Application at the Faculty of Science, Lund University

The Registrar
Lund University
P O Box 117
SE-221 00 Lund
Sweden

Application for ☐ **position**
☒ **promotion to position**

Title and subject field	
Professor, Computational Biology and Biological Physics	
Reference number if announced	Earliest possible date of appointment

Applicant information

Last name and all first names		Date of birth/Personal number
Ohlsson, Börje Ola Mattias		19670610-2917
Home address		
Gilleskroken 19, 226 47 Lund		
Nationality	Male/Female	Tel. no. (home)
Swedish	Male	0703299310
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mattias@thep.lu.se		046 2227782
Present position and employer		
Senior Lecturer (universitetslektor), Lund University		

Place and date	Signature

My academic qualifications portfolio for the promotion to a professorship position, contains the following parts:

- List of attachments
- (B) CV
- (C) List of selected publications including comments. The publications are found in attachment C1)
- (D) Research qualifications (including list of publications)
- (E) Teaching qualifications
- (F) Leadership and administration qualifications
- (G) Cooperation, innovation and entrepreneurship qualifications
- (H) Selected publications (according to C)
- (I) Attachments

List of Attachments

Number	Description
B1	B.Sc. in Physics
B2	Ph.D. in theoretical physics
B3	Qualification for readership (docent)
C1	10 selected publications
E1	Education for PhD supervisors
E2	Learning and Teaching in higher Education - an Introduction
E3	Learning and Teaching in higher Education - Continuation
E4	Communication in science education
E5	Course evaluations for FYTN06
E6	Course evaluations for BINP13
E7	Director of undergraduate studies
F1	Project management and leadership training
F2	Deputy Head of Department
G1	Patents

(B) Curriculum Vitae

Contact information

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Education

- Doctor of Philosophy (Ph.D.) in Theoretical Physics / Complex Systems, Lund University, Sweden, "Artificial Neural Networks and Combinatorial Optimization", 1995.

- Bachelor of Science (B.Sc.) in Physics, Lund University, Sweden, 1991.

Employment

- Professor, School of Information Technology, Department of Intelligent Systems and Digital Design, Halmstad University, Sweden (2018-09-01 – present), currently 40% (next year 50%)

- Senior Lecturer, Computational Biology and Biological Physics, Department of Astronomy and Theoretical Physics, Lund University, Sweden (2014-04-01 – present), currently 60% (next year 50%)

- Researcher, Computational Biology and Biological Physics, Department of Astron-

omy and Theoretical Physics, Lund University, Sweden (2005-10-01 – 2014-03-31), research 70%

- Researcher, Clinical Physiology, Department of Radiology and Physiology, Lund University, Sweden (2002-01-01 – 2005-09-30), research 80%

- Machine Learning Developer, Exini Diagnostics AB, Lund (2002 – 2017), subsidiary employment at 20%

- Assistant Professor, Complex Systems Division, Department of Theoretical Physics, Lund University, Sweden (1998-01-01 – 2001-12-31), research 80%

Postdoc employment

1995-09-01 – 1997-12-31, Section for Digital Signal Processing, Institute for Mathematical Modeling, Technical University of Denmark.

Qualification for readership (docent)

2004, Theoretical Physics / Complex Systems, Lund University, Sweden.

Research, Education, Leadership and Innovation

For information on my merits in these different areas, I refer to sections (D) Research qualifications, (E) Teaching qualifications, (F) Leadership and administration qualifications and (G) Cooperation, innovation and entrepreneurship qualifications.

Supervision

PhD students that I have supervised as main supervisor or active co-supervisor. All listed co-supervised students graduated from other departments (within clinical or pre-clinical medicine) and I was the main supervisor for their computational work.

Main supervisor
Björn Linse, 2016 - 2020 (estimated)
Najmeh Abiri, 2015 - 2019 (estimated)
Jonas Kalderstam, 2011 - 2015
Michael Green, 2004 - 2008
Henrik Haraldsson, 1999 - 2003

Co-supervisor
Naeimeh Atabaki, - 2020 (estimated)
David Ansari, - 2016
Jakob Foreberg, - 2013
Dan Lindahl, - 2000
Holger Holst, - 2000

References

Carsten Peterson
Professor, Computational Biology & Biological Physics, Department of Astronomy and Theoretical Physics, Lund University, Sweden
carsten.peterson@thep.lu.se, +46 46 2229002 (office)

Lars Edenbrandt
Professor, Department of Molecular and Clinical Medicine, Sahlgrenska University Hospital, Gothenburg, Sweden
lars.edenbrandt@gu.se, +46 705 183305 (mobile)

Other information

Scientific output
- No. of peer reviewed original research articles: 72
- Bibliometric data (Google Scholar); Cited 2,648 times, h-index: 31, i10-index: 61.
- No. of patents (co-inventor): 2.

(C) Selected publications

Below are listed ten selected publications. A complete list of publications can be found at http://cbbp.thep.lu.se/~mattias/publications. I have selected publications from various medical and biomedical projects together with a few machine learning oriented publications. The majority of the publications are from current research, but I have included a few older publications that were significant in various aspects. *The publications can be found in attachment C1.*

(1) Automatic Gleason grading of HE stained microscopic prostate images using deep convolutional neural networks,
A. Gummeson, I. Arvidsson, M. Ohlsson, N. C. Overgaards, A. Krzyzanowska, A. Heyden, A. Bjartell and K. Åström
SPIE Proceedings 10140 (2017)

An example from the growing field of using deep learning techniques, in here convolutional neural networks, to analyze medical images. This publication was a result of a master thesis where I was co-supervisor for the deep learning part.

(2) Technical advances of the recombinant antibody microarray technology platform for clinical immunoproteomics,
Payam Delfani, Linda Dexlin Mellby, Malin Nordström, Andreas Holmér, Mattias Ohlsson, Carl A. K. Borrebaeck and Christer Wingren
PloS ONE 11:7, e0159138 (2016)

This publication describes an antibody microarray platform for immunoproteomic analysis. I was responsible for developing and applying the machine learning methods employed.

