

**1 Doctorate degree** - Dec 17, 1982

Discipline: Computer and Information Science. Thesis title: *Filtering and Reconstruction in Image Processing*, Supervisor: Gösta Granlund, Linköping University, Sweden

**2 Postdoctoral fellow** - 1984 -1985

The Rockefeller University, Laboratory of Neurobiology, New York, USA. (Headed by Nobel Laureate Torsten Wiesel.)

**3 Docent degree** - Oct, 1992

Computer Vision, Linköping University, Sweden

**4 Present Employment**

**Professor**, July 2000 - present, Linköping University, Department of Biomedical Engineering, Division of Medical Informatics.

**5 Previous Employment**

**Associate Professor**, January 1986 - June 2000, Linköping University, Department of Electrical Engineering, Division of Computer Vision.

**Visiting Professor**, September 1998 - December 1998, Technical University of Denmark, Department of Mathematical Modeling, Section for Image Analysis.

**Acting Professor**, July 1990 - July 1991, Department of Electrical Engineering, Division of Computer Vision.

**Postdoctoral Fellow**, September 1984 - December 1985, The Rockefeller University, Laboratory of Neurobiology (Headed by Nobel Laureate Torsten Wiesel), New York.

**Research Assistant**, January 1976 - September 1984, Linköping University, Department of Electrical Engineering, Division of Computer Vision.

**Image Processing Consultant** (50% employment), January 1984 - September 1984 and January 1986 - April 1986, Context Vision AB, Linköping. (50% leave of absence from Linköping University.)

**7 Honors, Awards and TV**

**'The Gold Mouse'** Our fMRI research was awarded the best Swedish IT-project 2001 price. (NyTeknik:s Framstegspris) Personally awarded **Erna Ebelings Pris 2000** for outstanding contributions in the field of medical image analysis. TV-Presentation of the awarded fMRI project on the nationally broad-casted news program *'Around the Country'* 2002.

**8 Doctorate Student Supervision**

Supervised ten PhD students to completion and is currently supervising five. Was the main supervisor for the following PhD:s (Official 'head supervisor' for the six most recent):

*Adaptive Analysis of Functional MRI Data* Ola Friman, LiTH No 836, Sept 2003.

*Motion Estimation for Perceptual Image Sequence Coding* Kenneth Andersson, LiTH No 794, January 2003.

*Motion Estimation and Compensation in Medical Imaging* Magnus Hemmendorff, LiTH No 703, Sept 28 2001.

*Learning Multidimensional Signal Processing* Magnus Borga, LiTH No 531, 1998.

*Reinforcement Learning and Distributed Local Model Synthesis* Tomas Landelius, LiTH No 469, 1997.

*Focus of Attention and Gaze Control for Computer Vision* Carl-Johan Westelius, LiTH No 379, 1995.

*A Tensor Framework for Multidimensional Signal Processing* Carl-Fredrik Westin, LiTH No 348, 1994.

*Controllable Multidimensional Filters and Models in Low Level Computer Vision* Mats Andersson, LiTH No 282, 1992.

*Adaptive Multidimensional Filtering* Leif Haglund, LiTH No 284, 1992.

*Hierarchical Curvature Estimation in Computer Vision* Håkan Bårman, LiTH No 253, 1991.

**9 Collaboration****Ongoing international** (Short list)

Prof. Carlos Alberola-López (2001 → Present) Universidad de Valladolid.

Prof. Rachid Deriche (2006 → Present) INRIA Sophia-Antipolis

Dr. Steven Haker (2003 → Present) Brigham and Womens Hospital, Boston

Prof. Benoît Macq (2001 → Present) Université Catholique de Louvain.

Dr. Jean-Philippe Thiran (2001 → Present) Echole Polytechnique Fédérale de Lausanne.

Prof. Juan Ruiz-Alzola (2001 → Present) Universidad de Las Palmas de Gran Canaria.

Dr. Carl-Fredrik Westin (1996 → Present) Harvard Medical School, Boston.

Prof Roland Wilson (1981 → Present) Warwick University, Coventry.

