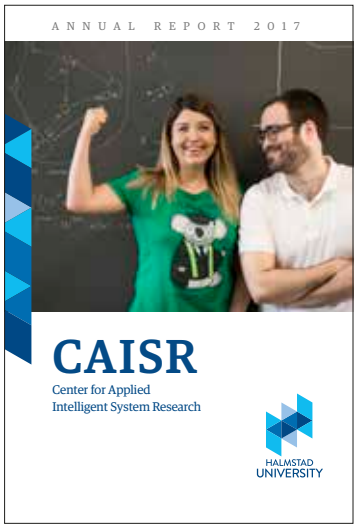
ANNUAL REPORT 2017

CAISR

Center for Applied Intelligent System Research

HALMSTAD UNIVERSITY



Cover - PhD students

Cover page shows PhD students Ece Calikus and Pablo Del Moral that are working in the CAISR research environment. Pablo is an industrial PhD student enrolled in the EISIGS industrial graduate school, and he is working with the company Getinge on data mining for predictive maintenance of sterilizers at hospitals. He has a master degree in data science from University of Granada. Ece Calikus is a PhD student in the SeMI Synergy project, working mainly with data mining for characterization and fault detection in district heating substations in collaboration with HEM and Öresundskraft. She has a master degree in computer science from University of Greenwich.

CAISR

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Annual Report 2017

Knowledge Foundation

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Annual report 2017

The Director's statement

It seems like 2017 was the year when machine learning (ML) broke a barrier. Several successful industrial applications and demonstrations of neural networks, especially deep neural networks, in the last years have meant that the industry is now convinced that competence in machine learning (and also AI in general) will be crucial. Large companies are now investing and building up their strengths (staff competence and computing power) in this area. It is today almost impossible to go to an event dealing with the future of industry, health care or public society without hearing the terms "AI" and "ML". This is good news for CAISR; some of our core researchers have worked with AI and ML for more than 20 years and we have a good scientific track record in the field over this time (described later in this report). The breakthrough of AI and ML also means that many Swedish research funding organizations are now directing more funds towards the ML field.

CAISR is a major research activity at Halmstad University, with a research turnover of 20-25 million, which corresponds to almost 15% of Halmstad University's total research turnover. CAISR now includes more than 40 people, involved in research, industrial and public collaborations, education, and management. CAISR has around a dozen PhD students. CAISR staff members have key roles in Halmstad University's collaboration arenas, and are very active with academy-industry mobility. The industrial matching and involvement, mostly in the form of in-kind efforts, are substantial.

Our decision in 2011 to focus CAISR on the two application areas intelligent vehicles and healthcare technology was a very good choice. It is in vehicles and healthcare that we see a lot of growing interest in ML and AI today. Companies in the vehicle industry are experiencing a monumental shift, going from defining their vehicles through mechanical engineering to defining them through software. The car experience of tomorrow will be defined a lot by software, and AI will be a cornerstone technology. Similarly, the healthcare sector faces a big change where fewer people will be hospitalized and much more of the care will take place in our private homes. AI and big data analytics are cornerstone technologies here to build decision support systems for this.

We had two particular highlights on the education side during 2017. One was the Bachelor thesis "Indirect Tire Monitoring System – Machine Learning Approach", which resulted in a scientific publication at *the 11th International Congress of Automotive and Transport Engineering: Mobility Engineering and Environment (CAR 2017)*. The work was awarded the prize for best thesis 2017 among the Bachelor theses in engineering at the School of ITE. The students also received top awards for this from the local IT-industry HMS Industrial Networks, and by Sparbanksstiftelsen Kronan. Another was the Master's thesis "Modelling the Level of Trust in a Cooperative Automated Vehicle Control System", which resulted in a scientific publication in *IEEE Transactions on Intelligent Transportation Systems*. This Master's thesis also received the 2017 Best AI Master's Thesis Award from the Swedish AI Society.

During 2018 we intend to carry our successes in education further and offer continued education in AI and ML for people employed in the industry.

Thorsteinn Rögnvaldsson

Scientific **core**

CAISR's scientific agenda is aware systems research, defined as:

Research on the design of systems that, as autonomously as possible, can construct knowledge from real life data created through the interaction between a system and its environment. This data necessarily includes streaming data. Such systems should be able to handle events that are unknown at the time of design.

The construction of knowledge can be illustrated with the knowledge pyramid (see figure); the higher a system reaches on the pyramid, the more aware it can be. A fully aware system will have interaction both upwards and downwards in the pyramid.