(3) The International Heart Transplant Survival Algorithm (IHTSA): A new model to improve organ sharing and survival,
J. Nilsson, M. Ohlsson, P. Höglund, B. Ekmehag, B. Koul and B. Andersson
PLoS ONE 10:3, e29868 (2015)

This is a prime example from my collaboration with Dr. Johan Nilsson with heart surgery projects. This publication describes our main model for survival of heart

transplanted patients. I was instrumental in the planning and choice of methods for this publication.

(4) Training neural networks directly on the concordance index for censored data using genetic algorithms,
J. Kalderstam, P. Edén, P-O. Bendahl, C. Strand, M. Fernö and M. Ohlsson
Artificial Intelligence in Medicine 58:2, 125-132 (2013)

This publication was selected because it represents my step into the field of survival analysis using neural networks. I developed the methods and did most of the writing.

(5) A novel automated platform to quantify the extent of skeletal tumor involvement in prostate cancer patients with Bone Scan Index,
D. Ulmert, R. Kaboteh, J. J. Fox, C. Savage, M. J. Evans, H. Lilja, P-E. Abrahamsson, T. Björk, A. Gerdtsson, A. Bjartell, P. Gjertsson, P. Höglund, M. Lomsky, M. Ohlsson, J. Richter, M. Sadik, M. J. Morris, H. I. Scher, K. Sjöstrand, A. Yu, M. Suurkula, A. J. Vickers, L. Edenbrandt and S. M. Larson
European Urology 62:1, 78-84 (2012)

An important publication, published in a high impact journal, that concerns the important role of the Bone Scan Index for prostate cancer patients. My position on the author list does not reflect the value of my work and efforts. I was very active in the statistical analysis and the writing.

(6) Detailed comparison of amyloid PET and CSF biomarkers for identifying early Alzheimer's disease,
S. Palmqvist, H. Zetterberg, N. Mattsson, P. Johansson, L. Minthon, K. Blennow, M. Ohlsson and O. Hansson
Neurology 85:14, 1240-1249 (2015)

Example of an Alzheimer's disease project together with Dr. Oskar Hansson. I did all the machine learning analysis and part of the writing.

(7) Molecular serum portraits in patients with primary breast cancer predict the development of distant metastases,
A. Carlsson, C. Wingren, M. Kristensson, C. Rose, M. Fernö, H. Olsson, H. Jernström, S. Ek, E. Gustavsson, C. Ingvar, M. Ohlsson, C. Peterson and C.A.K. Borrebaeck
Proceedings of the National Academy of Sciences USA 108, 14252-14257 (2011)

A breast cancer publication where machine learning was used to establish a serum protein signature for the development of distant metastases. In this project I devised a multi-loop verification procedure now commonly used.

(8) Exploring new possibilities for case based explanation of artificial

neural network ensembles,
M. Green, U. Ekelund, L. Edenbrandt, J. Björk, J. L. Foreberg and M. Ohlsson
Neural Networks 22:1, 75-81 (2009)

A machine learning publication where we used data from the collaboration with Ulf Ekelund (acute chest pain patients) to explore new methods for case-based feedback. I was active in all parts of this publication.

(9) WeAidU - A decision support system for myocardial perfusion images using artificial neural networks,
M. Ohlsson
Artificial Intelligence in Medicine 30, 49-60 (2004)

Almost 15 years old, but still important for me. It was a publication that I wrote to describe a working prototype of a decision support system for a heart related examination. A product along these lines was developed and marketed by Exini Diagnostics AB.

(10) Artificial neural networks for recognition of electrocardiographic lead reversal
B. Hedén, M. Ohlsson, L. Edenbrandt, R. Rittner, O. Pahlm and C. Peterson
The American Journal of Cardiology 75:14, 929-933 (1995)

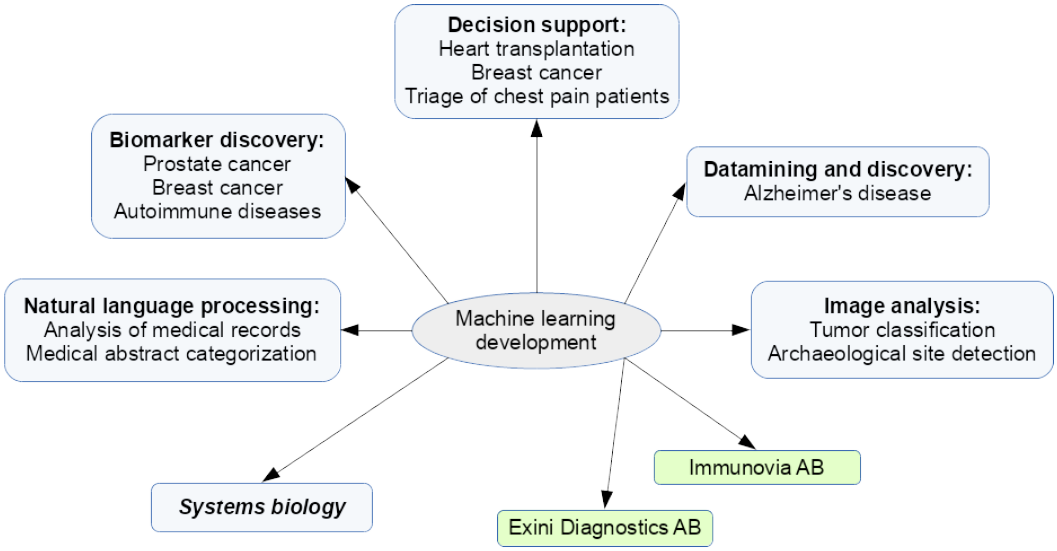
One of my first publications with Lars Edenbrandt, where I developed a machine learning method for the detection of misplaced ECG leads. I did all of the analysis! This method was part of a patent later filed by Siemens-Elema AB.

(D) Research qualifications

Summary of research

Development and application of machine learning for computational biology and medical informatics.

My research is carried out in close collaboration with clinical or pre-clinical research groups, mostly from departments within Lund University, Sweden. The applications range from pure model building in order to understand biological processes or diseases, to very specific medical decision support tasks. The graph below summarizes the activities. Green boxes indicate collaborations with companies. My research



on machine learning is mainly application driven and involves both linear and non-linear methods for advanced pattern recognition, time series analysis and survival

analysis. For the non-linear methods focus lies on artificial neural networks and deep learning.

