Since the mid 1980s Gunilla Borgefors has co-operated with Dr. Gabriella Sanniti di Baja at Istituto di Cibernetica, Napoli, Italy, on various aspects of digital shape in two and higher dimensions. Skeletonization (or thinning) denotes the process where objects are reduced to structures of lower dimension. We have developed skeletonization methods for 3D images in co-operation with the UU image analysis group. Another aspect of digital shape is resolution structures, where we have developed methods for shape preserving pyramids and multiresolution skeletons.

As an spin-off of the volume image analysis we have started a co-operation with the Dept. of Diagnostic Radiology at UU, where the aim is to use grey-level morphology to improve the visualisation and analysis of MR angiography images. This project is part of VISIT.

The general objective of Aquatic remote sensing research is to strengthen digital remote sensing in general, focused on the fields of bio- and geosciences. The coupling to the geosciences creates a natural connection between remote sensing and Geographic Information Systems (GIS). The present activities vary from mapping and monitoring of waste water discharge and distribution of plumes in lakes and seas to planning and management of tropical coasts.

The use of satellite and airborne sensors for water quality surveillance has been a long term project in co-operation with, among others, NIVA, Norway. One important area of research is the development of image analysis techniques and environmental applications in imaging spectrometry.

During 1996 a big grant, for which Tommy Lindell is responsible, was given by EU. It concerns monitoring of the water quality of European lakes and includes participants from many European countries. This project become fully operational this year, with intens activity for remote sensing co-ordinated by CBA.

The GIS work is concentrated on environmental impact assessments and deals with the plan-

ning of new infrastructure and industrial establishment. Our main projects today deal with coastal zone mapping and planning. An large scale project in Jamaica, that started in 1994, was successfully finished this year.

In the future CBA will continue its research in the areas outlined above, with a focus on methods for analysis of multi-dimensional and multi-spectral images coming from various sensors.

1.3 Sammanfattning på svenska (Summary in Swedish)

Centrum för bildanalys (CBA) är en forskningsinrättning som grundades 1988, baserat på tre små forskningsgrupper från Uppsala universitet (UU), Sveriges Lantbruksuniversitet (SLU) och Naturvårdsverket (SNV). Den första juli 1995 ändrades konstitutionen i enlighet med hur CBA då såg ut, så att vi blev en ren universitetsorganisation. SLU och UU har från 1993 resp. 1996 var sin fast professur vid CBA. Personalen är anställd vid resp. universitet och doktoranderna antas vid någon av de tre fakulteter där vi har doktorandprogram (TN vid UU, S och JLT vid SLU), men CBA administreras i sin helhet av UU. I praktiken är verksamheten mycket väl integrerad. En värdefull följd av den nya konstitutionen är bildandet av CBA referensgrupp, som för närvarande består av sju organisationer med intresse för tillämpningar av bildanalys. Dessa är: Fiskeriverket, Försvarets forskningsanstalt, Riksantikvarieämbetet, SkogForsk, Naturvårdsverket, STFi, och Uppsala akademiska sjukhus.

Enligt vår konstitution gäller följande: "Huvudinriktningen för CBA skall vara digital bildanalys inom bio- och geovetenskaperna. Forskningen skall syfta till tillämpning inom främst miljö och vatten, jord- och skogsbruk samt medicin. ... Vid CBA skall bedrivas forskning, dels inom bild- och fjärranalys som sådan, med målet att utveckla bättre algoritmer, metoder och system för dessa typer av tillämpningar, dels inom de angivna områdena med direkta tillämpningar och projekt. CBA skall medverka till att bildanalystekniken sprids och tillämpas även inom andra institutioner. ... CBA skall vara ett kompetenscentrum med internationell kompetensnivå."

Budgetåret 1997, som beskrivs i denna årsrapport, var en tid av fortsatt stark expansion. Vi har varit framgångrika i att erhålla nya forskningmedel och ett antal nya stora projekt har startat. Flera av de nya projekten finansieras av de svenska forskningsstiftelserna, SSF (Strategiska stiftelsen) och MISTRA (Miljöstrategiska stiftelsen). CBA adminstrerar det nationella forskningsprogrammet VISIT (Viuell informationsteknik) där Lennart Thurfjell är programdirektör. Ewert Bengtsson och Gunilla Borgefors är båda projektledare i VISIT. Tommy Lindell är koordinator för ett stort EU-projekt fokuserat på vattenkvalité i Europas stora sjöar (SALMON) och ett SIDA-projekt om kustplanering på Jamaica. Gunilla Borgefors är projektledare inom MISTRA-programmet RESE (Fjärranalys för miljöövervakning).

Det mesta av CBA aktivitet liknar den vid vilken universitetsinstitution som helst, men administrationen blir med nödvändighet något mer komplicerad, p g a av vår nära relation till två universitet. årets budget omfattade drygt 14 miljoner kr, varav drygt hälften kommer från externa källor (stiftelser, forskningsråd, NUTEK, EU, m fl). Knappt hälften kommer från universiteten, varav c:a en tredjedel från UU resp. SLU, och en tredjedel från vårt deltagande i grundutbildningen på UU (som sker via andra institutioner).

När CBA var nytt dominerade UU, men nu är universitetens engagemang ungefär jämnstora ur alla synpunkter. Den återstående skillnaden är att det finns fler doktorander vid SLU och många fler seniorer vid UU. Vi är nu 31 personer (projektarbetare och examensarbetare oräknade), varav 21 är doktorander. Av dessa började tio under senaste året. Endast en disputation ägde rum under året, men detta beror på verksamhetens betydligt mindre omfattning för fem år sedan.

Forskningen vid CBA organiseras i tre grupper: bildanalys vid UU, som leds av Ewert Bengtsson; bild- och fjärranalys vid SLU, som leds av Gunilla Borgefors; och akvatisk fjärranalys vid UU, som leds av Tommy Lindell. Samtliga grupper bedriver förutom tillämpningsorienterad forskning grundläggande bildanalysforskning.

UU-gruppens huvudtema är medicinska tillämpningar där tomografiska bilder från olika sensorer samt mikroskopiska bilder av cancerogena vävnader och celler har analyserats.

Lennart Thurfjell har fortsatt sitt arbete med sin 3D datoriserade hjärnatlas. Ekonomiskt stöd har kommit från NUTEK och nu även från VISIT. Två doktorander arbetar inom detta projekt.

I samarbete med andra grupper utvecklar vi metoder för att utvärdera strategier för nålbiopsier vid prostatacancerdiagos baserade på 3D modeller.

Arbetet med datorstödd analys av ljusmikroskopiska cellbilder har en lång tradition i gruppen, det startade redan 1973. Vi samarbetar nu med det Chicago-baserade företaget AccuMed International, Inc. för att utveckla datorstöd för granskning av cellprover från gynekologisk hälsokontroll.

Ett projekt som just startat undersöker en ny teknik för telepatologi: "det virtuella mikroskopet". En detaljerad bild av hela preparatet, i färg och i olika fokalplan, skickas över nätet under lågpristid. När provet utvärderas av en patolog manipuleras bilden av ett "programvarumikroskop" så att patologen ser precis samma bild som från ett riktigt mikroskop.

Nya metoder för att använda färgbaserade klassificeringsalgoritmer på histologiska preparat har vidareutvecklats och testas för närvarande på kliniskt material. I år har en metod som kombinerar fördelarna med automatisk och interaktiv analys utvecklats. Odlade celler med kända egenskaper färgas in samtidigt med de okända proverna. De odlade cellerna används för att träna klassificerarna för proven.

Metoder för att kvantitativt utvärdera och beskriva strukturer i 3D volymbilder har också studerats i ett grundforskningsprojekt med ekonomiskt stöd från TFR. Detta projekt bedrivs inom båda universiteten, såväl som vid Istituto di Cibernetica i Italen. Ingela Nyström disputerade inom detta projekt i Juni 1997.

Gruppen har genomfört ett uppdrag för CERN i år. Det gick ut på att konstruera ett inspektionssystem för de 6000 km supraledande kabel som behövs till den nya partikelacceleratorn LHC. Kablen måste vara helt felfri, annars exploderar spolarna i de höga magnetfälten. Vi har utvecklat ett realtidssystem med en MAPP kamera under MSDOS, som installerades under hösten.

Såväl för att stödja dessa olika projekt som för att tillhandahålla ett förbättrat verktyg för utbildning i bildanalys har arbetet med den generella bildanalysprogramvaran IMP fortsatt.

Bild- och fjärranalysgruppen vid SLU leds av professor Gunilla Borgefors. Den långsamma men stadiga tillväxten sedan 1993 bröts i år då många nya aktiviteter startade. Den består nu av tolv doktorander som arbetar inom ett mycket brett spektrum av tillämpningar. Gruppens mål är trefaldigt

- att bedriva tillämpad bildanalysforskning i samarbete med grupper utanför CBA
- att bedriva grundforskning i bildanalys
- att vara en kunskapsresurs i bildanalys för SLU.

Arbete inom ett flertal skogstillämningar bedrivs. SJFR finansierar ett projekt där högupplösta infraröda färgbilder används för skogsinventering. Bildegenskaper som tas fram är t.ex. horisontell yta för trädkronor, trädarter samt trädens läge. Ett annat projekt har huvudsakligen samma mål, men en helt annan sensor används, den nya CARABAS radarn, utvecklad vid FOA i Linköping. Denna sensor är p g a de långa våglängder som används, väl anpassad till analys av vegetation. I år har CARABAS II testflugits, och givit bilder av betydligt bättre kvalité än första versionen.

Vi bedriver ytterligare två skogsprojekt, men i en helt annan skala. Forskarskolan Trä och träfiber finansierar ett projekt där syftet är att utveckla en objektiv, och så långt som möjligt, automatisk metod för karakterisering och analys av träfibrers form, där fibern modelleras i alla sina dimensioner. Inom VISIT finns ett projekt som ska analysera papperets inre struktur. Volymsbilder av fiberstrukturen i papperet ska skapas. Dessa ska sedan analyseras för att öka förståelsen för hur strukturen påverkar papperets optiska och mekaniska egenskaper.

Ett starkt tillämpningsorienterat projekt inom jordbruksområdet finansieras av EU genom Statistiska Centralbyrån (SCB), med medverkan av grödeexperter och meteorologer. Syftet är skördeprognos med användning av europeiska modeller, men anpassade till svenska förhållanden. Ett nytt projekt syftar i stället till att detekterna variationer inom de enskilda åkerfälten i satellitbilder. Om detta kan användas för att samla in historiska data om fälten kan dessa utgöra en grund för precisionsjordbruk. Ett mer grundläggade projekt inom området är att analysera fjärranalysbilder för jordbrukstillämpningar, speciellt metoder baserade på lokala pixelomgivningar snarare än enstaka pixel. Hittills har detta koncentrerats på detektion av åkrarnas kanter.

Det nationella RESE-programmet är strukturerat i ett antal delprojekt, där de s k tematiska projekten angriper konkreta miljöproblem, medan de s k tekniska projekten utvecklar kunskap och metodik till nytta för de tematiska. CBA ansvarar för ett av de tekniska projekten, som syftar till bättre utnyttjande av bildanalyskunskap inom fjärranalysen. Två delaktiviteter har startat: multispektral textur för segmentering och klassificering samt analys och visualisering av hyperspektrala och multimodala fjärranalysdata.

Vi har även startat ett projekt kring kvantitativ analys av matkvalité inom det likaså MISTRA-finansierade MAT21-programmet. Huvudsakligen kommer analysen att inriktas på miskroskopibilder av muskelfibrer och vetekärnor.

Gunilla Borgefors har sedan mitten av 1980-talet samarbetat med Dr Gabriella Sanniti di Baja vid Instituto di Cibernetica, Neapel, Italien. Samarbetet rör olika aspekter av digital form i två och fler dimensioner. Skelettering beskriver en process där ett objekt reduceras till strukturer av lägre dimensionalitet. Tillsammans med Ingela Nyström från UU-gruppen har en metod för skelettering av volymsbilder utvecklats. En annat sätt att betrakta digital form är upplösningsstrukturer, där vi har utvecklat metoder för formbevarande pyramider och multiskalskelett.

Som en följd av volymsbildanalysen har vi startat ett samarbete med Inst. för diagnostisk radiologi vid UU, där syftet är att använda gråskalemorfologi för att förbättra visualiseringen och analysen av MR-angiografibilder. Detta projekt är en del av VISIT.

Huvudmålet för den Akvatiska fjärranalysgruppen är att stärka digital fjärranalys i allmänhet, fokuserat på områdena bio- och geovetenskap. Kopplingen till geovetenskap skapar en naturlig koppling mellan fjärranalys och geografiska informationssystem (GIS). Nuvarande aktiviteter spänner från kartering och övervakning av utsläpp av avloppsvatten, fördelning av plymer i hav och sjöar till planering och hantering av kustzonsresurser i tropikerna.

Användningen av satelliter och flygburna sensorer för vattenkvalitéövervakning är ett lång-

siktigt projekt som bedrivits i samarbete med bland andra NIVA i Norge. Ett viktigt tillämpningsområde är utvecklingen av bildanalysteknik och miljötillämpningar inom avbildande spektrometri.

Under 1996 beviljades ett stort anslag av EU, med Tommy Lindell som ansvarig. Det avser övervakning av vattenkvalité i europeiska insjöar och bedrivs i samarbete med ett antal EU-länder. Arbetet kom i gång på allvar under året och ett antal aktiviteter organiserades av CBA.

Ett annat projekt som startade under året är medverkan RESE-projektet "Detektion av förändringar i akvatiska ekosystem och övervakning av algblommning", som leds av SMHI.

Arbetet med GIS är koncentrerat till mätningar av miljöpåverkan och handlar om att planera ny infrastruktur och industriella etableringar. Vårt huvudprojekt för närvarande är kartering och planering av kustnära zoner. Ett storskaligt projekt på Jamaica, som startade 1994, avslutades framgångsrikt i slutet av 1997.

Den kvantitativa omfattningen av verksamheten vid CBA framgår av de olika listorna över publikationer, seminarier, konferensdeltagande, studiebesök etc. i denna årsrapport. Vi skall här inte tynga texten med ytterligare statistik.

I framtiden avser vi att följa på den inslagna vägen, där forskning kring volymsbilder och multi- och hyperspektrala bilder kommer att ges särskilt utrymme. Efter den stora ökning av verksamheten som skett under de senaste två åren har vi numera ambitionen att fullfölja allt det som påbörjats, snarare än att växa lika våldsamt i fortsättningen.

1.4 How to contact CBA

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Fax:	+46 18 553447
Email:	cb@cb.uu.se
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Our homepage contains the latest information of research, activities, personell, positions, etc., together with maps that will help you locate us geographically.

2 Organization

The CBA consists of three research groups. We were at 19971231 a total of 32 persons, eight of which are Ph.D:s and 21 graduate students. Most of the activity at CBA is similar to a department within any university but the administration becomes somewhat more complicated due to our close relation to two different universities. Only about 38% of the budget of about 14,3 million SEK was covered by funds from the two universities. The rest came from various outside sources.

2.1 Constitution

The CBA was founded in 1988 based on three small research groups, from Uppsala University (UU), the Swedish University for Agricultural Sciences (SLU) and the Swedish National Environmental Protection Agency (SNV). In 1995 a re-organization of CBA took place to reflect the actual situation of that time, and from 1 July, 1995, we are a pure university entity (due to administrative rule, we can not be denoted "department.") The employees are employed at either university, and the Ph.D. students are admitted at any of the three faculties where we have a Ph.D. program — Science and Technology (NT) at UU, Forestry (S) and Agriculture, Landscape planning and Horticulture (JLT) at SLU — but the whole of CBA is administered through UU.

The CBA is directed by a board with representatives from the universities (three each) and the personnel organizations (two). The board meets about four times per year to draw up the overall policies for the work at CBA and to take responsibility for the budget. In between board meetings CBA is headed by a director who is appointed by UU and who also serves as chairman of the board. During this year Prof. Gunilla Borgefors has served as director with Olle Eriksson as deputy. The other board members have been: Ewert Bengtsson UU, Nils-Einar Eriksson TCO, Bengt Gustafsson UU, Anders Hemmingsson UU, Christer Kiselman UU (suppl), Tommy Lindell SACO, Thomas Nybrandt SLU, Håkan Olsson SLU, and Magne Tuvesson SLU (suppl).

According to the founding documents the objective of the CBA is "to create the know-how needed for an operative and sensible use of digital image analysis in society, particularly in the fields of environment and medicine". The research work is organized in three groups: The image analysis group at UU which works mainly with medical applications and is headed by Ewert Bengtsson, the group in aquatic remote sensing, headed by Tommy Lindell and the image analysis and remote sensing group at SLU headed by Gunilla Borgefors, which works with various applications in forestry, agriculture, environment, industry, and in basic research.

2.2 Finances

The CBA is financed through the two universities, through research grants and contracts and through cooperation projects with other organizations. The summary Table on top of the following page describes our overall economy for the year 1997 including both internal and external incomes and expenditures. 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. Additionally we have around 2 MSEK in personnel costs covered through teaching administrated through the Departments of Scientific Computing and of Geoscience at UU. The numbers are rounded to the nearest 1000 SEK. Which projects that are financed by whom can be ascertained in Section 5, where each project is listed. The total sum increased about 35% since the previous fiscal year (and that year was in its turn a 30% increase from the year before that). The same numbers are also given as pie charts in the Figure on the following page. It is worth noting that of our own activities (UU internal excluded) 62% are financed through outside funding.

Income		Costs	
UU	2245	Personnell	7926
SLU	2165	Equipment	343
UU internal	2371	UU internal	1102
Governmental grants[1]	3895	Rent	1234
Non-governmental grants[2]	1343	Operating exp.[3]	2500
EU grants	1043	University overhead	1058
Contracts	1103		
Finalcial nett	135		
Total income	**14300**	**Total cost**	**14163**

1) NFR, NUTEK, SJFR, TFR, Sw. National Space Board
2) MISTRA, SFF, etc.
3) Including travel and conferences

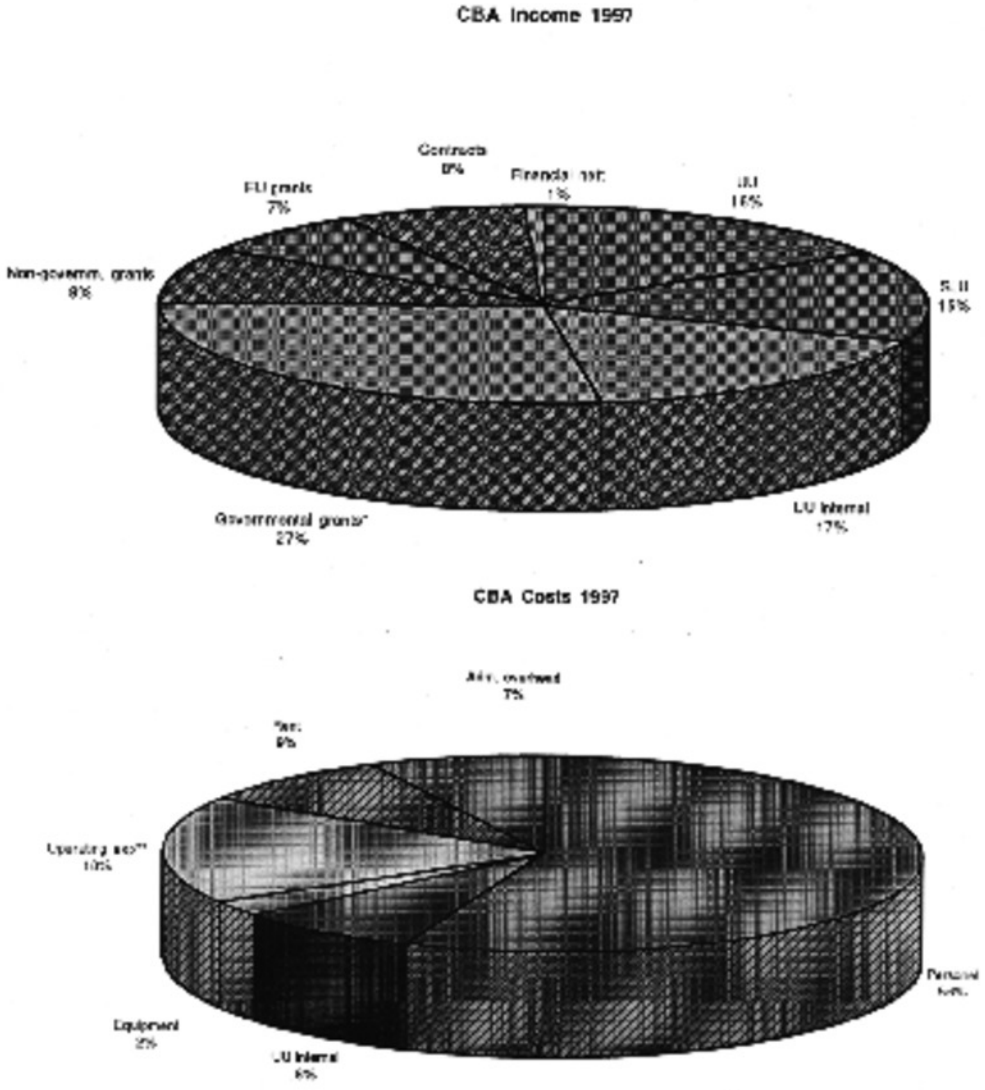

FIGURE: CBA Income and costs for 1997.

2.3 Reference group

To increase the interaction with the world outside the universities, the constitution of CBA defines a reference group of official bodies that makes a small annual contribution to CBA in exchange for a monthly information letter, consulting possibilities, and several informative meetings annually. Two half-day seminars were held during 1997. On June 4 the theme was volume images, where methods from the thesis of Nyström was the main feature. On November 20 the theme was colour images, with the coming thesis of Ranefall as the focus. In addition to these activities, each reference group member was invited to send one participant to our industrial course for free (see Section 4.1).