**Past international**, Please see

<http://www.lia.auc.dk/VAP/partners.html>

**10 Research Log** (References points to my pub-list)

Development of a new 3D radiological reconstruction method termed **'Ectomography'** [69].

Development of a theoretic framework for adaptive image filtering and analysis. [70], [71]. The image processing company *'Context Vision'* was founded based on these results, see section 11.

Was invited by Nobel Laureate Torsten Wiesel to join The Rockefeller University in New York as Postdoctoral Fellow. Developed a new, surface charge based, model for ion flow through visual receptor cells which resulted in a publication in *Science* [72].

Developed a novel method of representation and estimation of local structure of multi-dimensional signals using tensors and **tensor fields**. [73]. The use of tensor

representations for local signal features, e.g. orientation and velocity, has had far reaching consequences for the continuance of the research of the group. The fundamentals of the methods developed has been published as a textbook [74]. A continuation of the work resulted in a method for high resolution local frequency and bandwidth estimation. The method was cited in *Science* as the best available tool for local wave-length estimation in MR elastography, [75].

Developed a method for handling irregularly sampled and uncertain data. The method was termed **Normalized Convolution** and is based on a filtering technique using a local signal space metric [76]. The method has recently been extended to handle the real valued sample coordinates case, [3].

Advanced spatio-temporal filtering techniques and design of efficient learning systems are currently the main targets of research. The interest in the ideas brought forward by the group is high as can be seen in the list of invited talks, e.g. [46] and [62], see section 14. A good example is given by the introduction of **Canonical Correlation** based fMRI analysis, [4, 6, 9, 12, 11, 14], see section 7. An important recent result is the **LOGMAP** a fast manifold learning technique based on Riemannian normal coordinates, [29].

Perhaps the most important recent event, were I have had a key role, is the launching of the **Center for Medical Image Science and Visualization (CMIV)** at Linköping University in 2003. The center presently involves more than 70 persons and brings together technical and medical researchers, industry and clinicians in a very creative environment. CMIV convinced Linköping University, Hospital and County to declare Medical Image Science and Visualization a strategic area granting a total of 30.000 kSEK over 5 years.

## 11 Entrepreneurial achievements

Participated in the launching of the image processing company **Context Vision AB** in Linköping. Three important hardware designs were patented and tied to the company, e.g. [77, 78, 79] The algorithms developed are still the core of many of the products currently supplied by the company.

Algorithms developed in the *Spatio-temporal Subtraction Angiography* project have been implemented in the **SECTRA Imtec AB** system IDS4 which is currently marketed and sold. The core of the developed methods have been patented [68]. Two patents are pending, one on visual analysis of ear drums and one on visualization techniques.

## 12 Projects

Starting 1992 projects having a total level of more than 27 MSEK has been successfully completed.

### Current projects:

**SIMILAR - The Multimodal Interfaces Research Network** - EU:FP6 NoE, 350 kSEK/year 2004-2007.

### Manifold Valued Signal Processing

- VR/nt. 621 kSEK/year 2005-2007.

**Development of fMRI Techniques** - LiU strategic research funds, SMIV/CMIV. 800 kSEK/year 2004-2007.

**New Clinical Quality Level for Medical Image Volumes** - Industrial funding, ContextVision AB, 1.800 kSEK 2006-2007.

**MOVIII: Modeling, Visualization and Information Integration: A center for decision support in complex systems.** - SSF, Main Applicant Lennart Ljung, My groups share 500 kSEK/year, 2006-2011.

## 13 Short list of Professional Activities

Member of a number of boards and committees, e.g. The board of directors for **CMIV** - Center for Medical Image Science and Visualization, and Program committee for MICCAI (Int. Conf. on Medical Image Computing and Computer Assisted Intervention) 2007. Evaluation of scientific qualifications for national and international professor appointments. Member of the review committee for national and international PhD theses. Reviewer for a number of international journals.