Research activity

Article references to my own publications are given in square brackets and refers to the publication list. Other references are given directly in the text.

Previous research activity

I started my university studies in September 1986 with physics and mathematics as major subjects. I received my BSc in June 1991 after having spent one semester at the University of Bielefeld (Germany), where I did my diploma work in the field of statistical physics (surface tension in the q-state Potts model).

In March 1991 I commenced my PhD studies at the Department of Theoretical Physics in Lund within the Complex Systems group. My major topic was **Artificial Neural Networks** (ANN) covering both theoretical research and more application oriented work. My thesis supervisor was Professor Carsten Peterson and the research was focused on developing feedback ANN algorithms for different optimization problems and using ANN for medical information processing. Important contributions from this era are:

- **Track finding.** My first project concerned the important problem of track finding in High Energy Physics (HEP) experiments. In two publications we developed an elastic arms algorithm based on the idea of "deformable templates". This novel approach took time to penetrate the HEP community but is now used.
- **Knapsack problems.** One difficult class of combinatorial optimization problems are the ones with inequality constraints. Since most problems of this kind are NP-complete, there is a demand for fast algorithms providing good approximate solutions. We developed feedback ANN algorithms to provide good approximate solutions and this resulted in two publications.
- **Medical informatics.** During my last year as a PhD student, I started to collaborate with the Department of Clinical Physiology at the Lund University Hospital. We used ANN for the analysis of electrocardiograms (ECG) and scintigraphic heart images. The ANN approach turned out to be very successful and as a note, an algorithm for detecting misplaced ECG was patented by Siemens Elema.

In May 1995 I defended my thesis entitled "Artificial Neural Networks and Combinatorial Optimization".

With an initial grant from the *Hellmuth Hertz Foundation*, I became a research associate at the Institute of Mathematical Modelling (IMM; Lyngby, Denmark) in September 1995. Later I received a post-doc grant from EU (TMR) and stayed at IMM until 1997. At IMM, I worked on an automatic segmentation procedure for magnetic resonance (MR) images of the human brain, using deformable templates. I was also involved in a theoretical study on the design of artificial neural networks.

Between 1998 and 2001, I was an assistant professor at the Department of Theoretical Physics, Lund University and during 2002-2005 I held a research position at the Department of Clinical Physiology at Malmö University Hospital. Between 2006 and 2013, I was employed as a researcher at the Department of Astronomy and Theoretical Physics, Lund University.

My research during these years was focused on machine learning and its applications within computational biology, including medical informatics and analysis of protein sequences and structures. Important contributions from this period are:

- **Biomarkers for Alzheimer's disease and other dementia.** There is a need for biomarkers identifying Alzheimer's disease and other types of dementia. Several candidates for such biomarkers can be found using plasma proteins or proteins found in the cerebrospinal fluid. The quality of these biomarkers can be evaluated using suitable data materials from patients with various degrees of Alzheimer's disease, from patients with other types of dementia and from healthy controls. Machine learning methods are here part of the statistical analysis in order to identify [21] or rule out [24] such possible protein biomarkers.

- **Understanding cell fate decisions.** In these projects, the data comes from single-cell measurements and concerns the understanding of how primary stem and multipotent progenitor cells decide their fate. We have developed a computational framework that simulates stochastic commitment events, and affords mechanistic exploration of the fate transition. In these projects machine learning is used to identify putative commitment-associated genes and formalize probabilistic rules of commitment [22].

- **Triage of chest pain patients.** Patients who are admitted in emergency departments with chest pain or other symptoms indicative of potential myocardial infarction (AMI) or unstable angina pectoris (i.e. acute coronary syndrome, ACS) are common and represent a heterogeneous group. We have investigated using ANN both ECGs taken at the arrival in the emergency department but also ECGs taken in the ambulance [38, 34, 26] as a tool regarding the triage of ACS patients with useful results.

- **Analysis of genome data.** I have been involved in some projects concerning analysis of genome data coming from microarray experiments [44, 33].
- **ECG analysis.** I have studied the use of serial ECG analysis when detecting acute myocardial infarction (AMI) and how ANNs can help diagnosing AMI in the presence of left bundle branch blocks [60, 56].
- **Protein sequence and structure analysis.** An algorithm for obtaining a local reliability index for pairwise protein sequence alignments was developed, as well as a new algorithm for pairwise structure alignment [57, 53].

Current research

(Since 2014 I have a permanent position as Senior Lecturer at the Department of Astronomy and Theoretical Physics, Lund, University)

My current research is focused on developing machine learning methods and algorithms with the main application areas within medical diagnosis and medical decision support. This research is interdisciplinary in nature, and conducted in collaboration with researchers and doctors from pre-clinical and clinical departments. The applications range from pure medical decision support cases, where the aim is to help doctors making better and more reliable decisions, to pre-clinical research where the main task is disease understanding and biomarker discovery. This has been very successful and has included a large number of collaborations with different types of applications. Below is a list of active projects. I first describe my current research on the machine learning itself, the methods and algorithms that constitute the foundation of all the applications.

Development of machine learning algorithms

I have a long experience in the field of artificial neural networks (ANN) and their modern deep learning incarnation, although I also use a variety of other machine learning and statistical methods for the different medical applications. My method development within the field of machine learning is focused on ANNs and deep learning. Two current topics are:

- **Survival modeling.** In clinical prognosis and characterization of response to treatment, accurate time-to-event modeling is critical. The objective may be to evaluate of the effects of covariates or to predict the time of occurrence of one or more events. The Cox regression model is the most commonly used method for survival analysis in clinical research. It assumes proportionality of

the hazard and is linear in the modeling of the covariates (i.e. features). A popular method for assessing the performance of prognostic survival models (including censored data) is the Harrell's concordance index (c-index), which represents a natural extension of the receiver operating characteristics (ROC) used in classification problems.

Using neural network ideas, we have developed methods capable of directly optimizing the c-index [20] and finding risk groups [9]. In related current work, we are building general flexible survival models for applications involving large databases, based on deep learning techniques.