At present the reference group consists of the following organisations:

- National Board of Fisheries
- National Defence Research Establishment
- The National Board of Antiquitys
- The Forestry Research Institute of Sweden
- Swedish National Environmental Protection Agency
- Swedish Pulp and Paper Research Institute
- Uppsala University Hospital

2.4 Staff

Gunilla Borgefors, Professor, Ph.D., director, SLU
Olle Eriksson, Lecturer, Ph.D., deputy director, UU
Ewert Bengtsson, Professor, Ph.D., UU
Tommy Lindell, Docent, Ph.D., UU

Mattias Aronsson, Graduate Student, 9710–, SLU
Tomas Brandtberg, Graduate Student, SLU, UU
Peter Flink, Graduate Student, 9701–, UU
Anders Forsmoo, Graduate Student, SLU
Hans Frimmel, Graduate Student, UU
Roger Hult, Graduate Student, UU
Torsten Jarkrans, Lecturer, Ph.D., UU
Fredrik Lidberg, master thesis, 9701-9706, UU, Graduate Student, 9707–, SLU
Joakim Lindblad, master thesis, 9708-9711, Graduate Student, 9712–, UU
Petter Lindborg, Graduate Student, 9711–, SLU
Emma Lindqvist, Graduate Student, 9702–, SLU
Roger Lundqvist, Graduate Student, 9701–, UU
Tomas Löfstrand, Graduate Student, 9709–, SLU
Mattias Moëll, Graduate Student, SLU
Jakob Nisell, Graduate Student, part time (50 %), SLU
Bo Nordin, Researcher/Lecturer, Ph.D., UU
Ingela Nyström, Researcher/Lecturer, Ph.D., UU
Anna Pettersson, Graduate Student, SLU
Petter Ranefall, Graduate Student, UU
Erik Starbäck, Graduate Student, 9702-9708, SLU
Stina Svensson, Graduate Student, 9701–, SLU
Lennart Thurfjell, Researcher/Lecturer, Ph.D., UU
Mikael Vondrus, Graduate Student, 9702–, UU
Fredrik Walter, Graduate Student, SLU
Haiying Yuan, Graduate Student, 9702-9712, UU
Catherine Östlund, Graduate Student, UU

Helena Olsson, Administration
Marcelo Toledo, Administration

Hannes Edvardsson, master thesis, 9709–, SLU
Hua Guo, project work, –9702, SLU
Yueqin Sun, project work, UU
Fredrik Sörhede, master thesis, 9708–, UU

In addition to the above Graduate Students we are assistant supervisors to
Lars Egevad, Dept. of Pathology, UU (E. Bengtsson)
Anders Engqvist, Dept. of Agricultural Engineering, SLU (G. Borgefors).

The letters after the name indicate the employer for each person. The interpretation is as follows: UU - Uppsala University, SLU - Swedish University of Agricultural Sciences. The staff can in addition to regular mail, telephone and fax to the CBA be reached through email at an address which usually is their first name followed by `@cb.uu.se`.

3 Undergraduate education

CBA does not have responsibility for organizing undergraduate education at any of the two universities. The staff at CBA is, however, involved in teaching several courses organized by other departments. We also offer a number of Master thesis projects (examensarbeten) each year. Six were completed during 1997.

3.1 Courses

The undergraduate courses which staff from CBA have taught have mainly been organized through the Department of Scientific Computing at UU. These courses have dealt with subjects closely related to our research, i. e. Computerized image analysis and Computer graphics. We have also taught courses in programming in C and C++. There are also courses at other departments (given in list).

At SLU we have not yet given any undergraduate courses, but plans are in progress for offering courses in our field also at that university.

During the period covered by this report, we have been involved in the following courses:

1. **Software Tools TDB, 5p**
   Name: Olle Eriksson *Period:* 9701-9703
   Topic: ADA programming, debuggers and other tools, OOAD tools.

2. **Digital Remote Sensing for Geoscientists, 5p**
   Name: Tommy Lindell *Period:* 9701-9701, 9710-9710
   Department: Physical Geography.

3. **Computers and Programming, TDB1-evening, 5p**
   Name: Torsten Jarkrans, Fredrik Walter *Period:* 9701-9703
   Topic: Introduction to computer programming using C++.

4. **Computer assisted image analysis MN1, 5p**
   Name: Petter Ranefall, Torsten Jarkrans *Period:* 9701-9703.

5. **Introduction to scientific computing, 4p**
   Name: Hans Frimmel *Period:* 9701-9705
   Topic: Introduction to computer programming using C++.

6. **Mathematics and statistics with computer aided learning MN1, 10p**
   Name: Petter Ranefall *Period:* 9701-9703
   Department: Dept. of Scientific Computing and Dept. of Mathematics
   Comments: Ranefall was responsible for computer laborations in MATLAB.

7. **Scientific Computing, 5p**
   Name: Olle Eriksson *Period:* 9703-9705
   Topic: Advanced C++ programming.

8. **Introduction to Scientific Computing MN1, 10p**
   Name: Emma Lindqvist *Period:* 9703-9706
   Topic: Programming and numerical analysis
   Comments: Lindqvist assisted students during computer exercises in PC-, UNIX- and Internet usage.

9. **Computers and Programming, TDB3, 5p**
   Name: Lennart Thurfjell *Period:* 9703-9705
   Topic: Object oriented design and programming using C++.

10. **Computer assisted image analysis, MN1, 5p**
    Name: Ingela Nyström, Roger Hult, Stina Svensson, Roger Lundqvist, Erik Starbäck
    Period: 9703-9705
    Comments: 70 students.

11. **Computer Graphics, 5p**
Name: Torsten Jarkrans, Hans Frimmel *Period:* 9704-9705.

12. **Object Oriented Prgramming, TDB, 10p**
Name: Olle Eriksson *Period:* 9704-9804.

13. **Digital Image Analysis, TF, 3p**
Name: Roger Lundqvist *Period:* 9704-9704
Comments: Supervising computer laborations.

14. **Computers and Programming, TDB1, distance course, 5p**
Name: Torsten Jarkrans, Peter Flink *Period:* 9709-9711
Topic: Introduction to computer programming using C++.

15. **Introduction to Scientific Computing TDB, 5p**
Name: Olle Eriksson *Period:* 9709-9712. *Topic:* Basic C++ programming.

16. **Computers and Programming, TDB1, distance course, 5p**
Name: Fredrik Lidberg, Emma Lindqvist *Period:* 9709-9711
Topic: Introduction to computer programming using C++.

17. **Object Oriented Programming, 6p**
Name: Olle Eriksson, Hans Frimmel *Period:* 9709-9803
Comments: Given for Sandvik AB.

18. **Introduction to Scientific Computing MN1, 5p**
Name: Mikael Vondrus, Olle Eriksson *Period:* 9709-9711.

19. **Computer Graphics, TDB, 5p**
Name: Bo Nordin, Torsten Jarkrans *Period:* 9710-9712
Topic: Introduction to computer graphics, OpenGL, simple X/Motif.

20. **Object Oriented Programming In C++, 5p**
Name: Bo Nordin, Anders Forsmoo *Period:* 9710-9801

21. **Remote Sensing for Geoscientists, 5p**
Name: Tommy Lindell *Period:* 9710-9710
Department: Physical Geography.

22. **Introduction to Scientific Computing MN1, 5p**
Name: Torsten Jarkrans, Bo Nordin *Period:* 9710-9803
Topic: Introduction to computer programming using C++.

23. **Mathematics and Statistics with Computer aided learning MN1, 10p**
Name: Anna Pettersson, Stina Svensson, Peter Flink *Period:* 9711-9801.

24. **Computers and Programming, TDB2, distance course, 5p**
Name: Torsten Jarkrans *Period:* 9711-9802
Topic: Computer programming using C++. Continuing from Computers and Programming TDB1.

25. **Digital Remote Sensing MN1, 5p**
Name: Tommy Lindell, Catherine Östlund, Peter Flink *Period:* 9711-9801
Department: Physical Geography.

3.2 Master thesis projects

CBA has been responsible for the following master thesis projects. Some were carried out here at CBA, others at various industries etc.

1. **Using texture of remotely sensed images for classification of agricultural scenes**
   Student: Lars Bergqvist
   Advisor: Gunilla Borgefors
   Period: 9608–9701 *Pages:* 51
   Funding: TFR
   Keywords: texture analysis, co-occurrence method, agricultural remote sensing, stepwise discriminant analysis, PCA
   Abstract: Remotely sensed images are usually classified using spectral data alone. However, there are remotely sensed images with textured objects that can not be easily identified by their mean grey values. When the ordinary spectral identification fails, a texture analysis may help to solve the classification problem. This work evaluates a set of agricultural SPOT- images for the purpose of identifying different crops. The classification is performed with spectral data alone, and spectral plus texture data. The texture analysis approach used is the co-occurrence method, modified for use with multispectral images. Different methods for selecting the best texture measures are discussed and implemented. The results show that nothing, or little, is gained when texture data is added to the classification process. This can be explained by the fact that textures from crop fields are not class-typical in this resolution. Though the classification is not improved for these images, the working scheme from this project might be useful for other types of remotely sensed scenes with more distinct textures. Some alternative methods are covered as an introduction to future work in this area.

2. **Classification in multi-spectral forest scenes using texture based upon the co-occurrence matrix**
   Student: Fredrik Lidberg
   Advisor: Gunilla Borgefors
   Period: 9701–9706 *Pages:* 49
   Keywords: texture analysis, co-occurrence matrix, remote sensing, classification, feature selection
   Abstract: Traditionally, in remote sensing, classification has been performed using point-wise samples of the spectral information. For low-resolution images (> 20 m/pixel), this can often be sufficient, but as the resolution increases (with new sensors), smaller and smaller objects become discernible, resulting in images with textured appearances. Texture information is often important for describing objects and could possibly improve performance if included in the classification process. In this particular project, it is investigated if the use of texture can improve forest type classification in images at a resolution of 1 m/pixel. The image material consists of 14 different forest types based upon different characteristics such as tree species composition, age, height, timber volume, etc. Texture measures based upon the co-occurrence matrix are primarily studied, but texture measures computed from simple grey level histograms are also examined. To be more specific, a total of 28 scalar texture measures computed from grey level histograms, (second order) co-occurrence matrices and third order co-occurrence matrices are investigated. Using feature subset selection techniques the best combinations of texture (and spectral) features are determined for different numbers of features and classification performance is evaluated using a Bayes classifier under assumption of normally distributed class data. The results show that the classification can be improved by using texture, but no major differences exist between using texture measures computed from grey level histograms and those computed from co-occurrence matrices. For the used images and defined forest classes, it is also determined that only a few of the many examined texture measures contain a significant amount of discriminatory power and many texture measures supply the same information.

3. **Interactive Color Gamut Mapping**
Student: Johan Stensland, CBA
Advisor: Petter Ranefall
Period: 9701-9706 *Pages:* 44
Abstract: In this undergraduate thesis, methods for fast, interactive color gamut mapping are discussed. The theories and algorithms have been implemented in a software toll, Gamma. The program provides an interactive environment for gamut mapping, displaying the gamuts in 3D from arbitrary viewing angles. All transformations are parameterized, and the effect of adjusting any parameter is immediately shown on the screen. The transformations are applicable to images loaded into the program. Even though Gamma was developed to run on the image devices at the Centre for Image Analysis, the methods developed here are general enough to be applicable on any equipment. A source profile transforms source dependent RGB to device independent XYZ. This is done by a two-step formula. A destination profile transforms device dependent XYZ to destination dependent RGB. This is done by interpolating values in an LUT. Useful gamut mapping transformations in the XYZ space are established. In short, they aim to make the two gamuts look more alike. Together, the profiles and the transformations enable a modifiable mapping of colors onto colors in XYZ space. Since the XYZ color space is hard to interpret visually, and since the Lab color space is the da facto standard in the color trade, Gamma presents only the Lab space to the user. Internally, however, all calculations are carried out in the XYZ space, since it has the necessary arithmetic properties. The results of this work are so far promising. The first set of printouts of the transformed images looks more like the versions on the CRT, than printouts of the originals do. The time required to transform a medium sized image is acceptable (5 to 10 sec on a Sun Sparc 4).

4. **A 3D Visualization Module for the Computerized Brain Atlas**
Student: Stefan Müller
Advisor: Lennart Thurfjell
Period: 9704-9706 *Pages:* 22
Abstract: The Computerized Brain Atlas (CBA) software system integrates different medical imaging techniques into the same program. Beyond displaying the images of individual patients, anatomical structures of a detailed 3D atlas data base, which is adaptable to fit the patients anatomy, can be selected and displayed in those images. This capability makes it possible to identify individual structures easier and to correlate between different imaging techniques. In addition, the CBA tools also provides a number of tools for region of interest analysis and for image processing. Displaying structures was only in 2D in earlier versions of the CBA tool. But current developments in Computer Hardware and the availablility of standard 3D render packages, such as OpenGL, makes it possible to provide fast, medium- and high-quality 3D rendering on low-end Workstations and even on Personal Computers. Thus, part of this work was to design a 3D Visualization Module that makes it possible to display the atlas data base structures, which already have been triangulated earlier. The second part was to integrate the modeule into the CBA project and adding user interaction facilities, such as orienting the virtual camera with the mouse and adding clip planes.

5. **Evaluation of the possible commercial use of VRML and a proposed application for Internet**
Student: Magnus Hazell, Glenn Sunberg
Advisor: Stefan Öström (Telia Promotor AB), Werner Schneider (Center for Human-Computer Studies), Ewert Bengtsson (CBA)
Period: -9708 *Pages:* 70
Abstract: The World Wide Web is growing explosivly. It is increasingly being used for commercial applications. So far these have mainly been limited to 2D user interfaces. There is a potential for 3D virtual reality techniques to make these interfaces more attractive for users. In this master thesis project the possibilities of creating a 3D virtual shop were investigated. A number of alternative techniques were studied and VRML was chosen. An application was implemented based on the Kvantum Supermarket in Uppsala. The application was installed on a server at Telia Promotor and used for demonstrations. Greater bandwidth and high performance clients and servers are needed to make this kind of applications really useful.

6. **Image Analysis for real-time quality control**
   Student: Joakim Lindblad
   Advisor: Ewert Bengtsson
   Period: 9708-9711 *Pages:* 23
   Abstract: This paper concerns the assembly of a system for automated real-time quality control of the superconducting LHC cable. A stralghtforward algorithm which is based on direct analysis of a line by line image of the cable is presented and the performance of a computer implementation of the algorithm is analyzed. The results are satisfying, though many practical problems still remains to be solved before a fully functional system can be running in CERN. The Intel Pentium processor is shown to be sufficiently fast for real-time image analysis, but the PC-standard may lack some in I/O capacity for the task.

4 Graduate education

At the end of the period covered by this report, there were at CBA six graduate students in computerized image analysis at UU, three in remote sensing at UU, and twelve in image analysis and remote sensing at SLU, i. e., a total of 21. Ten of these started their studies during the period and one student defended her PhD thesis.

4.1 Courses

Every autumn CBA organizes a graduate course in "Application oriented image analysis". The course is intended for researchers and research students in other fields who wish to learn digital image analysis for use in their own research. Therefore, the focus is more on practical issues than on theory. The course usually has students from both universities, together with some from industry. This March we arranged a compact two-day version of this course intended for people in industry for the first time. We have also given a number of other graduate courses. During the period covered by this report the following graduate courses were given:

1. **Advanced image analysis**
   Period: 9701-9704
   Credits: 5
   Examiner: Ewert Bengtsson
   Lecturers: Ewert Bengtsson, Gunilla Borgefors, Lennart Thurfjell, Johan Waldén, Fredrik Walter.

2. **Application Oriented Image Analysis for Industry**
   Period: 970319-970320
   Examiner: Gunilla Borgefors
   Lecturers: Gunilla Borgefors, Ewert Bengtsson, Bo Nordin, Ingela Nyström, Lennart Thurfjell
   Topic: A concentrated course in basic image analysis intended for people in industry. It was arranged in cooperation with Division of Continuing Education at Uppsala University.

3. **Research Methodology for Image Analysis**
   Period: 9710-9711
   Credits: 2
   Examiner: Gunilla Borgefors
   Lecturers: Gunilla Borgefors, Ewert Bengtsson, Lena Vretblad
   Topic: A course about how to be a good Image Analysis scientist.

4. **Application Oriented Image Analysis**
   Period: 9710-9712
   Credits: 5
   Examiner: Gunilla Borgefors
   Lecturers: Gunilla Borgefors, Ewert Bengtsson, Tommy Lindell, Ingela Nyström, Lennart Thurfjell
   Computer Exercises: Hans Frimmel, Roger Hult, Torsten Jarkrans, Anna Pettersson, Stina Svensson
   Topic: Introduction to Image Analysis concepts. In addition to the lectures there are three half-day computer exercises.

4.2 Dissertation

On Quantitative Shape Analysis of Digital Volume Images

Ingela Nyström

Dissertation date: 19970523

Pages: 42 *Year:* 1997; Uppsala Dissertations 288

Publisher: Almqvist & Wiksell International, Stockholm, *ISBN:* 91-554-3990-X

Abstract: We are living in a three-dimensional (3D) world, and should look at things accordingly. Nowadays, a number of biomedical imaging devices that generate digital volume images are available, e. g. computed tomography (CT), magnetic resonance (MR) imaging, positron emission tomography (PET), single photon emission computed tomography (SPECT), electron microscopy tomography (EMT), and confocal microscopy (CM).

Only rarely can the methods used on 2D images be directly generalised to 3D; the complexity of digital 3D topology results in special cases to be taken into account. This thesis presents new methods for representing the shape of volume objects in binary volume images:

- normalising object orientation and position,
- computing covering polyhedra,
- reducing the set of centres of maximal spheres, and
- computing skeletons in 3D.

This addition to the volume image processing toolbox gives us a larger variety of methods to choose from when describing the shape of objects. As only the configurations in local neighbourhoods of the voxels are used as criteria in the computations, the methods are simple and time efficient.

The methods are applicable to a wide range of 3D applications, and have been tested with good results on a number of synthetic and real images, e. g. EMT of human immunodeficiency virus (HIV) and MR angiography images.

On the front page the convex hull and the curve skeleton of a "car" can be seen.

5 Research

The CBA is conducting a whole range of projects ranging from basic image analysis research to direct application work. By keeping close touch both with the theoretical front line research and with real life application projects we believe we can make the best contribution to our field. In keeping with the stated goal for our center we have given priority to applications in the fields of biomedicine and the environmental sciences. Lately, we have also started projects relevant for the forest industry. Most of the application projects are carried out in close cooperation with other departments.

In this section we list our current research projects and provide a short description of each. They are grouped by application and ends with basic projects.

5.1 Current research projects

1. **Topic: 3D medical image analysis based on a computerized brain atlas**
   Name: Lennart Thurfjell, Ewert Bengtsson, Roger Hult
   Funding: NUTEK
   Period: 9501–
   Partners: Depts. of Neuroradiology and Clinical Neurophysiology, Karolinska Institute and Hospital; Dept. of Physics, University of Stockholm; PET Center, UU.
   Abstract: This is a long term project where tools for analysis of neuroimaging data in medical research as well as for clinical use are developed. A corner stone in the project is a computerized brain atlas which was developed in an earlier project and documented in a thesis by Thurfjell in May 1994, as well as in several journal papers. It is used clinically and for research in around twenty centers world wide. During 1997 the Applied Medical Imaging, AMI, a company which markets and supports the atlas software has started a more active international marketing effort. In the current project several new algorithms that will extend the usability of the atlas are being developed. Examples of such algorithms are improved inter-individual registration methods. The atlas will also be used as a platform for model based image segmentation methods, an important enabling technology for routine use of 3D imaging and "virtual reality" techniques in medical diagnosis and treatment planning. The present graduate student, Roger Hult, started on this project in the end of 1995. The project is closely related to the "3D Medical Image Fusion" project (se below). The medical cooperation partners are at KS and at Uppsala PET Center are very important for this project.

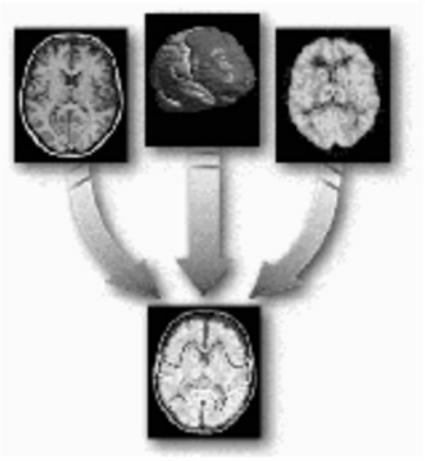

FIGURE: The figure shows an MRI-volume (left), a PET-volume (right) and a 3D brain atlas (middle) fused into one image where the PET-data is superimposed onto the MRI-data and where the brain atlas is used to outline the different brain lobes.

2. **Topic: Fusion of 3D Medical Images**
   Name: Roger Lundqvist, Tomas Löfstrand, Ewert Bengtsson, Gunilla Borgefors
   Funding: Swedish Foundation for Strategic Research, VISIT program and NUTEK
   Period: 9707–
   Partners: Örjan Smedby, Dept. of Diagnostic Radiology and Uppsala PET-center, UU; Context Vision
   Abstract: To support diagnosis based on medical volume images it is becoming increasingly important to fuse data from different examinations, i.e. to relate and extract information from medical images of the same patient acquired with different techniques. Moreover, the images need to be presented to doctors in such a way that they can be easily and correctly interpreted, but without removing essential information. The goal for this project is to develop new methods for registration, visualization and segmentation of medical images. The work within the project is focused on two application areas; analysis of PET, SPECT, MR and CT brain images where voxel-based registration methods are being developed, and analysis and visualization of angiography images. In the clinical situation, the standard visualization method is still to simply display a volume image slice by slice. Any other visualisation method must be proceeded by an analysis step, to *select* what is to be displayed. This project aims at developing gentler processing procedures based on grey-level topology, that preserves the grey-level information but still enhances the images. As an example, in MR-angiography, a problem is to follow a single vessel through the image or to distinguish arteries from veins on parts of the body where they lie in close parallel. To solve this, we are developing grey-level connectivity methods. Connectivity to a seed point in an identified vessel is propagated through the image and the degree of connectivity determines the displayed grey-level in a Maximum Intensity Point (MIP) projection.