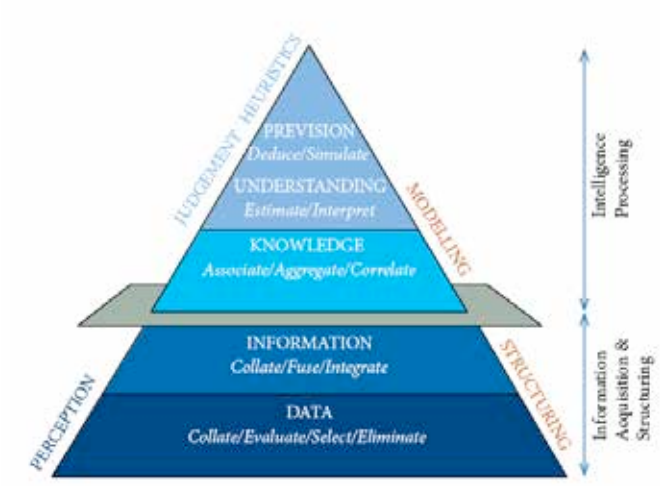


Figure 1. The knowledge pyramid, adapted from Ackoff (1989). "From Data to Wisdom". Journal of Applied Systems Analysis 16: 3–9.

The bottom level in the pyramid, data, deals with collecting and representing data. A key research question here is how to autonomously select what data to collect. How can a system decide what data are (or will be) relevant? A related question is how to construct (learn) general features that apply to many problems. With endless streams of data (the "internet of things") it is impossible and uninteresting to save all data; it is necessary to save snapshots, compressed, or aggregated representations of the data. These representations should apply to many different tasks (this is related to transfer learning). Also, the conditions can change; features that look unimportant today may end up being important tomorrow. An aware system needs to be curious, able to explore and learn.

The information level relates to questions that begin with "who, what, when and how many", creating "events" from the data in the layer below. Examples of operations that are required for this are classification, rearranging/sorting, aggregating, performing calculations, and selection. Much ML research (including that on deep learning models) has been devoted to this stage. Important open research questions here regard autonomous clustering and categorization of events. How can events be autonomously grouped into categories for later use?

The knowledge level is about creating "rules" from the information. This requires combining information from different sources. Is an observed "event" from one data source associated with another "event" in another data source? Can such associations be formulated into rules? An obvious example is the supervised learning setting, where "events" (input) are matched to correct responses (target) provided by a human expert and encoded into a rule (model). An interesting question deals with knowledge representations (knowledge structures); how can knowledge be represented so that it can be used for reasoning and prediction? A set of well-defined, highly-organized yet dynamic knowledge structures is a prerequisite for achieving awareness. A knowledge structure should evolve over time from experience, thus allowing for learning from data and human experts and be capable of taking into account different kinds of initial domain knowledge.

The top level, denoted the wisdom level, relates to the question "why" or "what will happen"? It is about the ability to project into the future and reason back into the past. An aware system must be capable of extrapolating information into the future, and be able to estimate and evaluate the consequences of actions based on previous observations.

The methods we develop in CAISR come predominantly from the ML domain, e.g. neural networks, random forests, and support vector machines. We also have a large body of work on biologically inspired visual features for image analysis.

Aware systems are important enablers to meet the challenge of health, demographic change, and well-being. One important application is ambient assisted living (AAL), which promises a decreased cost for elderly living services while maintaining a high quality of service. Aware systems research is about developing methods for autonomously analyzing streams of data and construct knowledge about individuals' living patterns. Another important application is to construct decision support systems for healthcare, to enable quicker and better decisions also in clinical healthcare.

Aware systems are also important enablers to meet the challenges of urbanization. More and more people live in urban areas. Worldwide, today more than half the population lives in urban areas. In Sweden it is more than 86% of the population, with similar numbers for the other Nordic countries. Urbanization is closely connected to development and economic growth. More urbanized regions tend to be more prosperous than less urbanized regions. Unfortunately, other things come with increased urbanization. When you increase the size of a city, you increase both the good and the bad socioeconomic quantities (diseases, wages, crime, litter, traffic, and so on).

Smart Cities and Communities is a concept that brings a hope for breaking up this connection between good and bad, i.e. a promise to get the good with urbanization without having to accept the bad. This is enabled by, e.g., development in wireless communications, sensor networks, and data analytics. With an "internet of things" approach, where the city provides streaming data of all its different operations, it is possible to mine this data to better optimize the operation, to detect problems, to better plan equipment maintenance, to make sure that transport, energy and water supplies operate satisfactorily. Doing this requires automated knowledge creation and aware systems.

Example paper 2017

Rögnvaldsson, Nowaczyk, Byttner, Prytz & Svensson, "Self-monitoring for maintenance of vehicle fleets", Data Mining and Knowledge Discovery (2018), vol. 32 (March 2018), pp.344–384 (published online 2017).