- **Accurate imputation of missing data.** A practical challenge in many data mining and machine learning applications is missing data. In medical applications, the missing data may stem from incomplete patient records or failing devices. Deep learning techniques offer new possibilities to tackle the important problem of imputing missing data.

  Of particular interest here is the *autoencoder* approach. We are currently developing both single [96] and multiple imputation techniques. Our multiple imputation method is based on so-called *variational autoencoders*, which are generative models that can be seen as a generalization of standard autoencoders.

Applications

I am currently engaged in a number of research projects where machine learning is being used to tackle pre-clinical and clinical problems. Here I briefly mention four of these projects.

Risk assessment in cardiac surgery. It is of outmost importance to assess the risk before performing a cardiac surgery. We are using machine learning methods to identify risk factors that will have a strong influence on the outcome of the surgery [43]. One specific type of surgery is heart transplantation. Here risk assessment can be formulated as a matching problem between a donor and a recipient. We are building survival models for identifying the best recipient given a donor heart [16, 10, 1]. Figure shows how we can establish a relationship between risk factors and estimated survival time. In recent projects we are investigating the influence of the HLA complex and the outcome of heart transplantation [7].

Bone Scan Index. The overall aim of this project is to model survival for cancer patients that have undergone bone scan imaging. It is of importance to perform bone scan examinations for patients with prostate or breast cancer to verify or exclude

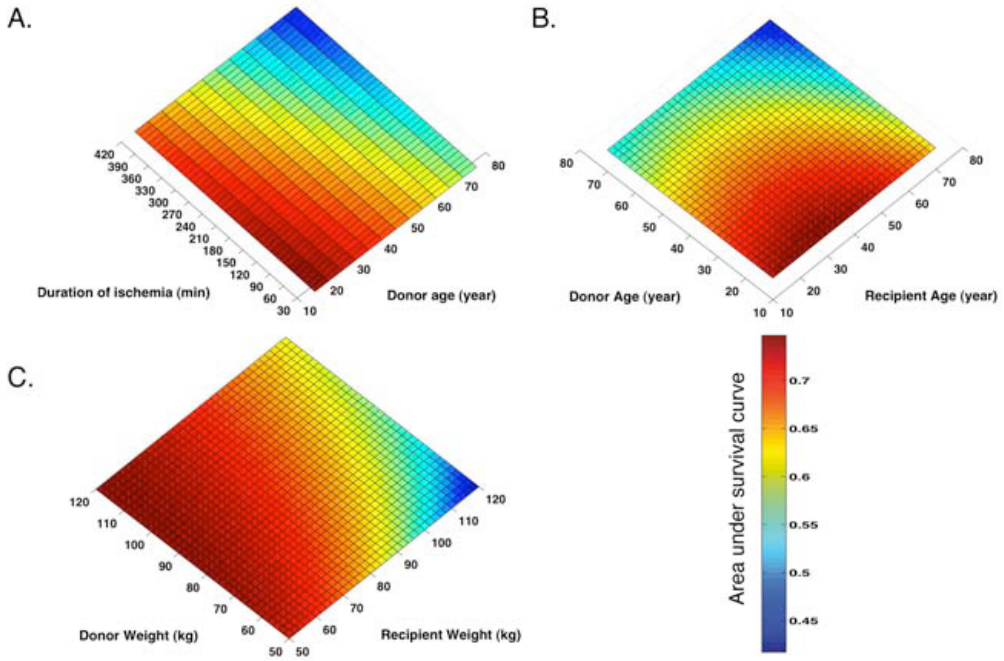


Figure 1: A simulation where the influence of two variables on survival is evaluated. (A) Left axis: duration of ischemia; right axis: age of donor. (B) Left axis: age of donor; right axis: age of recipient. (C) Left axis: weight of donor; right axis: weight of recipient. The colors show the predicted survival (dark blue = worst and dark red = best).

suspected metastatic disease. See figure for an example of such an image. Bone Scan Index (BSI) is the estimated extent of skeletal involvement by tumor in bone scans and can be calculated using automatic methods involving image analysis and machine learning [28]. Current projects are focused on BSI, including regional BSI measurements, and its correlations to survival of breast and prostate cancer patients [18, 19, 15, 6, 2].

Analyzing protein array data. Recombinant antibody microarrays are in these projects used to analyze protein expressions [5]. In one of the studies we used expressions from immunoregulatory proteins obtained from serum. The task was to predict, using machine learning methods, the development of distant recurrence after primary breast cancer operation [30]. Current projects concerns early detection of pancreatic cancer and differential profiling of autoimmune diseases [99].

Decision support for triage of breast cancer. While sentinel-node biopsy (SLNB) lacks therapeutic benefit for the majority of breast cancer patients posing node-negative disease, other would benefit from prompt systemic therapy or exten-

Figure 2: These two images (anterior and posterior view) represents a bone scan examination. Dark spots/areas in these images are possible metastasis.

sive axillary surgery. There is a need for preoperative tools to accurately estimate the amount of nodal metastasis. The aim for one study in this context was to use available clinicopathological characteristics as input to machine learning models and then be able to predict the nodal axillary status [97].

Plans for the future

Summary of future research and applications:

- Further pursue the key ongoing projects above, which all pose major challenges to bring all the way to the finishing line.
- Maintain and initiate new collaborations with national healthcare partners and identify potential usage of data mining and machine learning to improve the health care system.
- Specific image analysis applications using transfer learning. In some application areas the availability of labeled images are limited. Transfer learning techniques has the potential to overcome the problem of obtaining labeled data by utilizing models that have been learned on similar task, but with large data cohorts.

- To further develop machine learning methods, with a focus on neural networks and deep learning, based on needs coming from the applications.

New applications & collaborations

Two novel collaborations within the topic of transfer learning for image analysis have recently been launched, which are outside the medical domain.

Road detection in rural Africa. Knowing how market access influence agricultural production and livelihood is key for sound policymaking and is a basic need for modeling of climate change adaptation and impacts on food production. Yet large parts of the world are lacking well-documented and coherent road data which is a prerequisite for understanding the impacts of markets. This is indeed true for the rural Africa south of Sahara. The vast majority of methods for road extraction are developed for paved roads. Just a few methods to extract unpaved roads from imagery exists. They combine contextual information, topology and spectral features derived from satellite imagery. The results are usually weak; roads are sometimes missed and often misclassified due to shared properties with agricultural fields with bare soil, dried out riverbeds etc.