3. **Topic: Optimizing the 3D placement of needle biopsies of the prostate**
   Name: Hans Frimmel, Ewert Bengtsson
   Funding: UU
   Period: 9505–
   Partners: Christer Busch, Lars Egevad, Dept. of Pathology, UU Hospital; Ingrid Carlbom, Lucent Technologies, Inc.
   Abstract: In order to obtain a reliable diagnosis of prostate cancer in preparation for possible surgery or other therapy needle biopsies need to be taken of the prostate tissue. The placement of these biopsies is critical since too few or wrongly oriented biopsies may lead to a missed tumor and a false negative result. In this project we are studying how the biopsies should be placed based on 3D modeling of the cancer distribution obtained from the study of about 81 resected prostates which have been digitized slice by slice, registered and remapped to a common coordinate system. The resulting 3D cancer distribution is visualized through computer graphics techniques as well as used for mathematical optimizations of the needle placement strategies. The project is based on previous work at DEC research labs in Cambridge, USA and carried out in cooperation with the Department of Pathology at Uppsala University

4. **Topic: Computerized wound image analysis**
   Name: Ewert Bengtsson, Bo Nordin
   Funding: The industrial liason office UU, CWA Institute AB
   Period: 9502–
   Abstract: When an open wound is healing a necessary first step is for yellow and black inflammatory and necrotic areas to be cleared and red granulation tissue will become visible before the reepitalisation can take place. Based on this the wound healing process can be monitored through a quantitative analysis of color photographs of the wounds taken at regular time intervals. This quantitative evaluation of the healing process is of particular interest to pharmaceutical companies developing new wound treatment compounds. In 1988-90 we developed a hardware/software system for this purpose in collaboration with Pharmacia. Later this system was taken over by CWA Institute AB. In the mid 90-ties the old hardware had become obsolete and CWA asked us to implement a new version based on modern computer technology. We decided to use IMP (see another project description) as a platform and developed a new software for this application during 1995 with some final improvments and tests during 1996. During 1997 we have together with CWA been planning to modernize the system further by making it possible to accept images

and delivering results over Internet. In addition to the straight forward communication aspects this will involve the development of robust calibration procedures that can be used at the customer sites to ensure that we have full control over the photometric properties of the digital images that are received. This development is planned to take place during 1998.

5. **Topic: Computer assisted cervical cytology**
   Name: Ewert Bengtsson, Bo Nordin, Mikael Vondrus, Joakim Lindblad
   Funding: AccuMed International, Inc.
   Period: 9407–
   Abstract: The computer assisted or automated analysis of cell specimens from the uterine cervix, so called PAP-smears, obtained during gynecological health control is one of the long standing problems in digital image analysis. One of the groups that formed the CBA was active in this field 1973-1987. In the spring of 1994 we were contacted by the Chicago based company AccuMed which was interested in developing products based on our old results. A research cooperation contract was signed and we have since the summer 1994 carried out a number of studies in cooperation with AccuMed. During 1997 we have not had any student activity in this project (but in another project supported by AccuMed see below.) Parallell to this Ewert Bengtsson has been working together with AccuMed in planning the continued R&D in this field. This co-operation has invoved 3 week-long visits to Chicago. Also other researchers at CBA, mainly Bo Nordin and Gunilla Borgefors has contributed to the work. In 1998 we expect significantly increased activity in this project.

6. **Topic: The virtual microscope: A new concept for telepathology**
   Name: Ewert Bengtsson, Mikael Vondrus
   Period: 9703–
   Partners: Norman J. Pressman, AccuMed International, Inc.
   Abstract: Efficient consultations among remotely located pathologists typically require access to whole specimens rather than single images. One approach is to use a remotely controlled microscope with real-time transmission of high-resolution images. This method may be impractical due to the transmission bandwidth requirements and costs, and the technical problems associated with establishing concurrent communication links.An alternative approach is to transmit a representation of the entire specimen or region-of-interest overnight, at reduced bandwidth and cost, for subsequent review and teleconsultation. This method is analogous to reading transmitted radiological images via a Picture Archiving and Communications System the next morning, and applies to telepathology applications which are not time-critical. In this mode, a specimen is scanned digitally at the highest spatial resolution of interest, in color, and at multiple focal levels. A software-based "virtual microscope" manipulates this digital representation and displays high-resolution color video images that simulate optical images. The user of this virtual microscope can manipulate the virtual specimen, and change the field-of-view, focus level, and magnification. Pathologists at remote locations can use copies of the same database to view images simultaneously while in direct voice communication. Only the coordinates controlling the x, y and z positions and magnification factors need to be transmitted in real-time. The main obstacle to this concept is the amount of data extracted from a specimen (1 terabyte at 0.2 micron pixels, 1 x 2 inch, RGB color, and 10 focal levels). Methods to achieve 10^3 to 10^4 data compression were evaluated to reduce a specimen data set to the range of 100 megabytes to 1 gigabyte. Such a data set could be transmitted in a few hours using a standard internet connection, or in significantly less time with high-bandwidth links. A proposed implementation approach addressing compression, data structures, and system architecture will be presented.

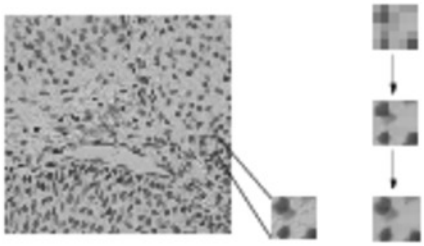

FIGURE: To take advantage of the many empty spaces on a specimen hierarchical compression might be suitable. To the left we have an image with a small section highlighted. To the right we have the compressed version of the section built up from low resolution information to high resolution information.

7. **Topic: Standardisation of histopathological grading through digital image analysis**
   Name: Torsten Jarkrans, Ewert Bengtsson
   Funding: NUTEK, UU
   Period: 9007–
   Partners: Christer Busch, Dept. of Pathology, UU Hospital
   Abstract: The diagnosis of cancer is mainly based on visual evaluation of histopathological specimens in a light microscope. In this evaluation the pathologist is usually very good at recognizing the type of cancer but has much more difficulty in recognizing the malignancy grade. The latter is important in the determination of an adequate treatment of the patient. In this project we are developing methods for computer assisted grading of tumors. We have concentrated the work on bladder cancer since this is a histologically well defined type of cancer. The analysis has proceeded along two different complementing lines: Evaluating the overall order/disorder of the tissue by texture analysis and evaluating the tissue architecture by identifying and measuring the relationships between the individual cells that make up the tissue. This is supplemented by graph theoretical methods for evaluating disorder in the organization of objects in histological tissues. Each line of research was presented as parts of two doctoral dissertations by Choi and Jarkrans respectively during the fall of 1996. The developed methods were also tested and compared on a new independent patient material during 1996. The results were published in 1997.
   Comment: This project has been completed as a NUTEK supported project but some follow up work is still being carried out by Torsten Jarkrans as his research activity within his lecturer position.

8. **Topic: Quantification of immunohistochemistry using digital image analysis**
   Name: Petter Ranefall, Ewert Bengtsson
   Funding: NUTEK
   Period: 9307–
   Partners: Christer Busch, Dept. of Pathology, UU Hospital
   Abstract: Modern methods in immunohistochemistry makes it possible to create very specific stains that quantitatively shows presence of proteins, enzymes, oncogenes etc. The human visual system is good at qualitatively evaluating images but not at retrieving the quantitative information. In this project we are developing methods for quantitative analysis of color images in cytology and histopathology. These methods provide new tools for histopathological research and clinical practice with substantial potential for becoming the basis for new products. Two different approaches have been followed based on supervised and unsupervised classification/segmentation of the images respectively. In the supervised case the operator marks a few typical areas in the image and a classifier is created and applied to the rest of the image based on this. This allows good control over the segmentation but also introduces some subjectivity. In the unsupervised approach a fully automatic segmentation is achieved based on the assumption that the image contains some positive and some negative cells. This removes the subjectivity in the selection of training areas but it is still necessary to visually select relevant fields of view for the analysis. Descriptions of both methods have been accepted for publication in journals. In 1997 a third approach combining the best properties of the two previous approaches was developed. In this approach we use cultured

cells stained in the same staining batch as the tissue which is to be analyzed. These cells are easy to automatically find and segment and they are used to train a supervised classifier which then is applied to the actual sample. All the methods have been implemented in a user friendly software and are being used in application oriented studies at the Department of Pathology at Uppsala University Hospital.

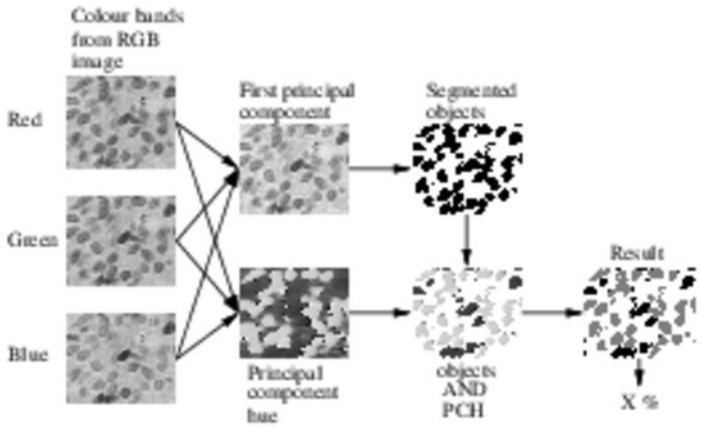

FIGURE: This scheme shows the principles for the automatic quantification of immunohistochemically stained cell nuclei.

9. **Topic: Food quality related quantitative measurements in microscopic images**
   Name: Petter Lindborg, Gunilla Borgefors
   Funding: Foundation for Strategic Environmental Research (MISTRA), FOOD21 programme
   Period: 9702–
   Partners: Dept. of Food Science, SLU, Uppsala
   Abstract: FOOD 21 is a broad scientific project, aimed to develop sustainable food production methods. To evaluate the results of the various experiments, the food quality project within FOOD21 requires quantitative analysis of a large amounts of microscopic (and possibly macroscopic) pictures on meat, cereal kernels, etc. This makes automatic or almost automatic image analysis methods necessary. These range from basic segmentation methods, where the percentage of various colours (substances) within the sample are determined; the number, size distribution and spatial distributions of various "spots", to developing both measures and measuring methods that can characterise net-like structures in biological samples. The novelty of this project is that sample preparation methods will be developed in close co-operation with image analysis methods, to get stable and objective results, and that microscopic colour images will be used thorough.

10. **Topic: Wood Fibre Morphology**
    Name: Mattias Moëll, Gunilla Borgefors
    Funding: Wood and Wood Fiber graduate school
    Period: 9509–
    Partners: Dept. of Forest Genetics SLU; CITU Borlänge
    Abstract: The morphology of wood fibres is of great importance to the mechanical properties of pulp and paper. For the forest industry to be able to produce new products, renew processes, and to maximise the use of the Swedish wood fibre potential, more knowledge of the fibre morphology is needed. The aim of this project is to develop an objective and, as far as possible, automatic methods for description and analysis of wood fibre morphology, where the fibre is modelled in all its dimensions. Currently the project consists of two parts, analysis of "free" fibres in light microscopy images and analysis of fibre cross-sections in confocal microscopy images of transverse sections of wood. In the light microscopy images, methods for correctly identifying and linking the parts of crossing fibres must be developed, as must methods for measurements of length, width and cell wall width along the whole fibre. The analysis of the confocal microscopy images is mainly concerned with measurement of cell wall width, lumen width and determination of the fraction of cell wall area. The confocal microscopy part of the project is a collaboration between CBA, Department of Forest Genetics and CITU.

11. **Topic: 3D tracking of fibers in paper**
Name: Mattias Aronsson, Gunilla Borgefors
Funding: Swedish Foundation for Strategic Research, VISIT programme
Period: 9710–
Partners: Björn Kruse, Arash Fayyazi, Dept. of Electrical Engineering, Linköping University; Stora Corporate Research, Falun
Abstract: Paper is a complex structure. The mesh of intertwined wood fibres is responsible for the mechanical strength of the paper as well as some of the optical properties, but is still largely unknown. To really be able to understand paper, it is necessary to be able to trace individual fibres in three dimensions. It is very difficult to capture the three dimensional weave of fibres and also to visualise the result in a useful way. A number of methods have been suggested, but very little has been done anywhere. The very nature of the paper itself has been an obstacle, e.g. when trying to use a confocal microscope the light penetration is very shallow. Another problem is that to resolution necessary to capture the width of the fibre is very high compared to the fibre length, so that the data volumes for "untangling" a piece of paper will be very large. Traditional slicing of an embedded sample and rebuilding the volume from the sliced will be tried, but hopefully better methods such as gradual evaporation by eximer laser and possibly CT methods will be available. From the 3D data, measures such as the length, the curvature, and, more important, the interlocking of the fibres will be possible to extract.

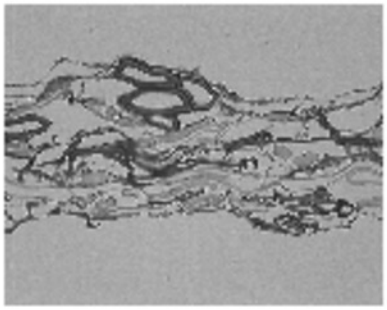

FIGURE: Image of a paperslice (1 μm thick), cut by a microtome.

12. **Topic: Digital image classification of compression wood in Norway spruce discs**
Name: Fredrik Walter, Gunilla Borgefors
Funding: SLU S-faculty
Period: 9401–
Partners: Mats Warensjö, Dept. of forestry products, SLU, Uppsala
Abstract: Compression wood is an important defect in wood products. To understand the relationships between compression wood and warpage in the sawn wood product, the Dept. of forestry products studies thin discs cut from Norway spruce. Our part of the project has been to develop an interactive system that automatically identifies normal wood and two degrees of compression wood in colour images of these discs. The areas of the three wood types and the approximate location of the compression wood were extracted. The extracted data from the analysis has been compared to the real sawn wood products. Most of the work has done previous years, but the programs is in use and therefore constantly modified.

13. **Topic: Automated analysis of forest using high resolution CIR aerial images**
Name: Tomas Brandtberg, Gunilla Borgefors
Funding: SJFR
Period: 950815–
Abstract: The main goal of the project is to develop methods for computerised forest inventory, using high spatial resolution colour infrared aerial images (CIR). The resolution of the 50 aerial images, used as a research set in the project, is high enough (flight height 600 m) to make the individual tree crowns visible and accessible for analysis. Image variables to be extracted are horizontal tree crown area, tree species and tree positions. Automation of the image analysis is emphasized. We have showed that it is possible to count the number of trees as accurately as a train

photo interpreter using scale-space related methods; to delimit tree crowns using local curvature; and to distinguish between spruce on one hand, and pine and birch on the other, using a structure-based algorithm. The two-dimensional aerial image information could, in the future, be integrated with a tree height profile, e.g. from a laser system, to make three-dimensional measurements possible. One journal and one conference paper was published during 1997.

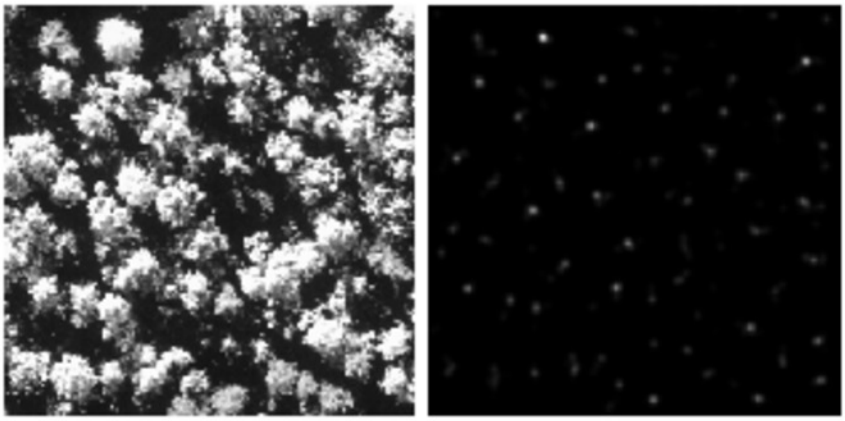

FIGURE: (left) High resolution aerial image (40x40m) over a group of middle-aged Scots pines. (right) Individual tree crowns identified by the developed segmentation algorithm.

14. **Topic: Extraction of forest parameters from CARABAS radar data**
Name: Fredrik Walter, Gunilla Borgefors
Funding: SLU S-faculty
Period: 9407–
Partners: Division of Surveillance and Seeker Systems, National Defence Research Establishment, Linköping
Abstract: CARABAS is a new type of radar sensor, developed at the National Defence Research Establishment (FOA). It is, in sharp contrast to conventional microwave SAR (Synthetic Aperture Radar), well adapted to interesting scatterers in the forest, i.e. trunks and other larger objects. The goal of this project is to develop methods for extracting forest parameters from the radar data. Forest tree volume has been compared to CARABAS I imagery. The study showed that there is a strong correlation between CARABAS radar data and forest biomass. During 1997 a study regarding automatic extraction of forest stand borders started, using data from the improved CARABAS II. In late 1997 the CARABAS II sensor registered images over the forest research park Tönnersjöheden in Halland. These images will be analysed during 1998. The analysis will be directed towards finding correlation between CARABAS II images and biomass, extraction of single trees, and delineation of homogenous forest stands. Some results from this project were published in "Scandinavian Journal of Forest Research".

15. **Topic: Change detection of clear felled areas using Almaz-1 SAR data in combination with SPOT P data**
Name: Fredrik Walter, Gunilla Borgefors
Funding: SLU S-faculty
Period: 970202-970801
Partners: Johan Fransson, Håkan Olsson, Dept. of Forest Resource Management and Geomatics, SLU Umeå
Abstract: Almaz-1 S-band satellite SAR data from two subsequent years in combination with optical satellite data have been analysed to determine the separability between recently clear-felled areas and forested areas. The basic assumption in this study design is that in an operational case, optical data before the clear-felling, and radar data from both before and after the felling will be available. The optical data were used for creating homogenous regions in the images. In these regions texture features were calculated in the Almaz images. These features were used to classify the Almaz image into clear-felled or forested areas. The result from this study has been documented in an article, which has been submitted to an international journal.

16. **Topic: Automated Analysis of Agricultural Remote Sensed Images**
Name: Anna Pettersson, Gunilla Borgefors
Funding: SLU JLT-faculty
Period: 9602–
Abstract: Information of agricultural activities are increasingly collected using remote sensing, especially within the European Union. Crop species identification, crop area, and yield prediction and estimation are important measurements, that can be facilitated by remote sensing. Today the image analysis is mostly manual, or at least is using heavy human interaction. As an increasing number of satellites and other sensors provide more and more information, there is a need for interactive or even automated analysis of the remote sensed images. The goal of this project is to develop better and more automated methods for the analysis of agricultural images than those available today. The focus will be on neighbourhood operations, rather than "classical" spectral analysis. As a first step, a method for automated field boarder extraction is under development. A priori knowledge of the field boarders will probably greatly improve the results of subsequent classification. A conference paper was published during 1997.

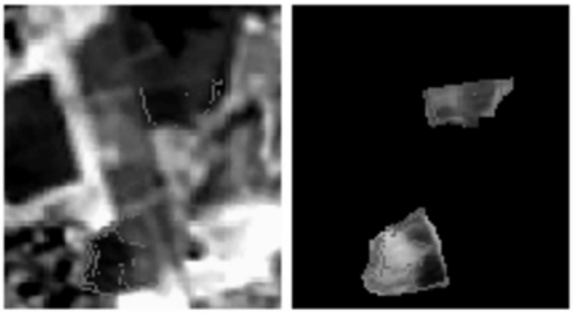

FIGURE: Multispectral edges computed from three spectral bands over an agricultural area (left) compared with interpolated yield information for precision agriculture (right).

17. **Topic: Application of remote sensing for agricultural crop production in Sweden**
Name: Jakob Nisell, Gunilla Borgefors
Funding: European Commission through Statistics Sweden (SCB)
Period: 9611–
Partners: Statistic Sweden (SCB); Dept. of Crop Production Sciences, SLU, Uppsala; Swedish Meteorological and Hydrological Institute (SMHI), Norrköping; Joint Research Centre (JRC), Ispra, Italy
Abstract: The main goal of the project is to find new objective and less expensive methods for crop yield estimation for Sweden. The Institute for Remote Sensing Application, IRSA, has been conducting and implementing a crop yield information system for mid European conditions, within the MARS project. Their methods will be adopted to Swedish conditions. We will use NOAA AVHRR images to follow vegetation growth over large areas in the Skåne and Skaraborg counties. Homogeneous areas of 5 km x 5 km will be defined and followed during the vegetation season. High resolution images from Landsat TM and/or SPOT will be used for calibration of the crop relationship to the AVHRR data and for the definition of the homogeneous areas. There will be a close collaboration with Department of Crop Production, SLU where a crop growth model based on the CGMS model is being developed.

18. **Topic: Satellite monitoring of within field variations of crop yield**
Name: Anna Pettersson, Gunilla Borgefors
Funding: Swedish Farmers Supply & Crop Marketing (SLR), SLU JLT-faculty
Period: 9705–
Partner: Lars Thylén, Swedish Institute of Agricultural Sciences, Uppsala
Abstract: The spatial variability of crops within fields is almost consistent over years and this spatial information can be used to develop management recommendations for the usage of fertilisation, pesticides etc., for a more sustainable land use and more economically sound cultivation. To get this information, yield history for several years must be available. This project investigates the possibilities of using satellite images for estimating the historic site-specific properties of agricultural

fields. Historical yields gained by precision agriculture is compared with three satellite images from different dates but within the same year. Crop yield data and image data are converted to the same format and correlated.

19. **Topic: Satellite Remote Sensing for Lake Monitoring (SALMON)**
Name: Tommy Lindell
Funding: EU
Period: 1996–
Partners: The project has the following participating partners:
CNR-IRRS, Milano, Italy, CNR-ISDG Venezia, Italy; JRC-EI Joint Research Centre-Environment Institute Water Research Management; Universit degli Studi, Dip.to Biologia, Milano; Helsinki Technical University - Laboratory of Space Technology; Finnish Environment Agency; CBA, UU; Dept. of Limnology, UU.
Abstract: The overall objective of the project is the evaluation of the capabilities of current and forthcoming spaceborne remote sensing for the monitoring of European lake water quality. To this end, the following specific objectives will be targeted:

    - interaction with end-users to define their needs for the monitoring of water quality (parameters, accuracy, frequency);
    - evaluation of the capabilities of current instruments and methods to fill these needs;
    - improvement of the processing methods for remote sensing data including calibration, atmospheric correction, and correction for solar zenith angle;
    - acquisition of airborne and in-situ data during campaigns involving instruments similar to the next generation of spaceborne instruments (e.g. hyperspectral passive observation, fluorescence lidar);
    - evaluation of the capabilities of these airborne instruments to fill these needs;
    - definition of an optimal spaceborne sensor for the purpose of lake water quality monitoring.