The paper describes an approach for building self-monitoring cyber-physical systems based on the concept of expected consensus among distributed self-organized agents on board the systems. The approach is demonstrated on a four year long field study with 19 city buses. The approach is intended for life-long learning for fleets of cyber-physical systems under computational and communication constraints.

The data level of the approach involves embedded software agents that use self-organization to explore the data streams onboard a vehicle, looking for less noisy and possibly interesting relationships among the streaming signals. The interesting (groups of) signals are repeatedly captured in snapshots and shared to a cloud service. The information level is the next step, where the snapshots are compared between the vehicles in the fleet, again using self-organization, and consistent outliers are detected. The knowledge level corresponds to matching detected outlier events to operations in the service records and from that infer what possible service needs and faults that correspond to consistent deviations from expected behavior.

Two of the 19 city buses in the field study.

Scientific **impact**

Our scientific position in artificial intelligence

The year 2017 marked a significant increase in both industrial and political interest in artificial intelligence (AI), and specifically machine learning (ML). These are core areas for CAISR and Halmstad University and a bibliometric study was therefore performed to estimate our national position in AI.

The study was based on Elsevier's Scopus data base. Scopus data were extracted for all Swedish universities 1998-2017 in the field of AI, which has subject code 1702 in Scopus. This could, however, not be done by just using the subject code, due to poor connection between the subject code and individual publication channels when searching in Scopus. Therefore the papers and citations statistics had to be extracted by searching for each individual publication channel listed under the subject code 1702. The publication types included were journal papers, reviews, and conference papers. This was done for all Swedish universities, except the artistic ones or highly specialized ones (like the Swedish Defence University).

It is important to understand that this produced a corpus of papers published in channels labelled with AI, but that there is no guarantee that an individual paper in the corpus actually deals with AI. The ten most cited papers from Halmstad University in this corpus dealt with three topics: ML in the form of neural networks, random forests, feature selection and combining classifiers; mobile robots for agriculture; and biometrics in the form of fingerprint, retinal and face recognition. Many of the most cited papers from Halmstad University were published in the two journals Pattern Recognition and Pattern Recognition Letters. Many of the least cited papers were published in Springer's Lecture Notes in Computer Science or Lecture Notes in Artificial Intelligence.

There are a total of 239 papers from Halmstad University in this corpus. About 2/3 of these papers were (co-)authored by current members of CAISR. Roughly 90% of the citations to the papers in this corpus are to papers (co-)authored by current members of CAISR.

The number of papers in the subject AI was compared to the total number of papers in Scopus over the time period; this was done for each university. This produced a relative size of AI in the scientific output from the university, which was divided by the relative size of AI over all Swedish universities (in the corpus) so that a relative specialization could be computed. A relative specialization above one for a university means that the subject AI is more common in the scientific output from the university than what it is on average from Swedish universities. The relative specialization for Halmstad for AI was just below six, meaning that AI is almost six times as common in the scientific output from Halmstad University than in the scientific output from a randomly chosen Swedish university.

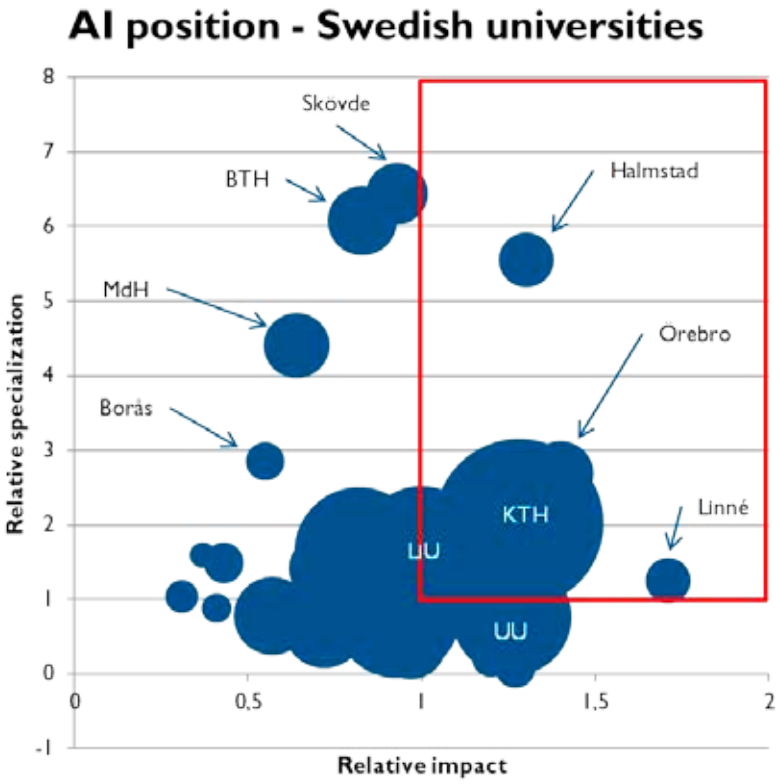


Figure 1: AI position for Swedish universities, based on citation and publication statistics in Scopus for papers published in channels labelled as "AI" during the years 1998-2017.