Can machine learning based methods reach further? RGB-imagery, and sometimes NIR-imagery, is typically available with a spatial resolution of 0.5 meters. Here we aim at using transfer learning techniques for convolutional neural network models. This is a collaboration with Ola Hall, Department of Human Geography, Lund University.

Archaeological site detection. The recent development of high spatial resolution geographic data have opened the possibility to employ machine learning techniques for automatic identification of new archaeological sites and features, that previously was impossible to spot. Discovering new archaeological sites will allow for: (i) providing a picture of the Scandinavian archaeological landscape never achieved before, (ii) identifying cultural relations among different archaeological sites and (iii) establishing a completely novel methodology for investigating the past. Again here we aim at using transfer learning techniques for convolutional neural network models. This is a collaboration with Nicolo Dell'unto, Department of Archaeology, Lund University.

Machine learning development

Despite the current popularity and increasing acceptance of machine learning techniques, there are many challenges ahead. More algorithm research/development is called for and I have identified some important areas below. My research will here benefit from the vast areas of applications I am involved in.

- **Unmasking "black boxes".** Machine learning methods in particular neural networks are now widely recognized as powerful modeling tools and are widely in many application areas. The power originates from its non-linear mapping capabilities together with efficient data-driven learning methods. When using neural networks for medical diagnosis or outcome prediction, it is of vital importance to be able to explain the reasoning behind an advice. Generally this is difficult for non-linear machine learning methods. This topic of unmasking the "black boxes" have become even more important with the present focus on deep learning.

  My research research on this topic was focused on the task of providing feedback on a case-by-case level [23, 35, 79], but I believe more research is needed, especially for deep architectures.

- **Variational Autoencoders.** Variational autoencoders are generative models that use variational inference with autoencoder like architecture to learn the underlying representation. Unlike autoencoders which only learn a functional representation of data, variational autoencoders can learn the data probability distribution. Variational autoencoders have many application areas in machine learning, such as imputation of missing data and data augmentation. From a theoretical point of view a current limitation of the variational autoencoder lies in the choice of prior distribution of the latent space. Using a weakly informative prior distribution would allow for a more robust approximation of the underlying data distribution. We have made initial progress in this direction [95].

- **Flexible survival analysis (continued).** Since more and more projects contain data with time-to-event information there is a need for more development on flexible survival analysis methods. Using a deep learning approach can provide additional increase in performance. Here it will also be important to provide feedback, especially if the endpoint is a medical decision support tool.

Research experience and qualifications

Research environment and scholarly networks

- *Research group.* The machine learning research group within the department currently consists of 2 senior researchers and 2 PhD students. In addition there are usually 1-2 bachelor students and 1-2 master students working in the group.
- *Create Health.* This is a Strategic Center for Translational Cancer Research and represents a multidisciplinary environment with researchers and clinicians from four different faculties, faculties of Engineering, Medicine, Natural Science and Social Science (Lund University). Many medical machine learning applications have origin within this network.
- *AIML@Lund.* Research on artificial intelligence and machine learning at Lund University is done at many departments at most faculties. The network for Artificial Intelligence and Machine Learning at Lund University (AIML@LU) is a faculty wide platform for research, education and innovation in the area. I am part of the steering group of this network.
- *Pufendorf DATA Theme.* The Pufendorf Institute for Advanced Studies hosts transdisciplinary work in the form of group based research activities, either as larger themes or in smaller Advanced Study Groups. The DATA theme developed approaches concerning how data can be stored and accessed, how data could be visualized and how to discover patterns in data. I was part of this theme that ran during fall 2017 - spring 2018. This network provides a great opportunity for interdisciplinary collaborations.

Supervision experience

Supervision of PhD. students

- Björn Linse, 2020 (estimated), co-supervisor Patrik Edén.
- Najmeh Abiri, 2019 (estimated), co-supervisor Patrik Edén and Carsten Peterson.
- Jonas Kalderstam, 2015, Lund University, "Neural Network Approaches to Survival Analysis", co-supervisor Patrik Edén, current employment **Senior Consultant**, Wunderdog, Lund, Sweden.

- Michael Green, 2008, Lund University, "Improving diagnosis of acute coronary syndromes in an emergency setting: A machine learning approach", co-supervisor Lars Edenbrandt, current affiliations **Chief AI Officer**, Blackwood Seven A/S, Copenhagen, Denmark (co-founder), **Chief Executive Officer**, Green Analysts AB, Sweden (founder).

- Henrik Haraldsson, 2003, Lund University, "Neural network ensembles and combinatorial optimization with applications in medicine", co-supervisor Carsten Peterson, current employment **Software Designer**, Ericsson, Stockholm, Sweden.

Co-supervision of PhD. students

- Naeimeh Atabaki, 2020 (estimated), Lund University, supervisor Paul Franks.

- David Ansari, 2016, Lund University, "Immunological risk factors in heart transplantation", supervisor Johan Nilsson.

- Jakob Foreberg, 2013, Lund University, "Improving early diagnosis of acute coronary syndrome and resource utilisation in acute chest pain patients", supervisor Ulf Ekelund.

- Dan Lindahl, 2000, Lund University, "Artificial neural networks classify myocardial perfusion images", supervisor Lars Edenbrandt.

- Holger Holst, 2000, Lund University, "New Methods for Automated Interpretation of Electrocardiograms and Lung Scintigrams", supervisor Lars Edenbrandt.

Important research collaborations

- During the last year of my PhD studies I started to collaborate with **Lars Edenbrandt**, current affiliation Dept. of Molecular and Clinical Medicine, Sahlgrenska University Hospital. I still have an active collaboration with L. Edenbrandt and his research group and the current focus is on quantitative nuclear image analysis for prostate cancer.

- All projects concerning risk assessment in connection with heart surgery and heart transplantations have been carried out in close collaboration **Johan Nilsson**, at the Dept. of Cardiothoracic Surgery, Lund University. J. Nilsson is currently using an office at our department to facilitate the collaboration.