    The project is focused on the use of remote sensing measurements, in different regions of the electromagnetic spectrum (optical, thermal infrared, microwave), with the support of limnological observations. The combinations of these measurements will allow the development and the evaluation of techniques for remote sensing data processing. The project is organized into five main work-packages: Introductory activities, Preliminary application of remote sensing algorithms, Synchronous remote sensing and limnological surveys, Data analysis and methodological validation and First use and dissemination of project results. The project results and conclusions will be widely distributed. The promotion will be achieved through various communication media:

    - scientific communications;
    - electronic (Internet & WWW, multimedia, etc.);
    - demonstrations packages designed for the local lake management agencies;
    - a CD-ROM for educational purposes.ing part in the project.

    Comment: Details of the project may be viewed at the SALMON home-page (http://www.tel-irrs.mi.cnr.it/SALMON/index.html)

20. **Topic: Methods for detection of changes in aquatic ecosystems and monitoring of algae blooms**
Name: Tommy Lindell, Haiying Yuan
Funding: Foundation for Strategic Environmental Research (MISTRA), RESE programme
Period: 9701–
Partners: Swedish Meteorological and Hydrological Institute (SMHI), Norrköping; et al.
Abstract: This project is focusing on marine and lacustrine environmental problems of concern for Nordic waters i.e. eutrophication, pollution and algae blooms.

    LONG-TERM GOALS
    • A demonstration project on algae bloom detection.

• A reflectance model adapted to class 2 waters, i.e. the Baltic Sea and applied to satellite data obtained from, for example SeaWiFS.
• Airborne hyperspectral analysis for aquatic applications.
• An airborne hyperspectral analysis system for simulating satellite data, useful for planning new instruments.

SHORT-TERM GOALS
• A preliminary investigation of satellite imagery and hyperspectral data from the two previous summers has started.
• A theoretical reflectance model has been defined.
• A plan is available, considering the co-operation with other projects within RESE and SALMON projects.

STRATEGIES
This project covers fundamental analysis problems of ocean optics and atmospheric influences on ocean satellite data. These methodology problems are necessary to solve for retrieving quantitative estimates of ecological variables. In this respect the project indeed is helpful for monitoring agencies, surveillance work and research community.

Airborne hyperspectral studies can improve and adapt image analysis at regional scale and guide satellite and airborne instrument development. Remote sensing methods for waste water influence on coastal ecology is established.

The main focus for CBA on this project is to develop methods of analysing hyperspectral images from the aquatic environment.

21. **Topic: Integrated Coastal Planning - Jamaica**
Name: Tommy Lindell
Funding: SIDA
Period: 1994–
Partners: John Norrman, Dept. of Geosciences, UU; Chiefs of County planning Lars-Ulrik Bergström and Örjan Molund, Chief of City Planning Kaj Wejander; the Staff of Natural Resources Conservation Authority, Kingston, Jamaica
Abstract: During the last year of the project the following was achieved. The phase was finalized by the completion of the Manual for Integrated Coastal Planning and Management in Jamaica and the Coastal Atlas of Jamaica in one printed and one CD-format, which were presented at a workshop in Kingston on Dec. 4, 1997.

A basic policy of the project has been to illustarte prerequesites for a balance between economic development and environmental considerations in the use of coastal, terrestrial and marine, resources. Also has been emphasised in the Terms of Redferences the importance of enhanced public awareness and participation and the strengthening of related legal framework. The development of appropriate techniques and methodologies to facilitate planning decision making and plan implementation is another important aspect of the project.

The Coastal Zone Management (CZM) Unit of the Natural Resources Conservation Authority (NRCA) has had the operational responsibility of the project. Uppsala University and its Centre for Image Analyses has served as an advisory consultant. The project has had a broad network of contact persons at all levels within the Jamaican adminstration . The project has also co-operated with a number of NGOs, engaged in coastal environmental issues.

The consultant's work has been carried out both in Sweden, and during short missions to Jamaica, by one or more persons each time.

The project investigations have revealed the urgent, wide need of active, creative planning of the coastal environment in order to attain a prosperous sustainable development. Special problems that have been identified include the following items:

- The fisheries, including the offshore cays, with regard to rules, methods, organisation and development of aqvaculture and mareculture.

- The protection and management of coral reefs and their entire ecology.
- Utilization and mangement of coastal wetlands.
- Updating and management of sewage treatment plants.
- Long term production of gravel and sand with special regard to find new sources and the necessity to optimize the use of different qualities.
- In order to track the trend of water quality and other environmental variables, reliable methods and performances of sampling and anlytical work have to be guaranteed.

The necessity to give Coastal Planning a firm and proper organisation has become obvious during the project. Also an increased awareness on the imprtance of public participation in the planning process.

22. **Topic: Classification of land-use and land cover in some Swedish counties**
Name: Tommy Lindell, Jakob Nisell
Funding: The counties of Gävleborg, Dalarna and Värmland.
Period: 1996–
Partners: The county administrations
Abstract: The mapping and monitoring of the natural resources of the counties in Sweden could be aided by remote sensing information. Värmland, Dalarna and Gävleborg county have requested a classification of its counties in order to estimate the different landcovers of its regions. The classification has been based on Landsat TM images and developed from earlier classifications of ours on the River Testeboån. The data will be further used for future change detection in the natural resources.

23. **Topic: Environmental applications of Imaging Spectrometry**
Name: Tommy Lindell, Catherine Östlund
Funding: Swedish Space Board
Period: 9207–
Partners: K. Sörensen, NIVA, OSLO, Norway, F.L. Berta Andersson, Dept. of Environmental Assessment, SLU
Abstract: To develop our own algorithms for data visualization and analysis based on SIPS and EASI/PACE. The system will contain a displaying function for spectral data and the connection to the recovery image. It should also contain the unpacking of the spectral data for displaying it in "signature" form and present it together with the recovery image for the detection and analysis of different features. There should also be a routine for calculating different types of statistics from the spectral data, including routines for atmospheric corrections and calibrations. The system should also display the spatial data together with the recovery image for the detection and analysis of different features. New ways of presenting and analyzing the data based on PCA and PLS will be developed. The knowledge will be applied to environmental mapping and monitoring in water and wetland sites, concentrating on detecting of different types of phytoplankton and other types of suspended matter and the classification of periphyton.

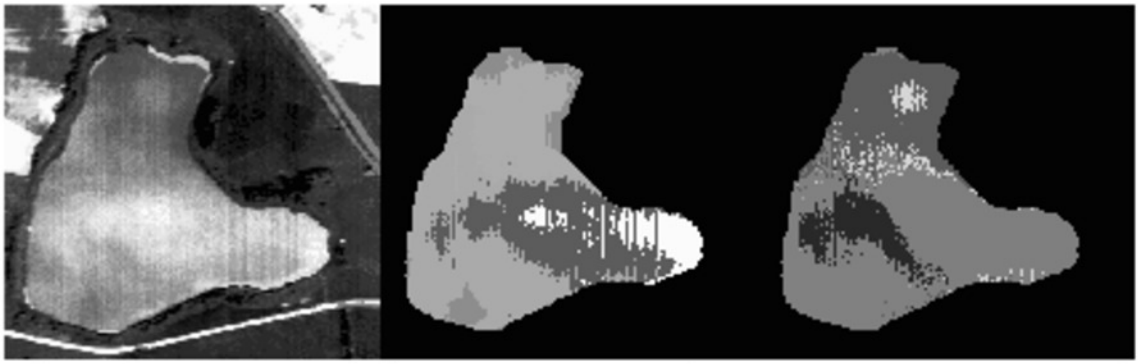

FIGURE: A very turbid lake (left) and the segmentation of watermasses by unsupervised classification (middle) and by thresholding the hue component of a IHS transformation of the three first principal components (right).

24. **Topic: Analysis and display of high dimensional remote sensed data.**
Name: Emma Lindqvist, Gunilla Borgefors
Funding: Foundation for Strategic Environmental Research (MISTRA), RESE program
Period: 9702-
Partners: The "thematic" projects within the RESE program
Abstract: New kinds of sensors for remote sensing, e.g. imaging spectrometers, will deliver data of great dimensionality, up to 100-200 spectral bands, as compared to "normal" multispectral images with only 5-10 spectral bands. Each hyperspectral pixel thus yields an almost continuous spectrum. The spatial resolution, on the other hand, is not equally high. Even more complex is the case when multisensor data together with other knowledge from the same geographic area are available, and the different measurements in the same pixel are of widely diverging types. The amount of data in hyperspectral images and multisensor data is enormous, and makes human interpretation impractical. That is why methods to select the most important information for display and analysis are needed. There are also problems when it comes to visualize multidimensional data on a computer screen, since there are, in priciple, only four dimensions available - the three colours red, green and blue, and motion.
Fusing hyperspectral and other types of data is also an interesting challange. In order to, e.g., create image with high spectral resolution and imporved spatial resolution, hyperspectral data can be fused with data of higher spatial resolution. It is also interesting to see what can be done with hyperspectral data fused with data from completely different sources, like radar.

25. **Topic: Multispectral Texture Analysis**
Name: Fredrik Lidberg, Gunilla Borgefors
Funding: Foundation for Strategic Environmental Research (MISTRA), RESE program
Period: 9702-
Partners: The "thematic" projects within the RESE program
Abstract: Classification of remotely sensed, or other, multispectral images can seldom be carried out satisfactorily using only point-wise information. By including information about the local context (i.e. texture) it should be possible to significantly improve classification results. In texture analysis a local neighbourhood is investigated — the goal is to describe the area in some intelligent manner that lets similar and dissimilar areas be recognised. The basis of a texture description is usually some mathematical model and many such models have been proposed (e.g. Co-occurrence matrices, Fractals, Markov Random Fields, Wavelets, Gabor Filters, Neural Networks). Texture analysis has been an important field in image analysis for a long time, but most works concern grey level images. In a multispectral image, it is certainly possible to perform texture analysis on separate bands one by one, but it is believed that a lot of information is lost in this process. To take all available information into account, texture analysis should be performed simultaneously on all bands, i.e. multispectral texture analysis.
The work within this project will regard the possibility of extending current texture models to multispectral data. Further, already proposed (multispectral) methods will be investigated and possibly refined and, if necessary, completely new ways of doing multispectral texture analysis will be searched for.
Applications are intended for remotely sensed images and during the project the image material will come from such sources. However, the end results will most likely be applicable to other types of multispectral (colour) data as well.

26. **Topic: Inspecting the LHC superconducting cable**
Name: Yueqin Sun, Ewert Bengtsson, Tobias Öhman, Joakim Lindblad
Funding: NFR, CERN
Period: 9603–
Partners: CERN
Abstract: In the development of the next generation elementary particle research accelerator at CERN, the Large Hydron Collider, LHC, 6000 km of superconducting cable has to be manufactured. This cable has to be "perfect" without any crossing strands or other irregularites. In order to ensure this the cable has to be inspected through computerized image analysis techniques. The CBA has been commissioned by CERN to develop such an inspection system in a three phase project. In the first phase, during the spring of 1996, a feasibility study was carried out using

static images and our general image analysis platform IMP. The results were documented as a Master Thesis report by Tobias Öhman and an CBA internal report by Yueqin Sun and presented at CERN in July 1996. Based on this study a real time inspection system was developed by Yueqin Sun and Joakim Lindblad during 1996-97. The analysis speed is about 2000 scanlines across the cable per second. For the data aquisition a MAPP camera from Integrated Vision Products in Linköping is used. The inspection computer is run under MSDOS which in this application serves as a real-time operating system. To allow simultaneous inspection and evaluation of earlier inspection results a second computer running Lab View from National Instruments is used. The two computers communicates through a specially developed communication protocol using the parallel ports of the computers. In 1998 the system will be tested and evaluated at CERN and a cable manufacturing plant and hopefully be used as the prototype for a series of systems that will be put into production use.

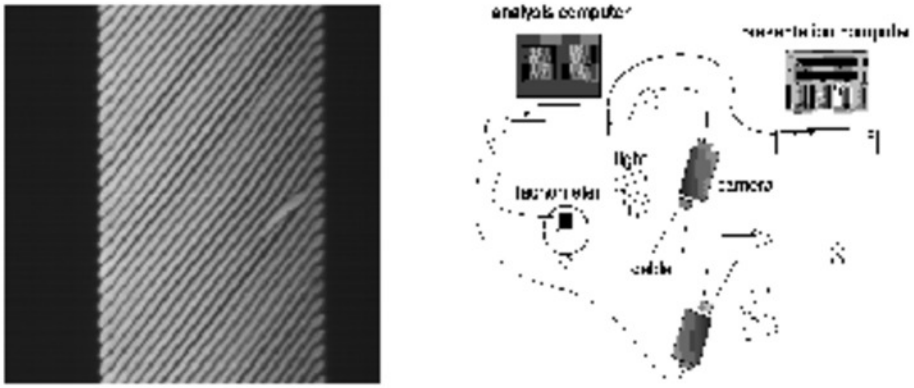

FIGURE: Part of the LHC cable, with a cross over error (left) and Schematic view of the system setup (right).

27. **Topic: Digital distance transforms**
Name: Gunilla Borgefors
Funding: SLU S-faculty
Period: 9309–
Abstract: This is an ongoing project where the geometry of discreet spaces is investigated. A major consideration is to measure global distances within the spaces using local operations, that is using distance transforms. Other aspects of the differences between R^n and Z^n are also considered. The digital geometry in 3D is quite complex, more so than generally realised. Lately, some effort has been spent on 4D distance transforms.

28. **Topic: Visualization of Distance Transforms in Four Dimensions**
Name: Hua Guo, Gunilla Borgefors
Funding: SLU S-faculty
Period: 9609-9702
Abstract: The first attempts of optimising weighted distances transforms in 4D is from 1984. However, not much has been done since, partially because visualization of the results is still a challenge. The purpose of this project was to visualize the hyper-spheres associated with different weighted distance transforms in 4D. These spheres are hyper-polyhedra with different number and shape of facets. The approach is to construct an image sequence of 2D projections of volume images resulting from traversing the hyper-volume with a plane.

29. **Topic: Multiresolution Binary Images: Shape and Skeletons**
Name: Gunilla Borgefors, Stina Svensson
Funding: SLU S-faculty, CNR
Period: 9501–
Partners: Gabriella Sanniti di Baja, Giuliana Ramella, Istituto di Cibernetica, CNR, Arco Felice, Italy
Abstract: Multiresolution structures have proved very useful in image analysis. However, when

the resolution of a *binary* image is changed, the shapes of the objects in the image can become seriously distorted. "Normal" averaging can not be used, as each pixel value must be either one or zero. We have developed several methods for shape preservation in binary pyramids in booth 2D, and recently 3D images, methods that are significant improvements of existing ones. This year, the work has concentrated on multiresolution skeletons. Skeletonization, where an object is reduced to a stick-like figure, has been a successful approach to shape manipulation and recognition. Multiresolution skeletons combine the advantages of skeletons and multiresolution structures. With our binary pyramids as underlying structures, multi-scale skeletons and skeleton hierarchies have been constructed. The co-operation has resulted in four publications at reviewed conferences during 1997.

$2^6 \times 2^6 \times 2^6$ $2^5 \times 2^5 \times 2^5$ $2^4 \times 2^4 \times 2^4$

FIGURE: Example of a multiresolution representation of a shape.

30. **Topic: Skeletonization of volume images**
Name: Ingela Nyström, Stina Svensson, Gunilla Borgefors
Funding: TFR, UU, SLU S-faculty
Period: 9501–
Partners: Gabriella Sanniti di Baja, Istituto di Cibernetica, CNR, Arco Felice, Italy
Abstract: Skeletonization (or thinning) denotes the process where objects are reduced to structures of lower dimension. Skeletonization reduces objects in 2D images to a set of planar curves and objects in volume (3D) images to a set of 3D surfaces. In volume images, skeletonization might furthermore compress the skeleton to a set of 3D curves. Unlike the surface skeletons, which are reversible, if properly constructed, the curve skeleton would express only certain aspects of the original shape. Skeletonizing volume images is a promising approach for quantification and manipulation of volumetric shape, which is becoming more and more essential, especially in medical image analysis, but also in such applications as 3D tracking of fibres in paper.
We have developed a novel method for reducing a 3D object to a surface skeleton. This surface skeleton can then be reduced to a curve skeleton using another of our methods. In both cases, voxels are iteratively removed according to conditions of their local neighbourhoods. In previous papers on 3D skeletonization, the methods have mostly been exemplified using quite tiny test images, that makes it difficult to understand what the results would be in more application oriented examples. Our methods have been tested with good results on large images. Nyström defended her thesis on 3D skeletons this year and several papers were published.

31. **Topic: Global shape description in 2D and 3D by polynomial expansion**
Name: Gunilla Borgefors
Funding: -
Period: 9701-
Partners: Örjan Smedby, Dept. of Diagnostic Radiology, UU; Christer Kiselman, Dept. of Mathematics, UU

Abstract: Shape description in volume and volume images is usually local, e.g. finite elements, surface facets, spline functions. This can be a severe limitation on usefulness, as comparison between different shapes becomes very difficult. In 2D, the Fourier descriptors are a successful and often used global shape description with adaptable accuracy. The aim of this project is to develop something similar in 3D, that is global 3D shape description orthogonal polynomials. The basic idea is to study the distance from the origin to the object boundary as a function of the direction vector. A preliminary study was published during 1997.

32. **Topic: SIMD and MIMD parallel algorithms for image analysis**
Name: Anders Forsmoo, Gunilla Borgefors
Funding: NUTEK, SLU S-faculty
Period: 9408-
Abstract: Images used in many practical applications contain huge amounts of data (but not necessarily much information). To be able to extract information in reasonable times, parallel architectures can be used. The purpose of this project is to develop parallel algorithms and implementations for image analysis, with a special emphasis on shape analysis, starting with distance transforms. These operations are global in the sense that information must be transferred long distances over the image. This is in sharp contrast to local filters, that are much simpler to implement in parallel. Distance transforms are used as part of many complex algorithms, such as matching of images, finding binary skeletons, path planning, and many other basic image analysis tools. The project should lead to increased understanding of the behaviour of parallel distance transforms on SIMD and MIMD architectures, which are very different and pose different problems. A paper on SIMD algorithms was published during 1997.

33. **Topic: The development of a general image analysis software platform**
Name: Bo Nordin, Ewert Bengtsson
Funding: UU
Period: 8807–
Partners: Uppsala Bildbehandling AB; Diascan AB, Uppsala; Wallac Oy, Åbo, Finland
Abstract: In recognition of the need in image analysis research to have a good platform for interactive work with digital images we several years ago started a project with the aim of developing such a platform. This has been a very large project (about 13 man years of which CBA has put in about 4) which would have been impossible to finance by regular research money. But through a cooperation with a group of companies we have coordinated our interests of obtaining a good software platform for research with their interest in development of a new software product: a general purpose software system on which specific commercial image analysis applications easily can be implemented. The effort reached the goals of creating a platform useful both for specific applicaltons and for general purpose image analysis work called IMP. Unfortunately a change of company ownership in Wallac led to a cancellation of the marketing plans. So presently a "product" is available but no marketing organization. At CBA the IMP system is used as a software basis for most of the teaching and research in image analysis. During 1997 we have been working on a major revison of the softwre, reprogramming the core system in C++ to make it more easy to maintain and extend. This revision is expected to be completed in 1998.

5.2 Cooperation partners

CBA has an extensive cooperation with other research groups locally as well as nationally and internationally. Our research philosophy is that good application work in image analysis requires good competence both in image analysis technology and in the specific application field. We have, and are constantly building, the highest possible expertise in image analysis within our center and are seeking the expertise in the applications through close cooperations with other researchers.

We are also trying to bring our results out from the research situation into real world use. In order to achieve this we are cooperating with several companies, local and central government agencies, and hospitals. In our list of projects above and the list of publications in the next section the names and affiliations of many of these cooperation partners can be found.

6 Publications

Our research results have been published in journals, books and conference proceedings as well as in our own report series. The list covers papers with a publication date in the range 970101–971231. As can be seen from the lists in the following sections we have published nine journal articles and book chapters, 14 papers in refereed international conferences, five papers in workshops and other non-refereed conferences and several reports and similar publications. CBA has its own report series, that has now been complemented with a series of internal reports.

6.1 Journals and book chapters

1. **Computer Assisted Analysis of Medical X-ray Images**
   Authors: Ewert Bengtsson
   Pages: 44-50 *Year:* 1996 *Journal:* Physica Scripta. Vol. T61
   Abstract: X-rays were originally used to expose film. The early computers did not have enough capacity to handle images with useful resolution. The rapid development of computer technology over the last few decades has, however, led to the introduction of computers into radiology. In this overview paper, the various possible roles of coputers in radiology are examined. The state of the art is briefly presented, and some predictions about the future are made.
   Comment: Was published in 1996, but not included in the publication list that year.

2. **Implementation and validation of a fully automatic system for intra- and inter-individual registration of PET brain scans**
   Authors: JLR Andersson, L Thurfjell
   Pages: 136-144 *Year:* 1997 *Journal:* Computer Assisted Tomography, Vol. 21, No.1
   Abstract: PURPOSE: Stereotactic coordinate spaces and methods to adapt subjects to that space are required when performing averaging of functional studies across subjects.
   METHODS: A rapid and fully automatic method to perform intersubject registration and adaptation to a previously defined coordinate space has been developed and implemented. The implementation has been performed within an existing software developed to facilitate manual registration and adaptation, thus offering a versatile combination of automatic and manual tools. Furthermore, a novel measure, based on the F-statistic for intersubject (block) differences, for the assessment of intersubject goodness of fit was suggested and validated.
   RESULTS: The intra- and intersubject registration was validated by its application to data from six human subjects participating in an activation study. The registration was performed both manually and automatically, and the results indicated that the automatic method performed at least as well as the manual. The block F-statistic was lower for the automatic method, and the z-scores were not significantly different for the methods. The localization of activated regions showed good agreement and differed by an average of 6 mm between the methods.
   CONCLUSION: It is concluded that the suggested method is a valuable alternative to the current manual approach.