It is satisfying that Halmstad University is in the group with high scientific impact in AI.

The total number of citations per paper was also computed, which gave an impact value. This was also divided by the same average value in Sweden, which produced a relative impact value. Figure 1 shows how the Swedish universities are placed in a two dimensional scientific position positioning graph, with relative impact on one axis and relative specialization on the other axis. Figure 1 shows that Halmstad University is among the most profiled universities towards AI and also with a quite high scientific impact (measured per paper) over the time period 1998-2017. However, the total number of papers is not large compared to the large universities.

The number of papers and the number of citations to papers are statistical quantities. It is necessary to get estimates of the variances of these numbers in order to gauge whether the performance of an individual university is well above or below average, or significantly better or worse than another university. The number of citations to a paper was here divided by the average number of citations to a paper in the corpus from the same year. This was done in an attempt to normalize away the effect of time, since old papers necessarily tend to have more citations to them than young papers (it is, however, notable that the result of the analysis was not affected much by this normalization).

Figure 2 shows the number of citations per paper versus the total number of papers. It also shows the expected average number of citations per paper, plus/minus one or two sigma (standard deviations) for the actual number of papers. The expected variation in the number of citations per paper decreases with the amount of papers. Figure 2 shows that even though Linné University has a much higher number of citations per paper than KTH (the Royal Institute of Technology), the latter is a much better result, more than two sigma above the expected average for that volume of papers.

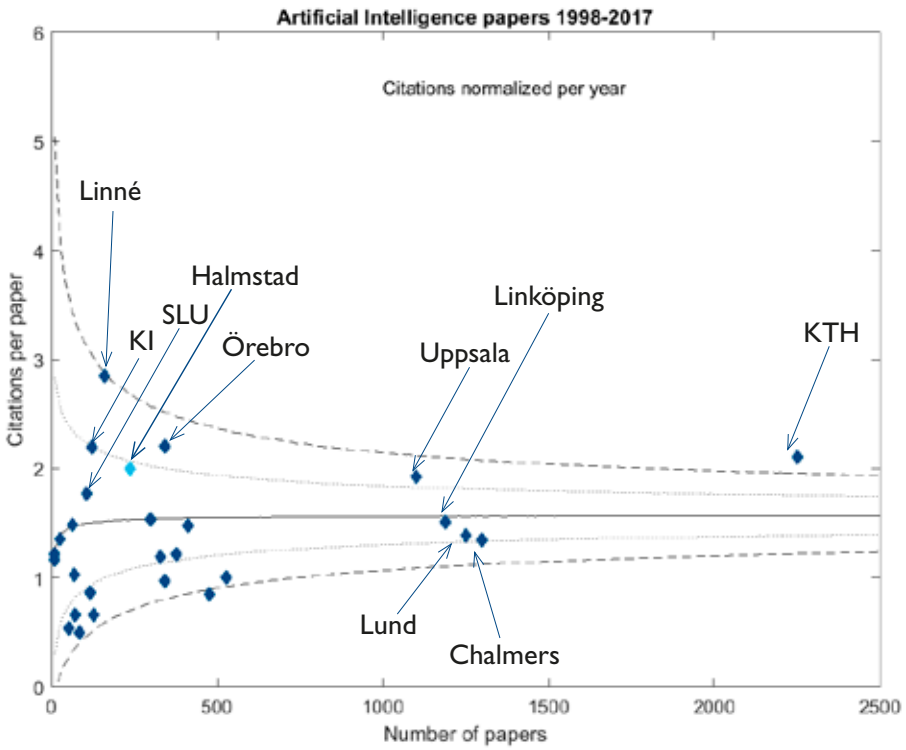


Figure 2: The number of citations per paper shown versus the number of papers for Swedish universities. Citations are normalized per year. The solid, dotted and dashed lines show the estimated average and plus/minus one and two standard deviations. Based on citation and publication statistics in Scopus for papers published in channels labelled as "AI" during the years 1998-2017.

Over the time period 1998-2017 has KTH has the highest number of citations per paper to its papers in AI. KTH is followed (in terms of scientific impact per paper) by Linné University, Örebro University, Uppsala University, the Karolinska Institute, Halmstad University, and the Swedish University of Agricultural Sciences (SLU). These are the universities whose impact per paper in AI has been above the national average over this time period. It is satisfying that Halmstad University is in the group with high scientific impact in AI.