- Projects concerning data analysis of recombinant antibody microarray data for detection breast cancer relapse and diagnosis of pancreatic cancer is carried out in collaboration with groups under **Carl Borrebaeck** and **Anna Isinger Ekstrand**, at the Dept. of Immunotechnology, Lund University.
- Some projects involves analysis and classification of medical images. I have recently started to collaborate with **Karl Åström** at Mathematics, Lund University in a few such medical applications.
- Projects involving diagnosis and early detection of Alzheimer's disease using various modalities have been carried out in collaboration with the research groups of **Lennarth Minthon** and **Oskar Hansson**, at the Clinical Memory Research Unit, Malmö, Lund University.
- Breast cancer projects using clinical data rather than genome data are carried out together with the group under **Mårten Fernö**, at the Dept. of Oncology, Lund University.
- I have had a long collaboration with **Ulf Ekelund**, at the Dept. of Emergency Medicine, Lund University. We have worked together on projects involving chest pain patients and their diagnosis.

Assessment of others' work

- **Faculty opponent.**

  2018, David Kofoed Wind *Statistical Models for WiFi Data and Educational Peer Review*, Technical University of Denmark (one of three opponents).

  2017, Dan Tito Svenstrup, *FindZebra - using machine learning to aid diagnosis of rare diseases*, Technical University of Denmark (one of three opponents).[1]

  2012, Jóan Petur Petersen, *Mining of Ship Operation Data for Energy Conservation*, Technical University of Denmark (one of three opponents).

- **Grading committee assignments.**

  2016, André Larsson, *Spatial Models of Gene Patterns in Plants*, Science faculty, Lund University

  2011, Dimitrios Bizios, *Machine Learning Algorithms for Improved Glaucoma Diagnosis*, Medical Faculty, Lund University

  2008, Magnus Wik, *The Sun, Space Weather and Effects*, Science faculty, Lund University

[1] Due to illness I could not attend the actual dissertation, but evaluated the thesis and assessed the documentation.

2006, Peter Johansson, *Computational methods in genomic and proteomic data analysis*, Science Faculty, Lund University

2003, Fredrik Sjunnesson, *Modeling of protein folding and genetic networks*, Science Faculty, Lund University

- **Referee assignments** for *Artificial Intelligence in Medicine*, *BMC Bioinformatics*, *Theoretical Biology and Medical Modelling*, *IEEE Transactions on Biomedical Engineering*, *Computer Methods and Programs in Biomedicine*, *Neurocomputing*, *Nuclear Instruments and Methods in Physics Research*, *EJNMMI Physics*

List of publications

For publications in collaboration with biomedical or medical groups, where I have made a significant contribution, I do not always end up being the first, second or last in the author-list.

Google scholar citation summary: Number of citations **2648**, h-index **31**, i10-index **61**

Published original articles

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Research Grants

My external funding comes from different joint contracts where I have been a co-applicant either directly or through the Computational Biology Group, which is part of the *Create Health* consortium. Over the last 5 years, the latter has funded 50% of my salary and 50% of a PhD position. The interdisciplinary research projects where I have been a direct co-applicant leading to success are listed below for the last five years. In these, joint PhD, postdoc and research engineer positions have been funded.

Name of project and PI	Starting year	Total budget	Funder
Development of new biomarkers and brain imaging techniques for Dementia and Parkinsonian disorders: key tools for exploring etiology to improve diagnosis and advance drug development, Oskar Hansson	2014	4 000 000	Swedish Research Council
Artificial Neural Networks - a method for mapping the Human Leukocyte Antigen system's impact on outcomes of heart transplantation, Johan Nilsson	2016	1 500 000	Hjärt-Lungfonden
Using 'Deep Learning' to analyse interactions between donor and recipient DNA that determine early and late heart transplant failures, Johan Nilsson	2018	1 000 000	eSSENCE - The e-Science collaboration
Effektivare och mer jämlik akutvård med hjälp av avancerade medicinska beslutsstödsystem, Jonas Björk	2018	5 336 171	Vinnova
NILS-studien (Non-Invasiv diagnostik av Lymfkörtel Stadium), Lisa Rydén	2018	7 000 000	Erling-Perssons Stiftelse

(E) Teaching qualifications portfolio

Summary of teaching activities

My teaching activity and experience ranges over several components and levels of educational work at a University.

- **Teaching experience.** I have since 1998 been teaching, including continuous course development, an advanced level course in *Artificial Neural Networks* (7.5 ECTS). This course was modified fall 2017 and became *Introduction to Artificial Neural Networks and Deep Learning* as a response to the rapid changing field of machine learning with artificial neural networks. This new course was given fall 2017 with about 180 attending students. In 2001 I was part of a team of 3 lecturers developing the course *Programming in Perl* (7.5 ECTS) aimed at Bioinformatics students with no or little experience in programming. Pedagogical issues were therefore important when developing this course. I was responsible for this course since the start and since 2008 the main lecturer. The course ended 2015. Since the launch in 1999 and to 2017 I was a lecturer in a course in Bioinformatics (current name is *Bioinformatics and Sequence Analysis*).

  All teaching experience includes the development and production of lecture notes, exercises (both theoretical and computer based) and examination questions.

- **Supervision of Bachelor and Master students.** I have been a supervisor of several Bachelor and Master projects, many with an interdisciplinary nature. A few of the projects have been pursued in collaboration with private companies.

- **Educational leadership.** I was director of undergraduate studies at the department of Theoretical Physics, Lund University between May 19, 2007 to June 30, 2010.

Personal reflection on teaching

Undergraduate teaching is very inspiring and I really enjoy the encounter with students. My teaching philosophy is rather simple: (i) be extremely well prepared on the subject, (ii) have a calm lecturing style and (iii) interact with the students.

I started to be part of the undergraduate education and the Department of Theoretical Physics, Lund University, directly when I returned from my post-doc position in Denmark. I became course responsible and single lecturer for a 7.5 ECTS course. For the duration of this course I developed new course material, practically by writing lecture notes only days before the actual lecture. I made a very simple discovery during that time. Solid preparation is one of the key ingredients for being a good teacher. I worked almost day and night to prepare the lectures and to discover key illuminating knowledge. I was very prepared, regarding the course content, prior to each lecture and despite having very little formal pedagogical training the course was a success, as evidenced by exam results and course evaluations.