3. **Construction of a standard reference for PET studies of methionine accumulation using a computerised brain atlas**
   Authors: Romanowski CAJ, Leslie DF, Thurfjell L, Ericson K, StoneElander S
   Pages: 389-393 *Year:* 1997 *Journal:* Neuroradiology, Vol. 39, No. 6
   Abstract: Positron emission tomography (PET) is valuable for assessing the biochemistry and physiology of the human brain. A computerised brain atlas has been developed which allows demonstration of anatomical regions of PET images and manipulation of these images into a standardised anatomical space. Once the images are in this standardised three-dimensional space it is possible to make comparisons between individuals and groups of individuals. We describe the use of this atlas in the generation of a set of mean reference images using methionine PET images of normal volunteers.

4. **Audio- and Video-based Biometric Person Authentication, LNCS 1206**
Editors: Josef Bigün (1), Gérard Chollet (2), Gunilla Borgefors
(1) EPFL, Lausanne, Switzerland
(2) CNRS URA-820, ENST, Paris, France
Pages: 450p. *Year:* 1997 *Publisher:* Springer, Berlin Heidelberg New York *ISBN:* 3-540-62660-3
Abstract: This book contains the proceeedings of First Int. Conf. on Audio- and Video- based Biometric Person Authentication (AVBPA'97), Crans-Montana, Switzerland, March 1997.

5. **Towards Structure-based Classification of Tree Crowns in High Spatial Resolution Aerial Images**
Authors: Tomas Brandtberg
Pages: 89-96 *Year:* 1997 *Journal:* Scandinavian Journal of Forest Research, vol 12
Keywords: Aerial image, automation, crown structure, digital image analysis Norway spruce, pattern recognition, remote sensing, texture, tree species classification
Abstract: Some metrics useful for characterising certain patterns of individual tree crowns are presented. They could be applied in an automated image analysis system for tree species classification in digital high resolution aerial images. The structure-based measures made use of the internal pattern (also called texture) of individual tree crowns. The infrared layer of colour infrared aerial images was utilized and the different crown patterns were extracted using the second order Laplace transform. Skeletonization was used for data compression and to enhance features to be used in the subsequent analysis. The resulting skeleton branches were one pixel thick but they still contained the structural pattern that was identified by the Laplace transform. The skeleton was split into simple segments without branches. The direction of each individual segment in a tree crown was calculated. A Hough transform technique was developed for analysing whether they collectively had a parallel or radial structural behaviour. It could clearly discriminate between Picea abies (L.) Karst, with a typical radial pattern, and Pinus sylvestris L. and Betula sp., some times dominated by parallel structures. The Scots pines showed, in our images, a more clearly parallel pattern, which was probably caused by a combination of the inclination angle of the sunlight and a slight camera motion during exposure. Whether any Scots pine had a parallel crown structure was not possible to determine.

6. **Effect of androgen deprivation on epithelial and mesenchymal tissue components in localized prostate cancer**
Authors: M. Hellström(1), P. Ranefall, K. Wester(2), S. Brändstedt(1), C. Busch(2)
(1) Department of Urology, Danderyd Hospital, Karolinska Institutet
(2) Department of Pathology, University Hospital, Uppsala
Pages: 421-426 *Year:* 1997 *Journal:* British Journal of Urology, Number 79
Keywords: Localized prostate cancer, neoadjuvant androgen deprivation, cancer volume, planimetry, immunohistochemistry, colour image analysis.
Abstract: Objective: To measure the area distribution of epithelial and mesenchymal components in the prostate of patients with localized prostate cancer after temporary androgen deprivation.
Patients and methods: Surgical specimens from 38 patients treated with the gonadotrophin-releasing hormone agonist triptorelin for 3 monthsbefore radical prostatectomy were examined (group 1). Specimens from a second group of 54 patients who underwent the same surgical procedure with no prior therapy were used as controls (group 2). The specimens were serially step-sectioned and whole-mount tissue sections prepared. The epithelial, smooth muscle and connective tissue components were stained separately with immunohistochemical ant histochemical techniques, respectively. Using colour-based image analysis, the tissue components were classified into three categories, displayed in different colours. The percentage of tumour areas occupied by cancer epithelial cells, connective tissue and smooth muscle was determined.
Results: In specimens from group 1, the cancer epithelium was sparse and scattered throughout the tumour area. A mean (SD) of 21 (11)Conclusions: Neoadjuvant hormone treatment of patients with localized prostate cancer was associated with a marked reduction in tumour density and thus in the total amount of cancer epithelium.

7. **Efficient shape representation by minimizing the set of centres of maximal discs/spheres**
Authors: Gunilla Borgefors, Ingela Nyström
Pages: 465-472 *Year:* 1997 *Journal:* Pattern Recognition Letters, vol 18
Keywords: shape representation, maximal discs/spheres, reverse distance transform, skeleton
Abstract: Efficient shape representations are important for many image processing applications. Distance transform based algorithms can be used to compute set of centres of maximal discs/spheres, that represents a shape. This paper describes a method that reduces this set, under the constraint that the shape can be exactly reconstructed using the reverse distance transformation. The reduced set can be used in the same ways as the "standard" set, e.g. for efficient storage, segmentation into parts of different thickness, shape manipulation, and skeletonization, all in 2D and 3D.

8. **Image analysis based grading of bladder carcinoma. Comparison of object, texture and graph based methods and their reproducibility**
Authors: Heung-Kook Choi (4), Torsten Jarkrans, Ewert Bengtsson, Janos Vasko (1), Kenneth Wester (2), Per-Uno Malmström(3), Christer Busch(2)
(1) Dept. of Pathology, Umeå University, Umeå.
(2) Dept. of Pathology, University Hospital, Uppsala.
(3) Dept. of Urology, University Hospital, Uppsala.
(4) School of Information and Computer Science, Inje University, Kim-Hae, Korea.
Pages: 1-18 *Year:* 1997 *Journal:* Analytical Cellular Pathology, vol 15, Shannon, Ireland
Keywords: Image analysis; Feature measurements; Grading of bladder carcinoma; Reproducibility
Abstract: The possibility that computerized image analysis could increase the reproducibility of grading of bladder carcinoma as compared to conventional subjective grading made by pathologists was investigated. Object, texture and graph based analysis were carried out from Feulgen stained histological tissue sections. The object based features were extracted from gray scale images, binary images obtained by thresholding the nuclei and several other images derived through image processing operations. The textural features were based on the spatial gray-tone co-occurrence probability matrices and the graph based features were extracted from the minimum spanning trees connecting all nuclei. The large numbers of extracted features were evaluated in relation to subjective grading and to factors related to prognosis using multivariate statistical methods and multilayer backpropagation neural networks. All the methods were originally developed and tested on one patient material and then tested for reproducibility on an entirely different patient material. The results indicate reasonably good reproducibility for the best sets of features. In addition, image analysis based grading showed almost identical correlation to mitotic density and expression of p53 protein as subjective grading. It should thus be possible to use this kind of image analysis as a prognostic tool for bladder carcinoma.

9. **A New Method for Segmentation of Colour Images Applied to Immunohistochemically Stained Cell Nuclei**
Authors: Petter Ranefall, Lars Egevad (1), Bo Nordin, Ewert Bengtsson
(1) Department of Pathology, Uppsala University, Sweden
Pages: 145-156 *Year:* 1997 *Journal:* Analytical Cellular Pathology, vol 15, number 3
Keywords: Colour image segmentation, Immunohistochemical staining, Pixelwise classification, Relaxation, Watershed segmentation, Automated cell counting.
Abstract: A new method for segmenting images of immunohistochemically stained cell nuclei is presented. The aim is to distinguish between cell nuclei with a positive staining reaction and other cell nuclei and to make it possible to quantify the reaction. First a new supervised algorithm for creating a pixel classifier is applied to an image that is typical for the sample. The training phase of the classifier is very user friendly since only a few typical pixels for each class need to be selected. The classifier is robust in that it is non-parametric and has a built-in metric that adapts to the colour space. After the training the classifier can be applied to all images from the same staining session. Then, all pixels classified as belonging to nuclei of cells are grouped into individual nuclei through a watershed segmentation and connected component labelling algorithm. This algorithm also separates touching nuclei. Finally the nuclei are classified according to their fraction of positive pixels.

10. **A New Method for Creating a Pixelwise Box Classifier for Colour Images**
Authors: Petter Ranefall, Bo Nordin, Ewert Bengtsson
Pages: 305-323 *Year:* 1997 *Journal:* Machine Graphics and Vision, vol 6, number 3
Keywords: Box classifier, Colour images, Supervised classification
Abstract: When segmenting colour images pixelwise classification is often a useful approach. In this paper a method for creating a pixelwise box classifier to be applied to multiband images is presented. It is based on a hierarchical colour space splitting algorithm originally presented as a method for selecting colours to a display that does not support full colour quality. Through the addition of the concept of interactively defined reference pixels the original unsupervised clustering algorithm is transformed into a supervised classification algorithm. This classifier is compared with the commonly used Maximum Likelihood (ML) classifier, with respect to speed and average colour distance. It is also shown that the algorithm applied to a reference image defines a metric in the colour space. The proposed method is particularly useful when the same classifier should be applied to several similar images, since the resulting box classifier can be implemented efficiently using table look-up techniques.

11. **The Coast of the South-East Mediterrenian - El Alamein to Haifa**
Authors: J. Norrman and Tommy Lindell
Pages: 18 *Year:* In: Ymer Årsbok 1997 *Publisher:* The Swedish Society for Anthrophology and Geography (SSAG), Stockholm
Abstract: The paper is part of a monography on The Middle East. It describes the environmental and infra-structural conditions of the area between El Alamein and Haifa. Special focus has been put on the Arabs Gulf area, which will be heavily affected if the Quattara Hydrosolar Project will be realized in the future. Very interesting oolitic unconsolidated sand is dominating the bottom of the Gulf.
Comment: In Swedish.

6.2 Refereed conference proceedings

1. **Surface Construction Especially Suited for Visualisation of Thin Structures**
Authors: Roger Hult, Ewert Bengtsson, Lennart Thurfjell
Conference: 10th Scandinavian Conference on Image Analysis (SCIA'97)
Pages: 359-363 *Year:* 1997 *Publisher:* Pattern Recognition Society of Finland
Abstract: An algorithm that is especially useful for visualising thin structures in 3D volume images is presented. A surface representation has been built, since it is quite difficult to visualise thin structures using direct ray-casting as a rendering method. Sometimes there is a need for displaying the voxels as is, i.e. no interpolation of any kind should be used. However, smooth shading is used as it gives a better three dimensional impression of the scene. The algorithm scans a volume and creates a list of triangles that have a normal defined at each vertex. This list can then be used by standard 3D graphics software.

2. **Parallel Distance Transform Algorithms on a General SIMD Computer**
Authors: Anders Forsmoo, Gunilla Borgefors
Conference: 10th Scandinavian Conference on Image Analysis (SCIA'97)
Pages: 471-478 *Year:* 1997 *Publisher:* Pattern Recognition Society of Finland
Abstract: This paper contains the description of and the results from implementations of distance transforms for digital image analysis on a general SIMD parallel computer. It is shown that considerable speedup can be obtained with general parallel computers, which was expected. Three different distance transforms have been implemented, using two different computation algorithms. Most of them can be found in the literature, but the non-arithmetic parallel algorithm for the 5-7-11 distance transform is new. It is shown that the choice of distance transform is important, as the computation time can be very different depending not only on neighbourhood size, but also on the local weights used in the neighbourhood. The choice of implementation algorithm is also significant.

3. **Mapping of the Coastal Zone of Jamaica**
Authors: Tommy Lindell
Conference: Proc. Fourth International Conference on Remote Sensing for Marine and Coastal Environments, Orlando, Florida
Pages: 11 *Year:* 1997 *Publisher:* ERIM, Cairo, Egypt
Abstract: Uppsala University, Sweden in co-operation with Natural Resources Conservation Authority (NRCA), Jamaica have been mapping the coastal zone of Jamaica from remote sources and field inventories for planning and management purposes. All beaches were field-checked and other types of shores classified from Landsat and aerial photos and data evaluated using Excel . The sub-water environment has been classified from Landsat TM, with reference data from echo sounder, GPS and manual observations stored into a computer directly in the field. A comprehensive database was created containing important information for the planners, like coastline types, maps of land and sea-bottom cover. An ARC/INFO structure has been created allowing NRCA to continually improve and update the knowledge of the coastal zone.

4. **Investigating Preprocessing of Multivariate Images in Combination with Principal Component Analysis**
Authors: Finn Pedersen, Leif Andersson and Ewert Bengtsson
Conference: 10th Scandinavian Conference on Image Analysis (SCIA'97)
Pages: 479-485 *Year:* 1997 *Publisher:* Pattern Recognition Society of Finland
Abstract: Principal component analysis (PCA) is quite widely used multivariate technique for finding interpretations of the variance-covariance structure, and to reduce the dimensionality, of the investigated (image) data set. However, PCA is not always used in a straightforward manner, it is quite often combined with preprocessing of the data. An overview of different possibilities used mainly in the remote sensing area, and investigations on the effects for a couple of cases, are presented. In an application example using a Landsat TM scene, the scene is subject to preprocessing combined with PCA, and the result is investigated. It is concluded that objective measures, possibly in terms of signal-to-noise ratios, are needed in order to handle the situation of obtaining several sets of PC images from one original image data set.

5. **Connected Components in 3D Neighbourhoods**
Authors: Gunilla Borgefors, Ingela Nyström, Gabriella Sanniti di Baja (1)
(1) Istituto di Cibernetica CNR, Arco Felice (Napoli), Italy
Conference: 10th Scandinavian Conference on Image Analysis (SCIA'97)
Pages: 567-570 *Year:* 1997 *Publisher:* Pattern Recognition Society of Finland
Abstract: We have developed a 3D connected component counting and labelling algorithm suitable for small neighbourhoods. Such an algorithm is useful in many voxel classification tasks. Its main advantage becomes apparent for large size images, when counting connected components in the local neighbourhood of every voxel is necessary. We have used the algorithm in a skeletonization algorithm for volume objects, that repeatedly counts connected components in the local neighbourhood of each skeletal voxel. Our algorithm is simple and fast; it identifies one component at a time in a recursive manner. We give solutions to all three connectivity cases in the 3x3x3 neighbourhood. Extended connectivities and neighbourhoods are considered both in 2D and 3D.

6. **Biopsy Needle Optimisation**
Authors: Hans Frimmel
Conference: 10th Scandinavian Conference on Image Analysis (SCIA'97)
Pages: 381-387 *Year:* 1997 *Publisher:* Pattern Recognition Society of Finland
Abstract: Prostate cancer is the most common form of cancer in human males. A considerable proportion are so called latent, small carcinomas which will never affect the quality of life of the patients. It is therefore important to develop reliable ways of diagnosing prostate cancer. Today the final diagnosis of cancer is usually obtained by inserting biopsy needles in the prostate. The aim of this paper is to define how these needles should be optimally placed to find the cancer. Such a protocol must be defined in terms of angles and distances so that the examiner can easily measure them at the ultrasound images available. The positioning of the needles relies in the present practice on ultrasound guidance and intuitive decisions by individual examiners, the outcome of which depends heavily on his/her own experience. Ultrasound guides sampling in two dimensions

but the feeling for 3D orientation is poor. Furthermore the ultrasound image does not visualise the tumour with acceptable specificity and sensitivity. A protocol which tells where in the prostate to put the needles to gain most information would thus be most helpful. This paper describes a fully automatic method for finding such a protocol using 3D computer made reconstructions of the prostate and the cancer. The method will be used together with other computer assisted interactive methods. The final goal is to find a protocol that is both reliable, efficient and easy to use. The method described is designed especially for the field of prostate cancer. However, creating cancer distributions in this way is not at all restricted to prostates. How cancer distributes is of concern when studying many different living human organs.

7. **Comparison of different methods to enhance special structures in a lake water mass**
   Authors: Catherine Östlund
   Conference: Third International Airborne Remote Sensing Conference and Exhibition
   Pages: 526-533 *Year:* 1997 *Publisher:* ERIM International Inc.
   Abstract: Compact Airborne Spectrographic Imager (CASI) data was collected over several lakes with varying water quality in Norway. Two of the lakes that are very turbid and have relatively large amounts of chlorophyll a are studied here. The aim is to visualise as good as possible the structures seen in the lakes in the images and, where possible, to connect the structures to water quality parameters. A common contrast stretch of the original images is compared with images transformed to Intensity-Hue-Saturation colour space or by Principal Component Analysis. Unsupervised classifications of the original and transformed images are also made. Comparing segmentations of the transformed images and classifications some similarities are found, but also some differences, mostly in favour of the segmentation of hue and intensity components derived from principal components. The connection to spectral signatures is not easily done, due to the fact that only one point in each lake was sampled in the field. However, some conclusions can be drawn about the visible structures with the help of field data and other knowledge of the lakes.

8. **Extraction of Homogenous Areas in Multispectral Images**
   Authors: D. Lagunovsky (1), G. Borgefors, F. Walter, A. Pettersson
   (1) Belarussian Academy of Science
   Conference: 4th Int. Conf. Pattern Recognition and Information Processing (PRIP'97)
   Pages: 103-108 *Year:* 1997 *Publisher:* Belarussian Academy of Science
   Abstract: The use of remotely sensed data for analysis of agricultural activities is becoming more and more important. The most common way of interpreting remotely sensed data is to use different kinds of interactive classification methods. To increase the degree of automation and classification accuracy, fields can be automatically detected prior to classification. This paper presents a way to perform such detection, using edge detection together with region growing.

9. **Using top down and bottom up analysis for a multiscale skeleton hierarchy**
   Authors: G. Borgefors, G. Ramella (1), and G. Sanniti di Baja (1)
   (1) Istituto di Cibernetica CNR, Arco Felice (Napoli), Italy
   Conference: 9th International Conference on Image Analysis and Processing (ICIAP'97)
   Pages: 369-376 *Year:* 1997 *Publisher:* (Lecture Notes in Computer Sciences 1310), Springer Verlag
   Abstract: Multi-scale skeletons of a 2D pattern can be conveniently employed in the matching phase of a recognition task. The multi-scale skeletons are here obtained by first simultaneously computing the skeleton at all levels of a resolution structure and then establishing a hierarchy among skeleton components at different scales, using a parent-child relationship. Although subsets of the skeleton expected to represent given pattern subsets may consist of different number of components at different scales, a component preserving decomposition is obtained that produces a hierarchy in accordance with human intuition.

10. **Using Binary Pyramids to Create Multiresolution Shape Descriptors**
    Authors: G. Borgefors, G. Ramella (1), and G. Sanniti di Baja (1)
    (1) Istituto di Cibernetica CNR, Arco Felice (Napoli), Italy
    Conference: First Brazilian Symposium on Document Image Analysis, (BSDIA'97)
    Pages: 129-140 *Year:* 1997 *Publisher:* Lecture Notes in Computer Sciences 1339, Springer Verlag
    Abstract: The analysis of a 2D graphical document can be accomplished by using a suitable linear

representation, e.g. the skeleton, of the pattern included in the document. In this paper, multiresolution shape descriptors of 2D graphical documents are obtained by using binary AND-pyramids. A multiscale representation is first obtained by simply extracting the skeleton of the pattern at all resolution levels of the pyramid. The so obtained skeletons are then transformed into multiresolution structures by suitably ranking skeleton subsets, based on their permanence at the various scales. The two different types of hierarchy built in this way both contribute to facilitate recognition. In fact, the skeleton is available at various scales, so one could initially match roughly using only skeletons at lower scales, where only the most significant parts of the pattern are represented.

11. **Multiresolution representation of shape in binary images II: volume images**
Authors: Gunilla Borgefors, Gabriella Sanniti di Baja (1), Stina Svensson
(1) Istituto di Cibernetica CNR, Arco Felice (Napoli), Italy
Conference: Discrete Geometry for Computer Imagery (DGCI'97)
Pages: 75-86 *Year:* 1997 *Publisher:* Lecture Notes in Computer Sciences 1346, Springer Verlag
Abstract: Multiresolution representations of discrete patterns are of great interest, specially when working with volume images. The huge amount of data that volume images contain at high resolution can be considerably compressed at lower resolution, and while the obtained representation still can be suited for simple shape analysis tasks, provided that shape is adequately preserved when resolution decreases. In this paper, we present new methods for building shape preserving binary resolution pyramids in three dimensions. The performance of the methods is quantitatively evaluated.

12. **Automatic quantification of immunohistochemically stained cell nuclei using unsupervised image analysis**
Authors: Petter Ranefall, Ewert Bengtsson
Conference: Analytical Cellular Pathology, Oslo
Pages: 58 *Year:* 1997 *Publisher:* IOS Press
Abstract: Quantification of immunohistochemical staining can be evaluated visually as the presence of a specific colour. But quantitative evaluation requires the number of stained cell nuclei and/or the proportion of stained specimen area to be measured. Pure visual estimates provides very crude results with great variability. Therefore image analysis based methods have been developed. In previous work we developed a method based on a supervised colour classifier from selected training areas. But even when working with this method, inter- and intraoperator variability is a problem. An objective standardised method for quantifying the proportions of different stained regions is desirable. Our approach is to normalise the data by making a principal component(PC) transformation of the colour space. PC1 is used to segment objects from background using dynamic thresholding of the P2/A histogram. PC2 is used to compute object area proportions. Here we use the assumption that the PC2 data can be described as a mixture of normal distributions. The mixture proportions are computed using an iterative maximum likelihood scheme. The method is completely automatic and the principal component approach makes it robust with respect to illumination and focus settings. In fact, our method shows less variation for varying illumination and focus than the intraoperator variation for supervised quantification with fixed illumination and focus settings.

13. **Multi-Scale Skeletons from Binary Pyramids**
Authors: G. Borgefors, G. Ramella (1), G. Sanniti di Baja (1)
(1) Istituto di Cibernetica CNR, Arco Felice (Napoli), Italy
Conference: 3rd Int. Workshop on Visual Form
Pages: 31-42 *Year:* 1997 *Publisher:* In: Advances in Visual Form Analysis, C.Arcelli, L.P. Cordella, G.Sanniti di Baja Eds., World Scientific, Singapore
City: Capri, Italy
Keywords: Binary pyramid, multiresolution representation, multiresolution skeleton, component ranking
Abstract: Multiresolution shape representations are highly desirable, as they provide a flexible tool that fits the user's needs better than single resolution systems. In this paper, the skeletons of a 2D pattern recorded onto a binary AND-pyramid are extracted at all resolution levels. The so obtained skeletons are then transformed into multiresolution skeletons by ranking skeleton subsets,

based on their permanence in the skeleton at the various scales. The potential of multiresolution representation is exploited in this way, since the skeleton is available at various scales and, at each scale, skeleton components are furthermore ranked according to their permanence along the pyramid levels.