Industrial collaboration

A substantial part of CAISR research is done in cooperation with industrial partners; it characterizes what we do (this also includes collaboration with the public sector). This is reflected in that a major part of our funding comes from organizations like the Knowledge Foundation, Vinnova (Sweden's Innovation Agency), and the European Union (regional funds as well as framework program funds). These are organizations that emphasize cooperation between industry, public sector and academic researchers. They also emphasize creating measurable impact from the research.

We do not subscribe to the idea that good research always finds its application. We believe that the probability for having research results that lead to impact outside of academia is higher if you start from problems that industries are experiencing, and try to deal with their real issues already from the start.

There are several studies on how to reach successful university-industry collaboration. They align well with our own experiences. Pertuzé at al. (2010)[1] state that "Managers see working with academia as beneficial only to the extent that it advances the company towards its goals", and comment that only 20% of university-industry collaboration projects lead to major impacts for the companies involved. Based on a study of more than 100 university-industry collaboration projects they formulate seven best practices for achieving successful collaboration (from the industry's perspective):

- There must be a vision within the company about what the university project will provide to the company.

- Appoint project managers who are networkers ("boundary spanners"). They should facilitate knowledge exchange with both the university researchers and the company.

- Share the company vision, the high level goals, of the project with the researchers.

- Invest in long-term relationships. Long-term relationships lead to better results over time.

- Establish strong communication linkage between company and university. It is beneficial to have the university researchers visit the company, the more often the better, and interact with the company people. Have regular and frequent project meetings (over video or telephone). Consider having company personnel spend time in the academic environment.

- Build broad awareness of the collaboration within the company. The more company people who know about the collaboration, the higher the chances of a successful outcome.

- Support the collaboration also after the project time, until the research can be exploited. Try to establish a sense of partnership between researchers and company staff.

Similar to Pertuzé at al. (2010), Edmonson et al. (2012)[2] note that productive industry-academy collaborations are long-term and build on close relationships. It is important to share the vision, have "cross-boundary" people in charge, and universities should be "strongly oriented towards helping solve the scientific and technological challenges that companies care about". Furthermore, they say that "it is individuals who understand both worlds – academia and business – that are the driving force behind successful partnerships". Their study is based on case studies of collaboration between research intensive multinational companies and high profile universities dominated by research.

These conclusions describe well what we strive for in CAISR. We work with "boundary spanners", i.e. people who spend time both in the academic setting and in the industrial setting. We aim to establish long-term relationships with trust. We emphasize frequent project meetings. We invite industrial partners to discussions and workshops on strategy, discuss best practices and how our partnership can evolve. Furthermore, we understand the value and role of our alumni students in establishing and maintaining these relations.

1 J.A. Pertuzé, E.S. Calder, E.M. Greitzer & W.A. Lucas, "Best Practices for Industry-University Collaboration", MIT Sloan Management Review, vol. 51, no. 4 (2010).

2 G. Edmondson, L. Valigra, M. Kenward, R.L. Hudson & H. Belfield, "Making industry-university partnership work – Lessons from successful collaborations", Report from the Science|Business Innovation Board AISBL (2012)

Partners

There are eight industrial partners in CAISR: Fotonic, Kollmorgen Automation, NEAT Electronics, Swedish Adrenaline, Tappa Service, Toyota Material Handling Europe, Volvo Technology and Volvo Bus Corporation.

Each partner has a seat in CAISR's industrial advisory board, which meets 1-2 times per year.

In addition to these partners are there a number of industrial and public partners to CAISR in other projects, projects funded through other sources than the Knowledge Foundation CAISR funds. These are: Affecto, Alfa Laval, EasyServ, Fysiotest, Getinge AB, Halmstad municipality, HEM - Halmstad Energi och Miljö, HMS Industrial Networks, HotSwap, Region Halland, Swatab, Sydpumpen and Öresundskraft.

The CAISR center researchers thus collaborate closely with more than twenty external partners.

However, CAISR is not just research in cooperation with industry and public sector partners. CAISR emphasizes education very much; the courses and the thesis projects are monitored closely. Our goal is to provide high quality education, manifested through excellent course evaluations and by a high ratio of thesis works that get published in scientific channels. In 2017 were 93% of the courses given by CAISR staff rated "good" or "very good" by the students. In the coming years we intend to increase our education offering to also include a substantial number of courses for continued education in AI and ML.

Boundary spanners

Volvo Group AB and Halmstad University have a long history of close collaboration, particularly on projects related to predictive maintenance, but also in other areas such as autonomous driving. Earlier collaborations between CAISR researchers and Volvo include e.g. RDM (2006-2010), Strategic Mobility (2008-2009), Strategic Recruitment (2009-2012), ReDi2Service (2009-2013), In4UpTime (2014-2016), ARISE (2016-2018) and HEALTH (2017-2019) projects, which have resulted in the predictive maintenance method that is currently being taken into production.