Another ingredient for being a good teacher, I believe, is being calm and to have a rather slow lecturing rate. I got this experience as an undergraduate student in course on quantum mechanics. The lecturer (Lars Silverberg) had a calm and slow lecturing style, using only the blackboard and always writing in capitals. Nevertheless the content of what he conveyed during the lectures was precise and reflected the important parts for understanding the subject. I learned a lot during that course! I always try to develop my lecturing technique but the blackboard is still the main arena for my lectures. This ensures an optimal speed for which I try to mediate the course content and teach the students. I also use projectors and computers simulations during my lectures to exemplify the theory and to show applications. For me the teaching and lecturing technique is subject to continued development where I always try to become a better teacher.

A third ingredient in my teaching philosophy is the way I interact with the students. I find it natural to treat the student as a colleague rather than being a non-interacting lecturer. I believe having discussions, asking questions and showing research can be an efficient path towards knowledge. Optimally this communication goes in both directions, where the student interacts by asking a lot of questions, providing alternative explanations or makes correctional comments. I have pursued this way of teaching from a first course in programming that I have been responsible for since 2001. Here it is particularly vital for the learning process to have discussions, showing examples and interact with the student. Personally I enjoy this way of teaching and I have had many inspiring moments during my time as a teacher.

I do not regard myself as a fully developed teacher. It is a continued development and there are always parts of the teaching that can be improved. During fall 2013

and spring 2014 participated in formal pedagogical education courses and I found this to be very useful and *revealing*. Still there is more to learn!

During May 2007 to June 2010 I was Director of Studies at the Department of Theoretical Physics, Lund University. This gave me insight into what builds a good learning environment at a higher education institution. There more to it than just being a high quality teacher in order to have a working learning environment.

List of teaching qualifications

a) Formal training

The extent (fulltime work) of each course is given in the brackets.

Education for PhD supervisors, December 2003 [two days].

Learning and Teaching in higher Education - an Introduction (Högskolepedagogisk introduktion). January 2014 [two weeks].

Learning and Teaching in higher Education - Continuation (Högskolepedagogisk fortsättningskurs). May 2014 [three weeks].

Communication in science education (Kommunikation i naturvetenskaplig utbildning). December 2014 [one week].

d) Teaching experience or equivalent

FYTN14 Introduction to Artificial Neural Networks and Deep Learning, 7.5 ECTS, advanced level. This course was given for the first time fall 2017. The course is a modification of FYTN06 (see below) to account for recent development in the field of artificial neural networks. For this course I have

- developed new course material for the deep learning content.
- part of the development of two new computer exercises using the jupyter notebook platform.

This course was given for the first time fall 2017, with above 180 registered students. The course evaluation was positive (see attached evaluations for 2017).

FYTN06, Neural Networks, 7.5 ECTS, advanced level. Lecturer and course responsible person when this course was given, 1998 - 2015. For this course I have

- developed new course material from scratch, including new lecture notes and theoretical exercises.
- developed two computer exercises, including writing handouts.
- continued development of written exam questions.
- handled all administrative tasks, such as scheduling, reporting course examinations and administration of course evaluations.

The course evaluations have always been very positive (see attached course evaluation for 2015).

BINP13, Programming in Perl, 7.5 ECTS, advanced level. Lecturer and course responsible person when this course was given, 2001 - 2015. Main lecturer from 2008. For this course I have

- been part of the development of this course from scratch in 2001. This includes developing the lectures and writing a course compendium (see `home.thep.lu.se/~mattias/teaching/binp13/binp13\_exercises.html`)
- developed computer exercises for both practice and examination purpose.
- being responsible for a computer room of about 20 computer workstations used during the teaching.
- handled all administrative tasks, such as scheduling, reporting course examinations and administration of course evaluations.

The response and evaluations for this course have been really good (see attached course evaluation for 2015).

BINP11 (former BIM083), Bioinformatics and sequence analysis, 7.5 ECTS, advanced level. The first years (1999-2006) this course was more extensive (15 ECTS) and aimed at providing an overview of the field of Bioinformatics. The current form (7.5 ECTS) is a more condensed form of the original one. The course is interdisciplinary oriented with students from biology, chemistry and medicine. I was a lecturer on this course between 1999 - 2017. For this course I have

- developed two lectures for this course, including course material and computer exercises.

- developed examination questions for my part of the course.
- being responsible for a computer room of about 20 computer workstations used during the teaching.

e) Supervision at the Bachelor's and Master's degree levels

(Master level) 1998, André Stranne, *Bayesian Neural Network Learning*

(Master level) 1999, Björn Persson, *A modified delta test*

(Master level) 2001, Peter Johansson, *Classification of ECGs and microarray data using support vector machines*

(Master level) 2001, Maximillian Schlosshauer, *Quantifying local reliability of sequence alignments using mean field annealing* (Split supervision)

(Master level) 2001, Fredrik Alenberg & Mattias Sjöstrand, *Aircraft Identification With Artificial Intelligence* (Split supervision)

(Master level) 2002, Lena Jönsson, *Analysis of mRNA stability in the bacterium Bacillus subtilis by the use of DNA microarrays* (Split supervision)

(Master level) 2006, Martin Anderson, *Making sense of Defensins* (Split supervision)

(Master level) 2007, Emil Gunnarsson, *Cardiac surgery mortality prediction using artificial neural networks and ensemble weighting methods*

(Bachelor level) 2008, Marc Phander, *A neural network approach to parameter evaluation in systems biology* (Split supervision)

(Bachelor level) 2011, Hampus Åström, *Wavelet transform as signal processing method for ANN-classification of acute coronary syndrome*

(Bachelor level) 2012, Filip Sandkvist, *Optimization of paper pulp production using Artificial Neural Networks and Simulated Annealing*

(Bachelor level) 2013, Raoul Larsson, *Linearisation of feed-forward artificial networks to study input importance*