14. **Shape description and segmentation in 2 and 3 dimensions by polynomial expansion**
Authors: Ö. Smedby (1), G. Borgefors
(1) Dept. of Diagnostic Radiology, UU
Conference: 3rd Int. Workshop on Visual Form
Pages: 559-568 *Year:* 1997 *Publisher:* In: Advances in Visual Form Analysis, C.Arcelli, L.P. Cordella, G.Sanniti di Baja Eds., World Scientific, Singapore
Keywords: 3D Shape, harmonic polymonial, polynomial expansion, inner product
Abstract: Based on the theory of Fourier descriptors as a tool for studying 2D shape, this study aims at creating a theory for 3D shape description with polynomials and developing segmentation algorithms based on this theory. The basic idea is to study the distance from the origin to the object boundary as a function of the direction vector. In 2D, this function maps a point on the unit circle to the distance. If Cartesian coordinates are used to parametrize the circle, a polynomial of corresponding degree is obtained. By analogy, 3D shape can be studied by approximating the distance by a polynomial in the Cartesian coordinates of a point on the unit sphere. The coefficients of this polynomial may be calculated with inner products defined by surface integrals over the unit sphere. Using spherical harmonic polynomials, a unique expansion with adaptable accuracy is obtained. Implementation issues involving the approximation of integrals with sums are discussed and preliminary empirical computations are performed. Since the algorithms for polynomial expansion of the boundary are linear, they are easily generalized to segmentation algorithms for non-binary images.

6.3 Non-refereed conferences and workshops

1. **What does a pathologist mean by "Intensity"?**
Authors: Petter Ranefall
Conference: Swedish Symposium on Image Analysis (SSAB'97)
Pages: 114-116 *Year:* 1997 *Publisher:* CVAP, NADA, KTH
Abstract: Staining intensity cold be an interesting feature when working with immunohistochemically stained specimen. But what do pathologists mean by "intensity"? In this paper the hypothesis that the pathological intensity concept corresponds to the inversion of the Lightness concept is tested.

2. **Quantitative Shape Analysis of Volume Images - Thinning Volume Objects to Surface Skeletons**
Authors: Gunilla Borgefors, Ingela Nyström, Gabriella Sanniti di Baja (1)
(1) Instituto di Cibernetica, CNR, Arco Felice (Napoli), Italy
Conference: Swedish Symposium on Image Analysis (SSAB'97)
Pages: 77-81 *Year:* 1997 *Publisher:* CVAP, NADA, KTH
Abstract: We present a method for thinning a volume (3D) object to a surface skeleton. The original can be recovered from its skeleton. The method is based on the notion of "multiple voxels", derived from that of "multiple pixels" in the 2D case. It consists of two phases. During the first phase, non-multiple voxels are iteratively removed. During the second phase, the remaining set of voxels is thinned to a set of one-voxel thick surfaces and curves. In contrast to most corresponding methods found in the literature, our skeletonization method requires only a small number of local operations per voxel, no extra memory, and no look-up tables. We exemplify the results of the method on a number of 2-5 Mbyte synthetic and non-synthetic images.

3. **A 3D Brain Atlas for Planning of Stereotactic Neurosurgery**
Authors: Lennart Thurfjell, Torgny Greitz (1)
(1) Departments of Neuroradiology and Clinical Neurophysiology Karolinska Institute/Hospital, Stockholm, Sweden
Conference: Swedish Symposium on Image Analysis (SSAB'97)

Pages: 55-59 *Year:* 1997 *Publisher:* CVAP, NADA, KTH, Stockholm
Abstract: We present a system used for planning of stereotactic neurosurgery. The system uses a detailed 3D atlas of the basal structures in the brain in combination with a previously developed atlas covering the whole brain. After a preceding matching of the atlas to the images used for the planning, information from the atlas helps the surgeon to define the location of the target and to find the best straight-line path for the tool used to reach this point. Results from using the new system on five pallidotomy cases are presented.

4. **Weighted Distance Transform Hyperspheres in Four Dimensions**
Authors: Gunilla Borgefors, Hua Guo
Conference: Swedish Symposium on Image Analysis (SSAB'97)
Pages: 72-76 *Year:* 1997 *Publisher:* CVAP, NADA, KTH, Stockholm
Abstract: The 4D digital space is starting to get used in image and other complex digital data analysis applications. Therefore, distance transforms in 4D are moving from being a theoretical curiosity to becoming a useful tool. The purpose of this paper is two-fold. The first is the presentation of some preliminary results on weighted distance transforms in 4D. Some good, regular, integer weighted DTs are given. The second purpose is to illustrate some of the problems and solutions of visualizing 4D digital images. The hyperspheres of three weighted DTs are used as examples.

5. **Quantification of immunohistochemistry using digital image analysis**
Authors: Ewert Bengtsson(1), Christer Busch(2), Torsten Jarkrans(1), Petter Ranefall(1)
(1) CBA, (2) Department of Pathology
Conference: NUTEKs medicintekniska konferens, Stockholm
Pages: 35 *Year:* 1997 *Publisher:* NUTEK
Abstract: The aim of our project is to develop methods for objective, reproducible, histopathological malignancy grading of cells and tissue from cancer tumours. In the study of immunohistochemically stained specimens it is essential to be able to quantify the amount of cells that have a positive staining reaction, i.e., have been stained, and to estimate the staining intensity. Different staining sessions can give different staining intensity, and a fix threshold for staining intensity, will thus not work very well. Earlier in this project, We have developed a new method for colour based segmentation, where the operator marks small training regions within some positive, and negative cells, respectively. Based on these colour samples, a classifier is created by recursive subdivision of the colour space. When this classifier is applied to other fields of view from the same specimen, a good segmentation into positive and negative pixels is achieved. The results shows good correspondence to careful subjective estimations. The method has, successfully, been used in various medical studies. By preprocessing the training data before the classifier is created, we have managed to make it more robust with respect to user errors in the choice of training regions. In spite of this, the need for training of the method involves a certain degree of subjectivity, and thus also time for manual work. Therefore, we have during the last year developed a fully automatic method for segmentation. The method uses a principal component transformation of the colour space, followed by an automatic threshold setting between cells and background, based on analysis of histograms. After this another automatic threshold setting is applied between cells with positive, and negative staining reaction, respectively. In preliminary studies, the method has shown to produce results comparable to the previous interactive method. Further tests on a larger material are in progress. Besides the amount of cells with positive staining reaction, estimates of the staining intensities are of interest. Therefore we are examining the possibility to quantify this staining intensity for each cell nucleus. As a preparation step for this, we have made a small pilot study to investigate what the subjective concept of "intensity" means, in image analysis terms, in this context. We have thereby found out that it mainly is equivalent to 100% - the intensity (or lightness) in the conventional HLS representation of the colour space. Besides the scientific publication, the developed methods will also be at Diascan AB's disposition for implementation in a new equipment for quantitative image analysis in cytology and pathology. (Diascan AB is at the moment interested of new partners for launching of these products.)
Comment : The conference and the proceedings were in Swedish.

6.4 CBA Reports

1. **Analysis of Imaging Spectrometer Data from Norwegian Lakes**
   Author: Catherine Östlund
   Pages: 24 *Year:* 1997 *Publisher:* CBA, Report No.22
   Abstract: The objective with this study is to test and evaluate data from the Compact Airborne Spectrographic Imager (CASI), and evaluate the potential of the instrument in a water quality application. Difficulties in the precalibration of the instrument affected the data in an irregular way across the image, and a method to eliminate the effects was developed. The results indicate that it is fairly easy to compensate for the error, but the shape and size of across-track variation changes between different scenes, and the problem can thus not be handled in a general way. Evaluations of the radiometric accuracy, wavelength band positioning and signal-to-noise ratio have also been done. Different atmospheric correction methods have been tested, and an empirical method based on data from two flight levels was used. The technique is easy to apply and useful for this purpose. Spectral data collected from different look directions has been compared, and it has been established that data is influenced by the relatively small difference in optical pathways. The experiences from the water environment indicate the usefulness of imaging spectrometry data for water locations. The exceptionally good spectral resolution allows analyses of changes in the water due to different water quality features. The correlation between received spectral radiance and water quality parameters such as turbidity and irradiance attenuation coefficient is high. However, a good correlation to chlorophyll a could not be established.

2. **A New Method for Creating a Pixelwise Box Classifier for Color Images**
   Author: Petter Ranefall, Bo Nordin, Ewert Bengtsson
   Pages: 18 *Year:* 1997 *Publisher:* CBA, Report No.23
   Abstract: When segmenting color images pixelwise classification is often a useful approach. In this paper a method for creating a pixelwise box classifier to be applied to multiband images is presented. It is based on a hierarchical color space splitting algorithm originally presented as a method for selecting colors to a display that does not support full color quality. This classifier is compared with the commonly used Maximum Likelihood (ML) classifier, with respect to speed and average color distance. It is also shown that the algorithm applied to a reference image defines a metric in the color space. The proposed method is particularly useful when the same classifier should be applied to several similar images, since the resulting box classifier can be implemented efficiently using table look-up techniques.

3. **Image Analysis Methodology Used For Crop Classification Using Satellite Images - A Survey**
   Author: Anna Pettersson
   ISNN: 1100-6641
   Pages: 49 *Year:* 1997 *Publisher:* CBA Report No.24
   Abstract: Remote sensing has become a major monitoring system in conventional agricultural inventory. One reason for this is the huge amount of data that can be collected in a relatively short time, especially from satellites. However, problems remain to take care of and interpret all this data. Manual interpretation of remotely sensed data is time consuming and demands skillfull staff. This study is a review of literature concerning remote sensing and image analysis treating agricultural crop estimations. Different aspects of remote sensing and agriculture is regarded, for Sweden as well as other parts of the world. Often, differrent types of interactive classification systems are used when processing satellite data. Research in image analysis is an important tool for the development of satellite image algorithms. The central point of this review is the research on automated crop classification, in a wide sense. This includes, e.g., automatic area segmentation in different ways. An attempt is made to cover some of the published work of this subject as a base line for future studies of the topic. Because of the broad aspects of this review, a covarage of all literature is impossible and therefore many different angles of the subject are only briefly mentioned.

4. **Hyperspectral image interpretation - a brief survey**
   Author: Emma Lindqvist
   Pages: 21 *Year:* 1997 *Publisher:* CBA, Report No.25
   Abstract: The enormous amount of data in hyperspectral image cubes has to be decimated in order to make it feasible to work with. This data reduction must be done in a sensible manner, so that the most important information is retained - alternatives to PCA are discussed in this report. Still, the images can not be classified in traditional ways, so new efficient methods must be developed. The almost continuous spectra of the hyperspectral pixels make it possible to find areas containing certain substances (minerals or vegetation), known as targets. One example of how to use the differences between spectral signatures in the ground is the detection of buried mines. Further, high-spectral-resolution images have inherently low spatial resolution. To circumvant this fact, data fusion can be performed between images with high spectral and spatial resolution, and techniques for this are also discussed in this report.

6.5 CBA Internal reports

1. **IPAD, version 2.0 & IMP - an IPAD Application**
   Author: Bo Nordin
   Pages: 49 *Year:* 1997 *Publisher:* CBA Internal Report No.6

2. **Manual for Integrated Coastal Planning and Management in Jamaica**
   Authors: J. Norrman, T. Lindell, L.U. Bergström, O. Mohlund and J. Nisell
   Pages: 217 *Year:* 1997 *Publisher:* CBA Internal Report No.7

3. **Short description of International Journals on Image Analysis and Remote Sensing**
   Editor: Gunilla Borgefors
   Pages: 59 *Year:* 1997 *Publisher:* CBA Internal Report No.8
   Comment: Resulting from the Ph.D. course "Scientific Methods for Image Analysis". In Swedish.

4. **Digital Photogrammetry & Airborne Imaging Spectronomy in Practice**
   Author: Emma Lundqvist
   Pages: 16 *Year:* 1997 *Publisher:* CBA Internal Report No.9
   Comment: Report from the two tutorials at Third Int. Airborne Remote Sensing Conference, Copenhagen 1997.

5. **A Coastal Atlas of Jamaica**
   Authors: J. Norrman, T. Lindell, L.U. Bergström, O. Mohlund and J. Nisell
   Pages: 538 *Year:* 1997 *Publisher:* CBA Internal Report No.10

6.6 Other publications

1. **Annual Report 1995/96**
   Editor: Lennart Thurfjell, Gunilla Borgefors
   Publisher: Centre for Image Analysis
   Pages: 56 *Year:* 1997

2. **Application of Remote Sensing for Estimation of Agricultural Crop Production in Sweden**
   Authors: Jacob Nisell, Per Nyman (1)
   (1) Crop Production Science, SLU, Ultuna
   Pages: 24 *Year:* 1997 *Publisher:* SCB Örebro
   Abstract: Interim report, June 1997, for the EU/SCB project "Application of remote sensing for agricultural crop production in Sweden".

3. **Experiences from the ESA ROSIS Campaign 1994. The Skagerrak Site.**
   Authors: Tommy Lindell, Catherine Östlund and Peter Flink
   Pages: 5 *Year:* 1997 *Publisher:* EMAC 94/95 Final Result, European Space Agency, WPP-136
   Abstract: As a part of the EMAC 1994 - ROSIS Flight Campaign image data from an archipelago in northern Skagerrak was investigated. The Reflective Optics System Imaging Spectrometer, ROSIS,

is an airborne imaging spectrometer with 84 spectral bands and it was flown over the Skagerrak site in May 1994. Six partly overlapping tracks were recorded and field measurements were taken at approximately 20 stations. The most dominating optical components are inorganic particles from the outlet of the Glomma river, and to some extent phytoplankton in a limited part of the area. The ROSIS spectral radiances were much lower than expected in the blue part of the spectrum due to problems with the instrument at time of recording. Variations in the spectral radiances for some of the channels in the green and the red part of the spectrum could be explained by the variations in total suspended material and phytoplankton pigments.

7 Activities

Computerized image analysis is a technology which is finding increased application in many fields. A consequence of this is an increasing interest in our work from the surrounding society. We are trying to meet this interest by organising workshops and seminars, receiving visitors, making visits, giving presentations, participating in conferences, etc. In the following sections we have tried to list these activities for the year 1997. The list mostly covers new contact points. We have left out all meetings within ongoing research projects and all lectures we have given or attended as part of the regular educational activities of CBA. Still the lists become quite extensive. Ewert Bengtsson has served as Dean of the Division of computer science and mathematics of the Faculty of Science and Technology of UU, this involved many ($\approx$ 100) meetings not listed here.

We have organized eight national and international workshops. We have organized two seminars with invited guests in addition to the 40 internal seminars held at CBA. We have also given ten other seminars outside CBA. We have given three invited and 17 other presentations at conferences as well as presented ten posters and attended another 13 conferences without making presentations. We have had two long term visitors at the CBA. We have made 45 visits to other research groups and we have received a large number of visitors at CBA at 31 different occasions. Finally, we have listed 20 international and 22 national committees and similar duties in which we have served.

7.1 Organized conferences and workshops

1. **SALMON Workshop**
   Organiser: Tommy Lindell
   Address: CBA
   Date: 970513-970517
   Topic: Joint meeting of SALMON participants
   Attendees: 23 persons from:
   CNR-IRRS, Milan
   CNR-ISDGM, Venezia
   JRC, Environmental Institute, Ispra, Italy
   University of Milan, Bilologia
   University of Helsinki
   Finnish Environmental Institute
   Dept. of Limnology, Uppsala University and CBA.
   Comment: Within the project Satellite Remote Sensing for Lake Monitoring (SALMON) sponsored by the EC, RTD Projects a first Joint Meeting was held in Uppsala att CBA under the organsation of Tommy Lindell. More detailed information on this meeting could be found in the Joint Meeting Report & Enclosures available at CBA.

2. **Reference Group Seminar**
   Organiser: Ingela Nyström
   Address: CBA
   Date: 970604
   Attendees: Personell from the Reference organisations
   Topic: Volume image analysis, theory and medical applications
   Comment: One in the series of half-day seminars organised twice annually to give information on ongoing research to our reference group.

3. **Field Campaign SALMON and associated projects**
   Organiser: Tommy Lindell
   Address: CBA and the field
   Date: 970731-970811
   Attendees: Personell from the projects.
   Topic: Field Campaign for the SALMON project.

4. **VISIT kick-off meeting**
   Organiser: Lennart Thurfjell
   Address: Ångström, Polacksbacken, Uppsala
   Date: 970902
   Attendees: A total of 60 persons from the research community and from industry attended the meeting.
   Topic: VISIT is a national research program in visual information technology financed by the Foundation for strategic research. The VISIT program started during 1997 and the purpose of the VISIT kick-off meeting was to mark the start of the program. The meeting was opened by the Vice Chancellor of Uppsala University, professor Bo Sundqvist and there were invited presentations by the director of the Foundation for strategic research, professor Ingvar Lindgren and by Annagreta Dyring and Uno Lindberg. Furthermore, there were presentations by representatives from industry and from the different research groups pariticipating in the VISIT program.

5. **CBA Strategic Planning Workshop**
   Organisers: Gunilla Borgefors et al.
   Address: School of Forest Engineers, Skinskatteberg
   Date: 970917-970918
   Attendees: All personell at CBA
   Topic: This two-day meeting was aimed at general discussion of long term strategic questions regarding the future of CBA. We concentrated on three topics: inventory of skills and interests; future research topics and structure; and graduate student questions. The social part of the workshop included a visit to "Galleri Astley".
   Comment: The helpfulness of the personell at the School of Forest Engineers was much appreciated.

6. **Jamaica Workshop**
   Organiser: Tommy Lindell
   Address: Leufsta slott, Uppland
   Date: 970923-970924
   Attendees: Prof. John Norrman, Planning Architect Lars Ulrik Bergstrom and F.K. Jakob Nisell.
   Topic: Preparation for the final report, Coastal Atlas and Manual for Integrated Coastal Planning and Management.

7. **Crop knowledge Seminar**
   Organisers: Anna Pettersson, Jakob Nisell
   Address: CBA
   Date: 971023
   Attendees: Anna Pettersson, Jakob Nisell, Per Nyman, Magne Tuvesson
   Comment: In cooperation with department of crop production science.

8. **Reference Group Seminar**
   Organiser: Petter Ranefall
   Address: CBA
   Date: 971120
   Attendees: Personell from the Reference organisations
   Topic: Colour, Colour spaces and Applications for colour image analysis
   Comment: One in the series of half-day seminars organised twice annually to give information on ongoing research to our reference group.

7.2 Seminars held outside CBA

1. **Name: Tommy Lindell**
   Address: Geosciences, UU
   Date: 970221
   Title: The SALMON Project.

2. **Name: Ewert Bengtsson**
   Address: Main Aula of UU
   Date: 970228
   Title: "Can computers see?"
   Comment: Installation lecture as part of the ceremony of beeing installed as professor of digital image analysis at UU.

3. **Name: Ewert Bengtsson**
   Address: Biacore AB, Uppsala
   Date: 970317
   Title: Research in image analysis at Uppsala University
   Comment: Part of a meeting between representatives of the Faculty of Science and Technology at UU and the management of Biacore AB.

4. **Name: Tommy Lindell**
   Address: Dept. of Limnology
   Date: 970416
   Title: The SALMON Project.

5. **Name: Tommy Lindell**
   Address: Swedish Space Corporation, Stockholm
   Date: 970424
   Title: Environmental program of the Swedish Space Board.

6. **Name: Ewert Bengtsson**
   Host: Göran Lundgren, chairman
   Address: Dataföreningen i Sverige, Uppsalaklubben (Data Society of Sweden, Uppsala branch)
   Date: 970428
   Topic: Presentation of "Research and education in IT at Uppsala Univ."
   Comment: The meeting took place at Pharmacia Biotech.

7. **Name: Tomas Brandtberg**
   Address: Dept. of Geodesy and Photogrammetry, Royal Institue of Technology, Stockholm
   Date: 970506
   Title: Course in Remote Sensing and Digital Image Analysis
   Comments: One hour lecture on digital image analysis applied on aerial images in forestry.

8. **Name: Petter Ranefall**
   Address: Dept. of Pathology, RiTø, Tromsø, Norway
   Date: 971107
   Title: QUACH - QUAntification in Cytology and Histology
   Comment: The oral presentation was followed by computer demonstrations.

9. **Name: Lennart Thurfjell**
   Address: Dept. for Radiology and Physiology, Malmö University hospital, MAS
   Date: 971119
   Title: Image analysis in medicine
   Comment: Thurfjell held a four hour invited lecture about registration and segmentation of medical images.

10. **Name: Catherine Östlund**
    Address: Swedish Space Corporation, Stockholm
    Date: 971120
    Title: Environmental program of the Swedish Space Board
    Comment: Presentation of Progress report.

7.3 Seminars at CBA with invited guest lecturers

1. **Name: Per-Erik Danielsson**
   Date: 971003
   Address: Dept. of Electrical Engineering, Linköping University
   Title: Second derivatives for 2D and 3D image analysis

2. **Name: Josef Bigün**
   Date: 971211
   Address: Ecole Polytechnique Federale de Lausanne, Switzerland
   Title: Perspectives on Person Authentication.

7.4 Seminars at CBA

Most of these seminars were held in English.

1. **Name: Lars Bergqvist**
   Date: 970113
   Title: Using texture of remote sensed images
   Comment: Presentation of Master Thesis.

2. **Name: Rickard Ericsson, Johan Steensland, Siri Svedberg**
   Date: 970120
   Title: Colour differences between paper and computer screens
   Comment: Presentation of Master Thesis.

3. **Name: Anders Forsmoo**
   Date: 970127
   Title: High performance computing.

4. **Name: Lennart Thurfjell**
   Date: 970203
   Title: Using Open GL for visualization.

5. **Name: Gunilla Borgefors**
   Date: 970210
   Title: Regular polyhedra - theory and practice.