In all our projects with Volvo we emphasize that staff from CAISR spend time in the Volvo facilities with the Volvo personnel, often as much as two days per week. This greatly improves the quality in the collaboration and increases the probability for a successful outcome (i.e. with good results for all partners).

All the persons in the picture are "boundary spanners", i.e. spend considerable time both at Volvo and in the CAISR academic environment. They also participate considerably in the engineering education at Halmstad University.

Eren Erdal Aksoy, Peter Berck, Sepideh Pashami, Slawomir Nowaczyk, Parivash Pirasteh and Yuantao Fan.

Predictive maintenance

Predictive maintenance aims at identifying imminent failures and intervening before they happen, early enough to avoid downtime and reduce the consequential costs of the breakdown, both in terms of physical damage and lost business opportunity. Good understanding of the current health condition of the assets also leads to shorter and more efficient repairs, since less time needs to be spent on diagnostics and fault tracing. At the same time, it is important that predictive maintenance methods are accurate in suggesting operations to be performed, since failures that are predicted too early lead to wasted lifetime of the components and lower confidence in the method.

There has for many years been continuous successful collaboration regarding uptime, quality and predictive maintenance between CAISR researchers and different partners within Volvo Group through several research projects, including ReDi-2Service, In4Uptime, ARISE and HEALTH, most of them funded through Vinnova (Sweden's Innovation Agency). Product quality and customer satisfaction is top priority for Volvo, and thus Volvo Trucks has been the first major brand to launch the "uptime promise" service. Volvo is continuously investing into further improvements, new technologies and better services in this area, and CAISR researchers are an important part of this work.

Every day, thousands of sensor measurements stream onboard of millions of vehicles, in addition to information created off-board, in workshops or factories. This huge amount of data contains clues as to what is happening to the vehicles, and how will they operate in the future. Scanning this information, deciding on what to store and analyze, and how to represent it, is crucial for successful failure predictions. However, doing it manually is overly expensive and time consuming, in addition to being depending on the knowledge and availability of individual experts – and since experts come with their own bias and preconceptions, the solutions based only on their expectations often do not capture all the different aspects of the problem. Predictive analytics has the potential to provide value by combining expert knowledge with insights obtained from the data, and using real-world results to validate and corroborate expert's knowledge.

There are many possible approaches for this. Our approach is largely based on the ``wisdom of the crowd"; looking for consensus among distributed self-organized agents, and highlighting the odd-one-out. Our solutions combine several techniques, allowing for life-long learning under computational and communication constraints. It is a step towards autonomous knowledge discovery in domains where data volumes are increasing, the complexity of systems is growing, and dedicating human experts to build fault detection and diagnostic models for all relevant faults is not economically viable.

In our solution, embedded, self-organized agents operate on-board the vehicles, modelling their states and comparing across vehicles, to find systems that deviate from the consensus. The group (e.g., a fleet of vehicles) is used to provide a continuous standard that automatically deals with e.g. varying ambient conditions. The intention is to detect faults and learn the characteristics of faults without the need for human experts to anticipate and define them beforehand. This can be used to build up a knowledge base that accumulates over the life-time of the systems. Furthermore, automatically learned data representations are a valuable tool to monitor the health status of various components.

The overall scientific goal of the intelligent predictive maintenance research effort is to construct algorithms that build up knowledge about a fleet of vehicles, over time, so that the fleet becomes "self-monitoring". Such monitoring goes beyond just the predictive maintenance, although it is probably the most obvious and clear benefit. Self-monitoring systems can detect malfunctions and estimate the remaining useful life of different parts, but also identify other issues, such as inefficient or suboptimal usage patterns. Finally, they should be able to describe the normal operation based on operations of fleet of vehicles and learn from other vehicles' malfunctions. Ideally, they should be able to present surprising findings (novel knowledge) to the human operators. The ability to construct such self-monitoring systems will be necessary in a smart society with "internet of things".

Vehicles that are "self-aware", i.e., possess the capability to monitor their own operation, allow for many new services. Better service planning can be done not only by identifying the necessary repair with good lead time, but also by directly informing the workshops about the upcoming needs, to schedule the repair. Remote diagnostics, ordering the necessary spare parts, allocation of resources, all while taking into account customer preferences, location and available resources – all of this leads to improved customer satisfaction.

Many companies are working on new technologies for predictive maintenance and uptime. This includes the automotive sector but also most other industries. We have adapted the methods developed based on the Volvo use case to other domains, for example with Getinge Sterilization we are working on predictive maintenance of medical equipment, and within the SeMI project we collaborate with six different companies on creating methods for self-monitoring for district heating, heat pumps and industrial communication. Moreover, we are using many similar ideas and techniques in the healthcare area, within our growing collaboration with Region Halland and the Halmstad Hospital.