(Bachelor level) 2014, Cordula Schwappach, *How is the Performance of a Neural Network Ensemble influenced by Over-fitting and Ensemble Size – A Numerical Investigation*

(Bachelor level) 2016, Edvin Jakobsson, *Applying the Maxout Model to Increase the Performance of the Multilayer Perceptron in Shallow Networks*

(Master level) 2016, Anna Gummeson, *Prostate cancer classification using Convolutional Neural Networks* (Co-supervisor)

(Bachelor level) 2017, Denhanh Huynh, *Applying Dropout to Prevent Shallow Neural Networks from Overtraining*

(Master Level) 2017, Lewis Belcher, *Convolutional Neural Networks for Classification of Prostate Cancer Metastases Using Bone Scan Images*

(Bachelor level) 2017, Erik Torstensson, *Using LASSO regularization as a feature selection tool*

(Master level) 2017, Frieder Henning, *Analysis of HLA-A, -B and -DR Alleles as Risk Factors for One-Year Mortality in Heart Transplants Using Artificial Neural Networks*

(Bachelor level) 2018, Jim Öhman, *Trainable Activation functions for Artificial Neural Networks*

(Bachelor level) 2018, Emmanuel Kring, *Exploring capsule networks*

(Master Level) 2018, Konstantin-Klemens Lurz, *Natural Language Processing in Artificial Neural Networks Sentence analysis in medical papers*

f) Educational leadership

May 19, 2007 - June 30, 2010, Director of undergraduate studies at the Department of Theoretical Physics, Lund University.

(F) Leadership and Administration

Summary and personal reflection

My research profile is built upon collaborations with many other research groups and individual researchers. My role in the different collaborations vary from being the project leader to a person that carries out the actual work. The wide range of institutional origins for the different projects that I have participated in, have increased my skills both as a project leader and participant.

I may sound trivial, but communication skills are vital, especially being from a science faculty department and collaborating with researchers from a medical department or staff from a hospital.

A lot of the projects that I participate in are run in parallel and this requires administrative skills in order to rapidly being able to swap between the different projects. Being able to create and maintain a good documentation for the various projects may sound as an obvious advantage. It is and have for me proven to be very efficient in order to maintain a short swap time.

In summary, my experience with many different types of collaborations and projects have prepared me in the role as an academic leader.

List of qualifications

a) Formal training

2006, Project Management and Leadership Training, Pareto 80/20.

b) Leadership positions within academia

2016-2018, Deputy head of department,

May 19, 2007 - June 30, 2010, Director of undergraduate studies at the Department of Theoretical Physics, Lund University.

2009-2010, Responsible for Lund University participation in the EU project "Advancing Clinico-Genomic Clinical Trials on Cancer" (FP6-IST-026996).

d) Assignments on boards and committees

2016 - 2018: Member of Department of Astronomy and Theoretical Physics Board.

2013 - 2015: Deputy member of Department of Astronomy and Theoretical Physics Board.

2010 - 2012: Member of Department of Astronomy and Theoretical Physics Board.

(G) Cooperation, Innovation and Entrepreneurship

Summary

Concerning cooperation I have given popular talks about my research at various locations, such as the popular "Teknik- och naturvetarcikeln" (2010). Perhaps the most important event occurs in the beginning of March every year, where high school students from south of Sweden come to Lund University and listens to popular talks in various topics. I have been part of this event since 2007.

In 1999 I was part of the process of founding "Lund University Telemedicine AB" (current name is Exini Diagnostics AB), which develops automated medical decision support systems. In late 2015 Progenics Pharmaceuticals, Inc. acquired Exini.

Personal reflection

Cooperation. Being a high school student I often read a lot of popular science magazines. A few times, when organized by the school, we could listen to researchers from some University talk about "science". It was always appreciated! Now as a researcher I try to convey my research to a wider society, where I find popular science talks to high school students to be an important task. I have been part (since 2007) of the annual event where high school students from south of Sweden visits Lund University and listens to popular science talks. My task and objective is to inspire young students to start University studies.

Innovation and entrepreneurship. My research profile as being an expert in machine learning with many applications in medical decision support have always been inspiring. There is a real possibility that my research can actually be used to improve healthcare and ultimately improve peoples health. This has always been a driving force in my research. I was lucky to be part of the founding of a company with

the aim of selling medical decision support software for specialized examinations. I had a subsidiary employment with Exini between 2002-2017 and I believe this have made me a better researcher.

List of qualifications

b) Information to public sector

2010, Participation in "Teknik- och naturvetarcirkeln", within the theme *Makalösa manicker – om naturens och människans maskiner*. I had three public presentations with the title *Hur lika är datorer hjärnor? - hjärnan som modell för lärande maskiner*

e) Participation in various media

2013, Participation in the brochure *Fem naturvetarröster om innovation* produced by the Science Faculty at Lund University. I was one of the five researchers interviewed about innovation.

2008, Article in "Forskning & Medicin", with the title "Databaser över friskt och sjukt" and concerns medical informatics.

1995, Article in LUM (Lunds Universitets Magasin) "Utexaminerad som specialist: Så lärde sig datorn tolka EKG" and concerns the use of machine learning to interprete electrocardiograms.

g) Entrepreneurship

In 1999 I was part of the process of founding "Lund University Telemedicine AB" (current name is Exini Diagnostics AB), which develops automated medical decision support systems. In late 2015 Progenics Pharmaceuticals, Inc. acquired Exini. I had a subsidary employment with Exini between 2002-2017.

During 2016-2018 I was involved in research and development at the company Immunovia AB (commissioned research). Immunovia discover and develops tools for early diagnosis of cancers and autoimmune disorders. My contribution was to develop the machine learning tools used for their platform.

h) List of patents

- R. Blankenbecler, M. Ohlsson, C. Peterson and M. Ringnér, "Method for Protein Structure Alignment", United States Patent 6859736, Februari 22, 2005 (filed Apr. 2 2001).
- B. Héden, M. Ohlsson, L. Edenbrandt, R. Rittner, O. Pahlm and C. Peterson, "Medical Apparatus for Analyzing Electrical Signals from a Patient", United States Patent 5640966, June 24, 1997 (filed Nov. 6 1995).