6. **Name: Fredrik Walter**
   Date: 970211
   Title: Visualization of 3D volume images using the so called semi boundary representation.

7. **Name: Ewert Bengtsson**
   Date: 970217
   Title: The role of CBA in Uppsala, Sweden, and The World.

8. **Name: Hua Guo**
   Date: 970217
   Title: Weighted distance transform hyperspheres in 4D.

9. **Name: Tommy Lindell**
   Date: 970224
   Title: The Jamaican coastal project.

10. **Name: Tommy Isaksson**
    Date: 970310
    Title: VRML-tools for application development.
    Comment: Presentation of Master Thesis.

11. **Name: Petter Ranefall**
    Date: 970317
    Title: On the shape of the HLS colour space.

12. **Name: Joakim Lindblad**
    Date: 970324
    Title: Real time error detection through image analysis of the super conducting LHC cable.

13. **Name: Tomas Brandtberg**
    Date: 970401
    Title: Texture analysis of tree crowns.

14. **Name: Bo Nordin**
    Date: 970407
    Title: IMP - the CBA image processing software.

15. **Name: Jakob Nisell**
    Date: 970421
    Title: Application of Remote Sensing for estimation of agricultural crop production in sweden.

16. **Name: Hans Frimmel**
    Date: 970428
    Title: LaTeX.

17. **Name: Anna Pettersson**
    Date: 970505
    Title: Multispectral edge detection.

18. **Name: Haidih Azadali**
    Date: 970512
    Title: Noise suppression in 3D
    Comment: Presentation of Master Thesis.

19. **Name: Ingela Nyström**
    Date: 970520
    Title: On quantitative shape analysis of digital volume images.

20. **Name: Fredrik Lidberg**
    Date: 970526
    Title: Classification in forest scenes using texture
    Comment: Presentation of Master Thesis.

21. **Name: Mattias Moëll**
    Date: 970602
    Title: Length measurements of fibers.

22. **Name: Olle Eriksson**
    Date: 970609
    Title: Computer system news.

23. **Name: Catherine Östlund**
    Date: 970616
    Title: A short introduction to meteorology.

24. **Name: Tommy Lindell**
    Date: 970811
    Title: Field campaign for the SALMON project.

25. **Name: Tommy Lindell**
    Date: 970818
    Title: The SALMON project.

26. **Name: Lennart Thurfjell**
    Date: 970825
    Title: VISIT - a national program in VISual Information Technology.

27. **Name: Tomas Brandtberg**
    Date: 970901
    Title: Entropy of scale-space for estimation of dominating image structure.

28. **Name: Roger Lundqvist**
    Date: 970908
    Title: A simulated annealing method for matching of 3D medical images.

29. **Name: Petter Ranefall**
    Date: 970915
    Title: Colour and texture.

30. **Name: Peter Flink**
    Date: 970922
    Title: Atmospheric corrections of satellite images.

31. **Name: Mattias Moëll**
    Date: 970929
    Title: Length measurements of wood fibers.

32. **Name: Mikael Vondrus**
    Date: 971006
    Title: The microscopeless microscope - Why and how?

33. **Name: Emma Lindqvist**
    Date: 971013
    Title: Hyperspectral image interpretation.

34. **Name: Stina Svensson**
    Date: 971020
    Title: Multiresolution representation of shape in binary volume images.

35. **Name: Anders Forsmoo**
    Date: 971103
    Title: Java scripts and the Heyhammar library.

36. **Name: Roger Hult**
    Date: 971110
    Title: MR-segmentation.

37. **Name: Jakob Nisell**
    Date: 971117
    Title: Multispectral crop classification.

38. **Name: Hans Frimmel**
    Date: 971124
    Title: Perl - Practical Extraction and Report Language.

39. **Name: Anna Pettersson**
    Date: 971201
    Title: Short term crop history from space?

40. **Name: Fredrik Lidberg**
    Date: 971208
    Title: A jigsaw puzzle assembler.

7.5 Conference participation

7.5.1 Special invited speakers

1. **Name: Ewert Bengtsson**
   Conference: Norwegian-Swedish IT-symposium
   Title: Examples from IT research
   Date: 971015
   Address: MIC-aulan, UU
   Comment: In Swedish. The title of the overall symposium was "Nya finansieringsformer för näringsliv och forskning norska och svenska IT-erfarenheter" Arranged by "Uppsala Chamber of commerce" (Uppsvenska Handelskammaren), Norwegian Embassy and UU. Bengtsson and Borgefors were part of the planning group.

2. **Name: Ewert Bengtsson**
   Conference: The IT revolution and companies of the future
   Title: The image as an instrument for providing information
   Date: 971113-971114
   Address: Hotel Gillet, Uppsala
   Comment: In Swedish. One hour invited talk as part of a two day national conference organized by NUTEK.

3. **Name: Gunilla Borgefors**
   Conference: Nordic Lab-Xpo 1997
   Title: Image Analysis - a tool for quantitative analysis
   Date: 971128
   Address: Älvsjömässan, Stockholm
   Comment: In Swedish.

7.5.2 Oral presentations - refereed conferences

1. **Name: Heung-Kook Choi**
   Conference: 5th Conference of the European Society for Analytical Cellular Pathology (ESACP)
   Address: The Norwegian Radium Hospital, Montebello, Oslo, Norway
   Date: 970525-970529
   Title: 1. A New Image Segmentation Method Using Texture and Color for Prostatic Histological Tissue Section.
   2. Comparison of Two Texture Based Methods for Cell Nucleus Segmentation of Bladder Carcinoma.

2. **Name: Petter Ranefall**
   Conference: 5th conference of the European Society for Analytical Cellular Pathology
   Address: Holmenkollen, Oslo, Norway
   Date: 970525-970529
   Title: Automatic quantification of immunohistochemically stained cell nuclei using unsupervised image analysis.

3. **Name: Ingela Nyström**
   Conference: 10th Scandinavian Conference on Image Analysis (SCIA'97)
   Address: Lappeenranta, Finland
   Date: 970607-970613
   Title: Connected Components in 3D Neighbourhoods.

4. **Name: Gunilla Borgefors**
   Conference: The 10th Scandinavian Conference on Image Analysis (SCIA'97)
   Date: 970609-970611
   Address: Lappeenranta, Finland
   Title: Future trends in image processing - panel participant.

5. **Name: Stina Svensson**
   Conference: Discrete Geometry for Computer Imagery 1997 (DGCI'97)
   Address: Montpellier, France
   Date: 971203-971205
   Title: Multiresolution representation of shape in binary images 2: volume images
   Comment: Video presentation was a success!

7.5.3 Poster presentations - refereed conferences

1. **Name: Hans Frimmel**
   Conference: 5th Conference of the European Society for Analytical Cellular Pathology (ESACP)
   Address: Norwegian Radium Hospital, Montebello, Oslo, Norway
   Date: 970525-970529
   Title: Three-dimensional reconstruction of prostate cancer for testing of biopsy protcols.

2. **Name: Gunilla Borgefors**
   Conference: 3rd Int. Workshop on Visual Form
   Title: Multi-Scale Skeletons from Binary Pyramids
   Address: Capri, Italy
   Date: 970528-970530.

3. **Name: Ewert Bengtsson**
   Conference: 10th Scandinavian Conference on Image Analysis (SCIA'97)
   Title: Investigating Preprocessing of Multivariate Images in Combination with Principal Component Analysis.
   Address: Lappeenranta, Finland
   Date: 970607-970613.

4. **Name: Anders Forsmoo**
   Conference: 10th Scandinavian Conference on Image Analysis (SCIA'97)
   Address: Lappeenranta, Finland
   Date: 970607-970613
   Title: Parallel Distance Transform Algorithms on a General SIMD Computer.

5. **Name: Hans Frimmel**
   Conference: 10th Scandinavian Conference on Image Analysis (SCIA'97)
   Address: Lappeenranta, Finland
   Date: 970607-970613
   Title: Biopsy needle optimisation.

6. **Name: Roger Hult**
   Conference: 10th Scandinavian Conference on Image Analysis (SCIA'97)
   Address: Lappeenranta, Finland
   Date: 970607-970613
   Title: Surface construction especially suited for visualisation of thin structures.

7.5.4 Oral presentations

1. **Name: Ewert Bengtsson**
   Conference: Swedish symposium on image analysis, SSAB'97
   Address: KTH, Stockholm
   Date: 970304-970305
   Title: Presentation of the VISIT National research program.

2. **Name: Petter Ranefall**
   Conference: Swedish Symposium on Image Analysis, SSAB'97
   Address: CVAP, NADA, KTH, Stockholm
   Date: 970304-970305
   Title: What does a pathologist mean by "Intensity"?

3. **Name: Ingela Nyström**
   Conference: Swedish Symposium on Image Analysis, SSAB'97
   Address: CVAP, NADA, KTH, Stockholm
   Date: 970304-970305
   Title: Quantitative Shape Analysis of Volume Images - Thinning Volume Objects to Surface Skeletons.

4. **Name: Gunilla Borgefors, Hua Guo**
   Conference: Swedish Symposium on Image Analysis, SSAB'97
   Address: KTH, Stockholm
   Date: 970304-970305
   Title: Digital spheres in 4D.

5. **Name: Lennart Thurfjell**
   Conference: Swedish Symposium on Image Analysis, SSAB'97
   Address: KTH, Stockholm
   Date: 970304-970305
   Title: A 3D Brain Atlas for Planning of Stereotactic Neurosurgery.

6. **Name: Ewert Bengtsson**
   Conference: NUTEK conference in medical technology (NUTEK:s Medicintekniska konferens)
   Address: Industrihuset Storgatan 19, Stockholm.
   Date: 970409-970410
   Title: Quantification of immunohistochemistry using computerised image analysis.

7. **Name: Catherine Östlund, Peter Flink**
   Conference: EMAC Final Results Meeting
   Address: ESA/ESTEC, Keplerlaan 1, Noordwijk, The Netherlands
   Date: 970414-970416
   Title: Experiences from the ESA ROSIS campaign 1994. The Skagerrak site.

8. **Name: Ewert Bengtsson**
   Conference: VISIT Kick-off
   Address: Ångströmslaboratoriet , Uppsala
   Date: 971002
   Title: Fusion of 3D medical images - project presentation.

9. **Name: Gunilla Borgefors**
   Conference: VISIT Kick-off
   Address: Ångströmslaboratoriet , Uppsala
   Date: 971002
   Title: 3D Paper structure - project presentation.

10. **Name: Fredrik Lidberg, Emma Lindqvist, Gunilla Borgefors**
    Conference: RESE Annual meeting and workshop
    Address: Kiruna
    Date: 971109-971112
    Topic: The RESE project "Image classification and Interaction Analysis".

11. **Name: Tommy Lindell**
    Conference: Jamaican Coastal Project
    Address: NRCA, Kingston Jamaica
    Date: 971130-971209
    Title: Final presentation of the Coastal Atlas of Jamaica and Manual for integrated planning and management of jamaican coast
    Comment: Presented for Officers of Natural Resources Conservation Authority, UNEP, World Bank, Jamaican parishes, University of the West Indies and NGOs.

12. **Name: Tommy Lindell**
Conference: Presentation of the Jamaican Coastal Project
Address: San Jose, Costa Rica
Date: 971209-971212
Title: Final Presentation of the Coastal Atlas of Jamaica and Manual for integrated planning and management of Jamaican coast
Comment: Presented for Government Officials and Universidad Nacional followed by discussions on future co-operative work in the field of coastal management and education.

7.5.5 Poster presentations

1. **Name: Tommy Lindell**
Conference: ERIM Fourth Int. Conf. on Rem. Sens. for Marine and Coastal Environment
Address: Orlando, FL, USA
Date: 970308-970319
Title: Mapping of the Coastal Zone of Jamaica.

2. **Name: Petter Ranefall**
Conference: NUTEK conference in medical technology
Address: Stockholm
Date: 970409-970410
Title: Quantification of immunohistochemistry using computerised image analysis.
Comment: In Swedish.

3. **Name: Catherine Östlund**
Conference: Third International Airborne Remote Sensing Conference and Exhibition
Address: Radisson Falconer Center, Copenhagen, Denmark
Date: 970707-970710
Title: Comparison of different methods to enhance special structures in a lake water mass.

4. **Name: Tomas Brandtberg**
Conference: Third International Airborne Remote Sensing Conference and Exhibition
Address: Radisson Falconer center, Copenhagen, Denmark.
Date: 970707-970710
Title: Curvature Value of Intensity Images for Corner Detection in Computer Vision
Comment: The title was invented by ERIM. The correct title should be: Curvature Estimation of Tree Crown Contours for Species Classification.

7.5.6 Attendee

1. **Name: Tomas Brandtberg, Peter Flink, Anders Forsmoo, Roger Hult, Fredrik Lidberg, Emma Lindqvist, Roger Lundqvist, Mattias Moëll, Anna Pettersson, Stina Svensson, Mikael Vondrus, Fredrik Walter, Haiying Yuan,**
Conference: Swedish Symposium on Image Analysis, SSAB'97
Date: 970304-05
Address: CVAP, NADA, KTH, Stockholm.

2. **Name: Ewert Bengtsson**
Conference: SSF seminar about national research programs and graduate schools
Date: 970307
Address: City conference Center, Norra Latin, Stockholm.

3. **Name: Gunilla Borgefors**
Conference: Kick-off meeting for the MISTRA project Food21
Date: 970324-970325
Address: Eklundshof, Uppsala.

4. **Name: Gunilla Borgefors**
   Conference: Wood Ultra Structure Research Centre (WURC) kick-off meeting
   Date: 19970410
   Address: SLU, Ultuna
   Comment: WURC is a competence cetre funded by NUTEK and the Swedish paper and pulp industry.

5. **Name: Mikael Vondrus**
   Conference: 5th conference of the European Society for Analytical Cellular Pathology (ESACP)
   Date: 970525-970529
   Address: Holmenkollen, Oslo.

6. **Name: Ewert Bengtsson**
   Conference: 5th conference of the European Society for Analytical Cellular Pathology (ESACP)
   Date: 970525-970529
   Address: Dept. of Pathology The Norwegian Radium Hospital, Montebello N-0310 Oslo, Norway
   Comment: Bengtsson was session chair of DNA-organisation and Chromatine Structure.

7. **Name: Fredrik Lidberg, Roger Lundqvist, Mattias Moëll, Stina Svensson**
   Conference: The 10th Scandinavian Conference on Image Analysis (SCIA'97)
   Date: 970609-970611
   Address: Lappeenranta, Finland.

8. **Name: Fredrik Lidberg, Emma Lindqvist, Catherine Östlund**
   Conference: Graduate student kick-off, RESE (Remote Sensing for the Environment) project
   Address: Rymdhuset, Kiruna
   Date: 970617
   Topic: Graduate student kick-off, RESE (Remote Sensing for the Environment) project
   Comment: Catherine Östlund participated as stand-in for Haiying Yuan

9. **Name: Emma Lindqvist, Peter Flink**
   Conference: Third International Airborne Remote Sensing Conference and Exhibition
   Date: 970707-970710
   Address: Radisson Falkoner Convention Center, Fredriksberg, Copenhagen, Denmark
   Comment: The conference was preceded by tutorials 970705-970706. Lindqvist attended "Digital Photogrammetry" and "Airborne Imaging Spectrometry In Practise". Flink attended "Calibration and validation of imaging spectrometer data".

10. **Name: Mattias Moëll**
    Conference: Workshop Wood fiber for Paper products.
    Date: 970825-970827
    Address: STFI, Stockholm, Fagerudd, Enköping
    Comment: Organized by the Graduate school: Wood and woodfiber

11. **Name: Mattias Aronsson, Tommy Lindell**
    Conference: Kick-off meeting for the SSF project VISIT
    Date: 971002
    Address: Ångströmslaboratoriet, Uppsala.

12. **Name: Gunilla Borgefors**
    Conference: IT seminar on new financing strategies for industry and research Norwegian and Swedish IT-experiences.
    Date: 971015
    Address: Uppsala University, Polacksbacken
    Comment: Organised by "Norges eksportrad" and "Uppsvenska Handelskammaren (Uppsala Chamber of Commerce)".

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

Unfortunately, there were no such visits during 1997.

7.7 Shorter visits to other research groups

1. **Name: All personell at CBA**
   Host: Kennert Torlegård
   Address: Department of photogrammetry, KTH, Stockholm
   Date: 970115
   Topic: Information about the activities at this department
   Comment: Part of the 1996 (delayed) "Lucia" trip.

2. **Name: Tommy Lindell**
   Host: Kai Sörensen
   Address: NIVA Oslo, co-operation partner in Imaging Spectrometry, Norge
   Date: 970116-970119
   Topic: Discussion on common project in Imaging Spectrometry.

3. **Name: Hans Frimmel**
   Host: Foundation for Health Education
   Address: Orlando, Florida, USA.
   Date: 970117-970119
   Topic: Essentials of Prostate & Genitourinary Imaging.

4. **Name: Jakob Nisell**
   Host: Joint Research Centre (JRC)
   Address: JRC, Ispra, Italy
   Date: 970129-970131
   Topic: Getting information on the MARS project.

5. **Name: Ewert Bengtsson**
   Host: Christer Fåhraeus, managing director
   Address: Med-AI Europe AB, Ideon Research Park, Lund
   Date: 970221
   Topic: Demonstration of R&D activity in medical image analysis. Attended presentation of Master Thesis by Daniel Elvin at Dep of Mathematics, Lund Univ. Discussion about possible future cooperation.

6. **Name: Ewert Bengtsson**
   Host: Rektor Stig Strömholm
   Address: UU
   Date: 970228
   Topic: Installation as professor of image analysis at UU in ceremony in the main aula of the university.

7. **Name: Ewert Bengtsson, Gunilla Borgefors**
   Address: IVA Conference Center, Stockholm
   Date: 970303
   Title: Meeting of the VISIT Reference Group
   Comment: Discussion about the plans for the VISIT research program.

8. **Name: Ingela Nyström, Gunilla Borgefors**
   Host: Örjan Smedby
   Address: Inst. för diagnostisk radiologi
   Date: 970307
   Topic: Discussion of skeletonization of MR angiography images. Pilot study started.
   Comment: Two pieces of log was left for MR scanning for display in the modern version of the "Augsburgska skåpet".

9. **Name: Tommy Lindell**
   Host: Anthony McKenzie
   Address: NRCA, Kingston Jamaica
   Date: 970308-970315
   Topic: Work on the coastal planning of Jamaica.

10. **Name: Tomas Brandtberg, Jakob Nisell**
Host: Stadsbyggnadskontoret
Address: Vaksalagatan 15, Uppsala
Date: 970312
Topic: Visit arranged by "Kartografiska sällskapet" in Uppsala. Geographic information system presentations (i.e. MapInfo).

11. **Name: Ewert Bengtsson**
Host: Peter Gombrich, Dick Domanik
Address: AccuMed Inc, 920 N Franklin St., Chicago IL, USA
Date: 970313-970316
Topic: Continued discussion as part of our research cooperation on automated cell image analysis of Pap-smears.

12. **Name: Tommy Lindell**
Host: Prof Dale A. Carlson
Address: University of Washington, Seattle WA, USA
Date: 970320-970324
Topic: Work for the Valle Foundation.

13. **Name: Gunilla Borgefors**
Host: Björn Gudmundson
Address: Dept. of EE, Linköping University
Date: 970402
Topic: Board meeting of SSAB.

14. **Name: Petter Ranefall, Johan Steensland**
Host: Gunilla Derefeldt
Address: FOA, Linköping
Date: 970403
Topic: Measurements of computer screens.
Comment: Part of master thesis work.

15. **Name: Peter Flink**
Host: Eugenio Zilioli
Address: Telerilevamento, IRRS-CNR, Milano, Italy
Date: 970416-970418
Topic: Educational visit to the SALMON partners at the CNR.

16. **Name: Catherine Östlund**
Host: Arnold Dekker
Address: Institute for Environmental Studies, Vrije Universiteit Amsterdam, The Netherlands
Date: 970416
Topic: Visit to the institute and discussion of Dr. Dekkers work with CASI data from Dutch lakes.

17. **Name: Fredrik Lidberg, Emma Lindqvist, Anna Pettersson**
Host: RESE, project 1
Address: Physical Geography, Stockholm University
Date: 970417
Topic: Rese Workshop.

18. **Name: Gunilla Borgefors**
Host: Bo Algers
Address: Dept. of Animal Environment and Health, SLU, Skara
Date: 970420-970421
Topic: Meeting of a project group of SLU department heads on department cultures. Presentation of SLU activities in Skara.

19. **Name: Tommy Lindell, Haiying Yuan**
Host: Dr. Bertil Håkansson
Address: SMHI, Norrköping
Date: 970422, 970926
Topic: Meeting within the AQUA-RESE Project.

20. **Name: Tommy Lindell**
Host: Swedish Space Corporation
Date: 970424
Address: Swedish Space Corporation, Solna
Title: Project meeting.

21. **Name: Anna Pettersson, Gunilla Borgefors**
Host: Swedish Institute of Agriculture Engineering (JTI)
Address: Ultuna, Uppsala
Date: 970520
Topic: A new project on investigating the usability of satellite images for estimating the within field harvest differences, compared with ground truth measured with precision agriculture was initiated.
Comment: The project will be partly funded by Swedish Farmers Supply & Crop Marketing (SLR).

22. **Name: Gunilla Borgefors**
Host: Berndt Gerhardson
Address: Plant Pathology and Biological Control Unit, SLU, Ultuna
Date: 970522
Topic: Meeting of a project group of SLU department heads on department cultures. Presentation of the host unit.

23. **Name: Roger Lundqvist**
Host: Torbjörn Sundström
Address: Umeå universitetssjukhus
Date: 970602
Topic: Discussion about future cooperation.

24. **Name: Ewert Bengtsson, Gunilla Borgefors**
Host: Uppsvenska Handelskammaren (Uppsala Chamber of Commerce)
Address: Uppsala Science Park
Date: 970603
Topic: Discussion on an IT seminar in the autumn in Swedish-Norwegian industry-university cooperation in this area. (Took place 971015).

25. **Name: Ewert Bengtsson, Sun Yueqin**
Host: D.Leroy
Address: CERN, Geneva, Switzerland
Date: 970617-970619
Topic: Visit to CERN to deliver the software developed for LHC superconducting cable inspection
Comment: Sun stayed until June 24.