From the machine learning and data mining perspective, predictive maintenance is a uniquely interesting application domain. It showcases a number of issues that still remain a challenge, especially in combination, for state-of-the-art algorithms. Therefore, it is a good benchmark and validation domain for new methods and algorithms. Many of the issues here translate to other domains. For example, predictive maintenance deals with big streaming data that include concept drift due to both changing external conditions, but also normal wear of the equipment. It requires combining multiple data sources, and the resulting datasets are often highly imbalanced. The knowledge about the systems is detailed but in many scenarios there is large diversity in both vehicle model configurations, as well as their usage, additionally complicated by low data quality and high uncertainty in the labels.

New Project

HEALTH

Hazard Estimation and Analysis of Lifelong Truck Histories

Unplanned downtime can be avoided by accurate prediction of the failure through continuously monitoring of vehicles' health status. However, to reveal patterns behind failures in a system as complex as a modern truck, new methods for analysing the data need to be developed. The HEALTH project aims to create a sequence model capturing the lifelong history of a truck, and use it to explain relations between different events such as failures, repairs, fault codes - leading to better maintenance. HEALTH will enhance current 100% uptime promise of Volvo Trucks by expanding the existing range of predictive maintenance solutions. Novel machine learning methods for representing lifelong histories of trucks will be used to precisely identify vehicles that are likely to fail soon, and corrective actions will be suggested based on the probable failure causes. Overall effects will include prolonging vehicle life, providing more timely and cheaper maintenance, and increasing traffic safety. The HEALTH project is planned for two years, starting October 2017. The work will be carried out in a close collaboration between Volvo Trucks Aftermarket and Halmstad University. The project is divided into five work packages focusing on data aggregation, fully and partially observable sequence modeling, causal analysis and the demonstrator. Implementation includes research and development of new machine learning methods, their deployment, and finally evaluation in real business setting.

Meet
Sławomir Nowaczyk
Associate professor

Slawomir Nowaczyk was already a merited academic when joining Halmstad University eight years ago. Having finished his undergraduate and master studies in Poland, he moved on to earn a PhD in machine learning at Lund University and then returned to Poland to complete a Post doc.

–In Poland, academic collaborations with the industry are very rare, and that is what attracted me to Halmstad. Here, I was connected to Volvo immediately and throughout the years I have had the opportunity to initiate and take part in several collaboration projects with different companies, says Slawomir Nowaczyk.

–A major benefit with the strong focus on collaborations outside the academic world is the access that it gives to "real problems" that the industry faces every day.

–Being able to talk to people and understand the challenges they encounter when conceptualising, designing, creating and maintaining different products and services is a great inspiration. Helping them to come up with ideas and solutions is one of my main missions. What the industry faces every day is always a lot more complicated and intricate than the ideas I come up with sitting on my own in my office. There is always an entangled context that the solution needs to fit into, which poses additional constraints on what is feasible and what is not.

Slawomir Nowaczyk spends on average two days a week at Volvo in Gothenburg and is currently involved in a number of research projects concerning trucks and buses, in particular building self-monitoring systems for them. The collaboration started with Redi2Service project in 2010, in cooperation with Volvo Technology, focusing on diagnostics and prediction of maintenance as well as business models and new services that can develop from modern technical solutions. Current projects include ARISE and HEALTH, all funded by Vinnova FFI programme.

–I'm mainly looking at the data and aim to give the vehicles self-monitoring capabilities. Today's trucks have a lot of digital sensors that collect data, and computers that process it. Many different components interact with each other in complex and often unpredictable ways. One of the main challenges is how to make these computer systems learn to predict failures before they happen, and make them figure out for themselves when parts need to be replaced.

A major benefit with the strong focus on collaborations outside the academic world is the access that it gives to "real problems" that the industry faces every day.

When Slawomir Nowaczyk started to study computer science at master level he quickly got into machine learning. The idea of a computer learning new things, not only mindlessly repeating actions it was told to perform, appealed to him and has been the core of his research throughout his academic career.

–I want to learn about taking advantage of the ubiquitous data that is being collected nowadays, and what you need in order to provide computers with structures that allow them to generalise and build new knowledge. Gaining knowledge is something we do naturally as human beings but we don't know exactly how we do it. Now we are trying to equip our computer systems with similar competences.

–It's very exciting not only because of all the new things such intelligent computers will be able to do, but also due to all the new things we can learn about the nature of our own thinking processes.

One of the biggest challenges in machine learning, according to Slawomir Nowaczyk, is to add some of the core human characteristics to a computer – for example curiosity.