## 14 Recent International Invited Seminars

*Images and Manifolds - Signal processing goes round the bend* British Machine Vision Conference, University of Warwick, UK, September, 2007

*Multidimensional Image Analysis and Manifolds* Imperial College, London, September, 2007

**The manifold ways of image analysis** University of Hawaii at Manoa, USA, April 2007

**Medical Image Science and Visualization in Linköping** University of La Laguna, Teneriffe and University of Las Palmas de Gran Canaria, 2005

**What's so good about quadrature filters?** ICIP conference, Barcelona 2003.

**A few High Points of Medical Informatics at Linköping University** Technical University of Denmark, Copenhagen 2002.

**The Image of a Thought** International presentation of Linköping University, Linköping 2002.

**Task driven feature generation: Finding relevant relations in high-dimensional signal spaces.** MIT AI-Laboratory, Boston, MA, USA, 2001.

**Automated Generation of Representations in Vision** ICPR conference Barcelona 2000.

**Learning Visual Operators from Examples: A New Paradigm in Image Processing** ICIAP'99 conference, Venice 1999.

## Selected Publications

The full list has more than 250 publications of which one text book, eight patents and more than 140 full papers in international journals or fully reviewed international conference proceedings. Listed below are of the refereed journal papers since 2000, [1] - [14], refereed international conference papers since 2000, [15] - [65], bookchapters [66], patents since 1999, [67] - [68], plus the remaining publications referred to in the text of my CV [69] - [79].

## References

- [1] A. Sigfridsson, L. Wigström, J.-P. E. Kvitting, and H. Knutsson.  $k-t^2$  BLAST: Exploiting spatiotemporal structure in simultaneously cardiac and respiratory time-resolved volumetric imaging. *Magn Reson Med*, 2007. Accepted.
- [2] A. Sigfridsson, J.-P. E. Kvitting, H. Knutsson, and L. Wigström. Five-dimensional MRI incorporating simultaneous resolution of cardiac and respiratory phases for volumetric imaging. *J Magn Reson Imaging*, 25(1):113–121, 2007.
- [3] K. Andersson, C-F. Westin, and H. Knutsson. Prediction from off-grid samples using continuous normalized convolution. *Signal Processing Journal*, 87(3):353–365, March 2007.
- [4] J. Rydell, H. Knutsson, and M. Borga. On rotational invariance in adaptive spatial filtering of fMRI data. *NeuroImage*, 30(1):144–150, March 2006.
- [5] H. Knutsson and M. Andersson. Implications of invariance and uncertainty for local structure analysis filter sets. *Signal Processing: Image Communications*, 20(6):569–581, July 2005.
- [6] O. Friman, M. Borga, P. Lundberg, and H. Knutsson. Detection and detrending in fMRI data analysis. *NeuroImage*, 22(2):645–655, June 2004.
- [7] M. Sundberg, M. Borga, H. Knutsson, A. Johansson, T. Strömberg, and P. Å. Öberg. Fibre optic array for curvature assessment - application in otitis diagnosis. *Medical and Biological Engineering and Computing*, 42:245–252, 2004.
- [8] K. Andersson, M. Andersson, P. Johansson, R. Forcheimer, and H. Knutsson. Motion compensation using backward prediction and prediction refinement. *Signal Processing: Image Communications*, 18:381, May 2003.
- [9] O. Friman, M. Borga, P. Lundberg, and H. Knutsson. Adaptive analysis of fMRI data. *NeuroImage*, 19(3):837–845, 2003.
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- [11] O. Friman, M. Borga, P. Lundberg, and H. Knutsson. Exploratory fMRI analysis by autocorrelation maximization. *NeuroImage*, 16(2):454–464, June 2002.
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- [15] B. Svensson, A. Brun, M. Andersson, and H. Knutsson. Estimation of non-cartesian local structure tensor fields. In *Proceedings of the 15th Scandinavian conference on image analysis (SCIA'07)*, Aalborg, Denmark, June 2007.
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- [17] A. Brun, C-F. Westin, M. Herberthson, and H. Knutsson. Intrinsic and extrinsic means on the circle – a maximum likelihood interpretation. In *ICASSP*, Honolulu, Hawaii, USA, April 2007. Accepted.
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