26. **Name: Ewert Bengtsson**
Host: Peter Gombrich, Norman Pressman
Address: AccuMed International Inc, 920 N Franklin St., Chicago IL, USA
Date: 970623-970630
Topic: Participation in general strategic planning conference for AccuMed as part of our research cooperation on automated cell image analysis of Pap-smears.

27. **Name: Catherine Östlund**
Host: Thomas Chrien, NASA, Tod Rubin, GER
Address: Geographical Institute, University of Copenhagen
Date: 9707
Comment: Östlund attended a tutorial before the conference: "Calibration and validation of imaging spectrometer data".

28. **Name: Fredrik Lidberg, Emma Lindqvist**
Host: NADA
Address: KTH, Stockholm
Date: 970822-980122
Topic: Course in Knowledge Discovery in Databases and Data Mining, weekly meetings.

29. **Name: Ewert Bengtsson**
Host: Jan Friberg, managing director of STUNS
Address: Uppsala Science Park, Glunten, Uppsala
Date: 970915
Topic: Discussion about medical/technical research in Uppsala and about how to attract international investors in that field to Uppsala.

30. **Name: Tomas Brandtberg**
Host: SAAB Survey Systems AB, Jönköping
Address: Säve Airport, Göteborg
Date: 970915-970916
Topic: Seminar on Saab TopEye airborne topographic survey system, including a test flight with the helicopter system.

31. **Name: All personell at CBA**
Host: Lars Höök
Address: School for Forest Engineers, Skinnskatteberg
Date: 970918
Topic: Presentation of the school.

32. **Name: Gunilla Borgefors, Tomas Löfstrand**
Host: Örjan Smedby
Address: Dept. of Diagnostic Radiology, Uppsala University
Date: 971003
Topic: Meeting with Context Vision to discuss cooperation within the MR-angiography project.

33. **Name: Tommy Lindell**
Host: SALMON European Union Project
Address: JRC, Ispra, Italy
Date: 971007-971009
Comment: Steering group meetings with Dr. Eugenio Zilioli, Italy, Prof. L. Premazzi, JRC, Ispra, Italy and Prof. M. Hallikainen, Helsinki, Finland.

34. **Name: Tomas Brandtberg**
Host: Dept. of Forestry, Danish Forest and Landscape Research Institute
Address: Horsholm, Denmark
Date: 971009
Topic: Planning of EU-project in FAIR programme on digital image processing of aerial photographs of forests.

35. **Name: Petter Ranefall, Roger Hult, Anders Forsmoo, Mattias Moëll**
Host: A Karlsson Industriteknik AB and MATROX
Address: Stockholm
Date: 971021
Topic: Technical seminar about PC-based image analysis.

36. **Name: Gunilla Borgefors, Mattias Aronsson, Mattias Moëll**
Host: Örjan Sävborg
Address: Stora Corporate Research, Falun
Date: 971023
Topic: Meeting with the participants in the VISIT project "Paper structure". Presentation of Stora Corporate Research.

37. **Name: Ewert Bengtsson**
Host: Johan Lindeberg, NUTEK + NUTEK managing group for Health and medical technology
Address: Arlanda Sky City Conference Center, Arlanda
Date: 971103
Topic: Discussion about our research application for continued support for the brain atlas project.

38. **Name: Petter Ranefall**
Host: Christer Busch
Address: Department of pathology, RiTø, Tromsø, Norway
Date: 971106-971107
Topic: Installation and demonstration of program for quantification in cytology and histology (QUACH).

39. **Name: Ewert Bengtsson**
Host: Peter Gombrich, Norman Pressman
Address: AccuMed International Inc, 920 N Franklin St., Chicago IL, USA
Date: 971117-971124
Topic: Continued discussion as part of our research cooperation on automated cell image analysis of Pap-smears.

40. **Name: Ewert Bengtsson**
Host: Branko Palcic, Alan Harrison
Address: Oncometrics Imaging Corp, Vancouver, B.C., Canada
Date: 971119-971120
Topic: Demonstration and discussion of the research activities at Oncometrics to evaluate the possible cooperation in the future.

41. **Name: Ewert Bengtsson**
Host: Calum MacAulay
Address: Cancer Imaging Department, British Columbia Cancer Agency, Vancouver, Canada
Date: 971120
Topic: Demonstration and discussion of the research activities at BCC.

42. **Name: Gunilla Borgefors, Tommy Lindell**
Host: Krister Torkelsson
Address: Military Surveillance Group at Uppsala Air Force, Uppsala
Date: 971121
Topic: Discussions on possible co-operation in image analysis and remote sensing.

43. **Name: Ewert Bengtsson**
Host: Tim Morrison
Address: Industrial and EU-liaison Office, UU
Date: 971208
Topic: Discussion of possible co-operation with the Prosolvia company in competence centers.

44. **Name: All personell at the CBA**
Host: Bengt Edvardsson
Address: Dept. of Astronomy, UU
Date: 971217
Comment: Part of the 1997 "Lucia" trip.

45. **Name: Ewert Bengtsson**
Host: Sven Kullander
Address: Dept of radiation sciences, UU
Date: 971222
Topic: Presentation of VISIT administrative structure and experiences in preparation for the AIM SSF program.

7.8 Visiting scientists (staying at least 2 weeks)

1. **Name: Johan Fransson**
   Host: Fredrik Walter
   Address: Dept. of Forest Resource Management and Geomatics, SLU, Umeå
   Date: 970217-970317
   Topic: Cooperation on detection of clear-cutted areas using ALMAZ radar images.

2. **Name: Morten Larsen**
   Host: Tomas Brandtberg
   Address: Dept. of Mathematics and Physics, Royal Veterinary and Agricultural University, Fredriksberg, Denmark
   Date: 970303-970331
   Topic: Remote sensing in forestry. Estimation of Tree Positions from Aerial Photos, using tree crown templates based on optical models.

3. **Name: Håkan Boström**
   Host: Fredrik Walter
   Address: Linnéskolan, Uppsala
   Date: 970407-0418
   Topic: So called APU-student from the "Dator-programmet" first grade
   Comment: He was educated in UNIX, C++ and image analysis during the two weeks. He also got information about the ongoing projects at CBA.

7.9 Other visitors

1. **Name: Kai Sörensen**
   Host: Tommy Lindell
   Address: NIVA, Oslo Norway
   Date: 970116-970119
   Topic: Imaging Spectrometry.

2. **Name: Christer Fåhraeus**
   Host: Ewert Bengtsson
   Address: Med-AI Europe AB, Ideon Research Park, Lund
   Date: 970211
   Topic: Discussion about the possible cooperation interest between Med-AI Europe AB and CBA.

3. **Name: Yvonne Ridderstråle**
   Host: Gunilla Borgefors
   Address: Dept. of Animal Physiology, SLU, Ultuna
   Date: 970211
   Topic: Possible cooperation on measurements of the structure of goat udders.

4. **Name: Professor emeritus Curt Forsberg**
   Host: Tommy Lindell
   Address: Limnology, Uppsala
   Date: 970212
   Topic: SALMON Project Planning Meeting.

5. **Name: Thomas Hård af Segerstad**
   Host: Ewert Bengtsson, Gunilla Borgefors
   Address: Dept. of the History of Art, UU
   Date: 970219
   Topic: Discussion about how digital image handling can be introduced to handle the art image collections of the Department of Art History.

6. **Name: Peter Dahlström**
   Host: Ewert Bengtsson
   Address: STUNS, Glunten, Uppsala
   Date: 970225
   Topic: Discussion about the IT activities of UU in relation to STUNS.

7. **Name: Sören Vinge**
   Host: Ewert Bengtsson
   Address: Uppsala Nya Tidning, Uppsala
   Date: 970226
   Topic: Newspaper reporter making interview about the research at CBA, resulted in a half page article in UNT.

8. **Name: Bo Nordell**
   Host: Ewert Bengtsson, Lennart Thurfjell
   Address: KS Neuroradiology, stockholm
   Date: 970311
   Topic: Discussion about the possibility of having a joint graduate student between KS and CBA financed by General Electric.

9. **Name: Dean Kaj Rosén, Leif Mattson, Ola Sallnäs**
   Host: Gunilla Borgefors
   Address: Faculty of Forestry, SLU
   Date: 970314
   Topic: Presentation of CBA and its activities.

10. **Name: Sam Ekstrand, Desiree Johansson (1), Göran Alm, Mats Leine (2)**
    (1) IVL, Stockholm
    (2) Physical Geography, Stockholm University
    Host: Gunilla Borgefors, Fredrik Lidberg, Emma Lindqvist
    Address: Centre for Image Analysis
    Date: 970326
    Topic: RESE discussion
    Comment: Tomas Brandtberg, Anna Pettersson and Fredrik Walter participated.

11. **Name: Mats Nylinder, Christina Lundgren**
    Host: Gunilla Borgefors
    Address: Dept. of Forest Products, SLU, Ultuna
    Date: 970415
    Topic: Discussion of joint application on non-destructive 3D analysis of timber.

12. **Name: Pedro Polo, Jairo Roa, Enrique Ortiz**
    Host: Ewert Bengtsson
    Address: Javarian University, Bogota, Colombia
    Date: 970418
    Topic: Presentation of " Some medical applications of IT" to this delegation of vice-rector, dean and head of IT from University of Bogota.

13. **Name: Mikael Niva**
    Host: Ewert Bengtsson
    Address: Department of Ecological Botany
    Date: 970422
    Topic: Discussion about how image analysis can be used to analyse the vegatation in test areas for reindeer grazing in the mountains. Possibilities of cooperation with CBA.

14. **Name: Kerstin Frith, Peter Schmid and Gunnar Holmer**
    Host: Ewert Bengtsson
    Address: SWELAB Instrument AB, Stockholm
    Date: 970507
    Topic: Discussing possible cooperation on image analysis of blood-cells.

15. **Name: Luc Oberli and Alan Burns**
Host: Ewert Bengtsson, Sun Yueqin
Address: CERN, Geneva, Switzerland
Date: 970522
Topic: Superconducting cable inspection
Comment: Discussion and demonstration of our results in the ongoing and planned future cooperation on superconducting cable inspection.

16. **Name: Heung-Kook Choi**
Host: Torsten Jarkrans
Address: School of Information and Computer, Inje University, Obang-Dong 607, Kim-Hae, Korea.
Date: 970523-970602
Topic: Conferral of doctorates (doktorspromotion) at UU and work with the project "Grading of urinaty bladder cancer"
Comment: Choi got his Ph.D. at CBA in 1996.

17. **Name: Kjell Andersson**
Host: Fredrik Walter, Tomas Brandtberg
Address: Glommen Skogselerforening, Aelverum, Norway
Date: 970530
Topic: Presentation of Tomas' and Fredrik's projects. Plus some information on the other projects at CBA. Kjell Andersson is working in a forest owner organisation, trying to gather information on various automatic and semiautomatic methods for forest invetory.

18. **Name: Örjan Mohlund**
Host: Tommy Lindell
Address: Consultant, (Former Director of Planning, County Authority)
Date: 970610
Topic: Jamaica.

19. **Name: Dr. Tomas Suk**
Host: Gunilla Borgefors
Address: Institute of Information Theory and Automation, Academy of Sciences of the Czech Republic
Date: 970616-970626
Topic: Visiting scientist on a scholarship from the Swedish Royal Academy of Sciences.

20. **Name: Professor Prinya Chindaprasirt**
Host: Lennart Thurfjell
Address: Khon Kaen University, Thailand
Date: 970619
Topic: Discussion of the research conducted at CBA. Demonstrations were given by Jakob Nisell and Lennart Thurfjell.
Comment: Professor Prinya Chindaprasirt is president of Khon Kaen University.

21. **Name: Anders Brahme 1), Sharok Kimiai 1), Clas Lundström 2)**
Host: Lennart Thurfjell
Address: 1) Dept. for hospital physics, KS; 2) SECTRA Imtec AB, Linköping
Date: 970619
Topic: Discussion about a joint collaboration regarding the development of a whole body atlas within the VISIT program.

22. **Name: Ingrid Carlbom**
Host: Ewert Bengtsson, Lennart Thurfjell, Hans Frimmel
Address: Lucent Technologies, USA
Date: 970822
Topic: Discussion about cooperation on 3D medical image analysis.

23. **Name: Jerker Carlsson, Ulf Larsson**
Host: Lennart Thurfjell
Address: Göteborgs Universitet and The Foundation for Strategic Research
Date: 970829
Topic: Discussions about how graduate education is organized within the VISIT program.

24. **Name: Marcus Berg**
Host: Ewert Bengtsson
Address: Department of High Voltage Research, Uppsala univ.
Date: 971006
Topic: Advise about image analysis equipment and methodology to analyse water droplets which is the thesis work of Marcus.

25. **Name: Charlotta Dahlqvist och Seidi Wager**
Host: Hans Frimmel
Address: CBA
Date: 971007
Topic: PRAO-visit
Comment: Look around at CBA, do useful things and learn something about Image Analysis.

26. **Name: The board of the Foundation for strategic research**
Host: Roger Lundqvist, Ewert Bengtsson, Lennart Thurfjell
Address: CBA
Date: 971008
Topic: Demonstration of VISIT-project "Fusion of medical images"
Comment: Lundqvist presented the computerized brain atlas program and answered some questions.

27. **Name: Gunnar Jansson**
Host: Ewert Bengtsson
Address: Dept. of Psychology, UU
Date: 971009
Topic: Discussion about 3D relief imaging as an input device for tactile "display" systems.

28. **Name: Ulf von Sydow**
Host: Gunilla Borgefors, Emma Lindqvist, Fredrik Lidberg
Address: Environmental Satellite Data Centre, MDC, Kiruna
Date: 971009
Topic: Discussions on our participation in the MISTRA project RESE.
Comment: Ulf von Sydow is Programme Director for RESE.

29. **Name: Shi Zongei, Chen Chuanmiao, Peng Lizhong, Chen Hua, Xu Zhongqin, Jun Zou, Mo Ju**
Host: Ewert Bengtsson
Address: Participants from China of NFR-NSFC Conference Numerical Analysis
Date: 971017
Topic: Presentation of Uppsala University IT activites in general and image analysis in particular.

30. **Name: Kenneth Alness 1), Lars Thylen 2)**
(1) Swedish Farmers Supply & Crop Marketing (SLR)
(2) Swedish Institute of Agricultural Engineering (JTI)
Host: Anna Pettersson, Gunilla Borgefors
Date: 971030
Topic: Satellite images for precision agriculture.

31. **Name: The Board and the Reference group of the RESE project**
Number: about 12
Host: Gunilla Borgefors
Address: Various
Date: 971218
Topic: Regular RESE reference group meeting and presentation of remote sensing at CBA.

7.10 Committees

7.10.1 International

1. **Name: Tommy Lindell**
Committee: Affiliate Associate Professor, Univ of Washington, Seattle, USA
Date: 1985–

2. **Name: Tommy Lindell**
Committee: Officer for Valle Scandinavian Exchange Program, Univ of Washington, Seattle, USA
Date: 1985–

3. **Name: Gunilla Borgefors**
Committee: Chair of the Membership Committee, International Association for Pattern
Date: 1990–

4. **Name: Gunilla Borgefors**
Committee: Editorial board member for Pattern Recognition and Image Analysis: Advaces in Mathematical Theory and Applications
Date: 1993–
Comment: Published by Interperiodica Publishing in Cooperation with the "Cybernetics" Scientific Council, Russian Academy of Sciences

5. **Name: Ewert Bengtsson**
Committee: Editorial board member of "Computer methods and programs in biomedicine"
Date: 1994–
Comment: Published by Elsevier

6. **Name: Ewert Bengtsson**
Committee: Editorial board member of "Machine Graphics and Vision"
Date: 1994–
Comment: Published by Polish Academy of Science

7. **Name: Ewert Bengtsson**
Committee: Board member of "European Society for Analytical Cellular Pathology" (ESACP)
Date: 1997–

8. **Name: Gunilla Borgefors**
Committee: Editorial board member, Rivista di informatica
Date: 1994–
Comment: Published by the Italian Association for Informatics and Automatic Computation, Milano, Italy

9. **Name: Gunilla Borgefors**
Committee: Editorial board member, Image Processing and Communications
Date: 1994–
Comment: Published by the Institute of Telecommunications, Bydgoszcz, Poland

10. **Name: Gunilla Borgefors**
Committee: Scientific Committee of PRIP'97: Fourth International Conference on Pattern Recognition and Information Processing, May 20-22, 1997, Minsk, Belarus.

11. **Name: Gunilla Borgefors**
Committee: Publication Chair and Technical Programme Committee of AVBPA: Audio- and Video-based Biometric Person Authentication, Crans-Montana, Switzerland, 12-14 March 1997.

12. **Name: Gunilla Borgefors**
Committee: Scientific Committee of 3rd Internation Conference on Visual Form, Capri, Italy, 28-30 May 1997.

13. **Name: Gunilla Borgefors**
Committee: Programme committee of IAPR-TC15 Workshop on Graph based Representations (GbR'97), Lyon, France, 17-18 April 1997.

14. **Name: Gunilla Borgefors**
Committee: Programme committee of "Discrete Geometry for Computer Imagery" (DGCI'97), Monpellier, France, December 1997.

15. **Name: Gunilla Borgefors**
Committee: Scientific committee of EUSIPCO'98, Rhodes, Greece, Sept. 8-11, 1998.

16. **Name: Gunilla Borgefors**
Committee: Scientific Committee of JCIS: The First International Workshop on Computer Vision, Pattern Recognition and Image Processing (CVPRIP'98), Research Triangle Park NC, U.S.A. .

17. **Name: Gunilla Borgefors**
Committee: Program committee of 10th Scandinavian Conference on Image Analysis (SCIA'97), Lappeenranta, Finland, 9-11 June 1997.

18. **Name: Ewert Bengtsson**
Committee: Member of the Program board for the international GKPO'98 Conference in Warsaw, Poland, 1997.

19. **Name: Gunilla Borgefors**
Committee: Expert for the evaluation for the position of Professor at Dept. of Cultural Studies and Art History, Bergen University, Norway
Date: 199710-199802

20. **Name: Ewert Bengtsson**
Committee: Dissertation committee and opponent for dissertation of Helene Schulerud, Institutt for Informatikk, Univ. i Oslo
Date: 970321

7.10.2 National

1. **Name: Ewert Bengtsson**
Committee: Dean of the division of mathematics and computer science of the faculty of science and technology at Uppsala University
Date: 960701– (3 years)
Comment: Includes many different meetings and other responsibilites such as being a member of the board of the faculty

2. **Name: Gunilla Borgefors**
Committee: Board member, Swedish Society for Automated Image Analysis
Date: 1986–
Comment: President 1988-1992

3. **Name: Gunilla Borgefors**
Committee: Member, Swedish Parliamentarians and Scientists
Date: 1987–
Comment: Members are elected. Only one scientist per field admitted.

4. **Name: Tomas Brandtberg**
Committee: "Kartografiska sällskapet" (Society for Cartography), Uppsala.
Date: 960129

5. **Name: Ewert Bengtsson**
   Committee: Member of the electorial committee for the faculty of science and technology at Uppsala University
   Date: 1993–

6. **Name: Gunilla Borgefors**
   Committee: National Reference group of the RESE research program
   Date: 9610–

7. **Name: Ewert Bengtsson**
   Committee: Appointments board (Tjänsteförslagsnämnden) for the mathematics computer science division at UU
   Date: 1996-1999

8. **Name: Tommy Lindell**
   Address: Department of Physical Geography Uppsala
   Date: 970124
   Title: Licentiat seminar in remote sensing.

9. **Name: Ewert Bengtsson**
   Committee: Strategic planning for the extended division of mathematics and computer science
   Date: 9701-9712
   Comment: Chaired a working group assigned with the task of creating a 10 year strategic plan for the division. Most of the planning work took place in 1996 but follow up work took place throughout 1997. The CBA hosted several meetings with this working group.

10. **Name: Ewert Bengtsson**
    Committee: Chair of the National Reference group of the VISIT research program
    Date: 9702–
    Comment: Responsible for coordination between the various research groups and the board of the VISIT research program financed by the Foundation for Strategic Research.

11. **Name: Gunilla Borgefors**
    Committee: National Reference group of the VISIT research program
    Date: 199702–

12. **Name: Ewert Bengtsson**
    Committee: Reference group on GLIS
    Date: 9704-9710
    Comment: GLIS is the new web-based general administrative information system under development for UU.

13. **Name: Ewert Bengtsson**
    Committee: Evaluation expert for Chair in Digital image systems and image analysis at Chalmers Technical University, Göteborg.
    Date: 9704-9706
    Comment: Internal promotion of Tomas Gustavsson.

14. **Name: Ewert Bengtsson**
    Committee: Chair of a working group to propose a new department structure in computer science at UU
    Date: 9704-9707
    Comment: Numerous meetings during this time period

15. **Name: Tommy Lindell**
    Committee: Evaluation expert for university lecturer position at Lund University
    Date: 970616, 971027
    Comment: Meeting in Lund

16. **Name: Ewert Bengtsson**
    Committee: Representative of TN faculty on appointment committee of Medical Faculty for Chair in Biostatistics
    Date: 9706-9712

17. **Name: Ewert Bengtsson**
    Committee: Evaluation expert for research proposals to the Academy of sciences of the Czech Republic
    Date: 9706-9708
    Comment: Evaluation of specific research proposals

18. **Name: Ewert Bengtsson**
    Committee: Member of a working group to propose an overall restructuring of the IT field att UU
    Date: 9708-9710
    Comment: Numerous meetings during this time period

19. **Name: Gunilla Borgefors**
    Committee: Expert for the evaluation for the position of Assistant Professor in forest remote sensing, Dept. of Geomatics, SLU, Umeå
    Date: 199709-199710
    Comment: "Forskningsassistent" is the Swedish title.

20. **Name: Ewert Bengtsson**
    Committee: Evaluation expert for position as lecturer in "Medieteknik med inriktning mot grafisk teknik, datorgrafik och digitala bilder" at Linköpings University
    Date: 9710-9712

21. **Name: Ewert Bengtsson**
    Committee: Evaluation expert for follow-up on the final report on a previously evaluated project proposal to the KK foundation
    Date: 9711

22. **Name: Gunilla Borgefors**
    Committee: Committee member for the Ph.D. dissertation of Håkan Wiman, Dept. of Photogrammetry, Royal Institute of Technology, Stockholm
    Date: 19971211