–In the fifties, artificial Intelligence researchers believed that playing chess is the ultimate intelligence test; once the computer can beat any human player, we will have achieved truly intelligent machines. But there is a lot more to real intelligence than just the mathematical or logical reasoning, he says and continues:

Sławomir Nowaczyk

Age: 40.
Title: Docent, Doctor, Associate professor in data mining.
Topics in focus: Data Mining, knowledge representation, joint human machine learning, self-organising anomaly detection, big data.

"We try to come up with methods and solutions that can work not only for a single problem, but for a whole bunch of them."

–If you put a person into a new environment, that person will not stand still, he will move around and interact with that environment. That is a characteristic that computers lack – but in order to be useful in the future they definitely need that kind of a trait. We can never predict everything that computers will encounter. They have to be able to identify things as interesting and try to deal with different novel situations on their own.

Slawomir is currently supervising six PhD students.

–Being an advisor to so many bright young people who are just now learning what does it mean to be a scientist is very rewarding, but also very challenging at the same time. Each of them is engrossed in their own project, with their own goals and their own dilemmas and frustrations – and it's up to us, the senior researchers, to show them how it all fits together.

At CAISR, a lot of effort is made on aligning research and finding similarities between different approaches leading to very fruitful interdisciplinary exchange.

–We try to come up with methods and solutions that can work not only for a single problem, but for a whole bunch of them. We try to identify the general principles within each particular project we work on. In that way, the algorithms we create can hopefully be used in many different ways. This is something I find very interesting and want to go deeper into.

Collaborating with the industry has provided Slawomir Nowaczyk with an extended network of academics and professionals, and this has given him insights – for example that many researchers face similar problems.

–The problems Volvo has with their trucks bear many similarities to the problems facing hospitals with their patients – once you look at data and large numbers, instead of what exactly those numbers mean, he says and describes a current project concerning hypertension patients.

–In this project we are trying to predict which patients will not fulfill their prescriptions and then we try to support them in order to improve medication compliance. It's a very important thing that will pay off in the future.

–Hypertension, at least in the milder forms, is example of disease that doesn't affect your daily life all that much today, but will do so in 5-10 years. The first phase of the project is to analyse why different patients don't take their medicine.

According to Slawomir Nowaczyk, there are a number of reasons. Some forget it, some mix up which pills to take at what time, some patients don't like the side effects. There is plenty of research on different possible reasons, so there is no need to start from scratch, and the project will build on that foundation.

In the future Slawomir wants to continue looking into similarities across different domains.

–My drive is to solve problems and come up with new solutions. Every time I solve a particular problem I get to discover new applications to which this solution can be adapted – or I get new ideas for improvements to address issues I did not think about before. Probably the most concrete goal in my professional life is to actually make a real impact towards building an artificial truly intelligent system.

AI for **Predictive** healthcare

Healthcare is facing major challenges; the current organization is not adapted to what will be required in the future. Changes in demographics are expected to create a greater demand for care and the discrepancy between the number of people in care-needing ages and the number of people in the labor force increases rapidly. In parallel to this, the disease panorama is changing, as well as the ability of the medical care to diagnose and treat diseases. New methods and drugs that reach the market tend to be advanced and costly. The healthcare system will simply put not fulfill its mission if it does not work differently from today.

In that perspective, health technology becomes central. There is considerable expectation that new technologies will fill the increasing gap between needs and resources. Large international investments are made in this area. Not least aimed at artificial intelligence (AI) since its methods are well suited for tasks that constitute the working days of healthcare workers: prediction and pattern recognition (read risk assessment and diagnostics). Neural networks/machine learning and other AI methods are particularly suitable for contributing to increased understanding of both complex organizational and biological systems. Healthcare needs to be part of the rest of society, where intelligent systems are developing and applying rapidly.

As a contribution to this development, Halmstad University, through CAISR and Region Halland, has established a research collaboration that enables real life studies where the conditions are optimized by having research staff employed with both parties. This allows researchers to work in the IT environment where the solutions will be applied. An important work during 2017 was to build the structure of cooperation by establishing contact routes, collaborative groups and mutual understanding of each other's conditions. This has been done, among other things, through joint initiatives such as predictive studies of emergency care patients, and a new project aimed at understanding how we can help patients achieve prescribed treatment (iMedA – a project funded by the Swedish Innovation Agency), intelligent home development work and collaboration within the Halmstad Health Technology Center (HCH). We have also begun exploring the opportunities for dynamic, need-driven duty roster planning in healthcare units based on predicted needs. Halland has excellent conditions for developing individualized care since Region Halland has developed the necessary IT support and systems for analysis and research, covering the patient's entire journey through the healthcare system.

Awais Ashfaq is one of the Ph D students working both at Region Halland and the university. Here on a Medical and Biological conference in Sarajevo.

During 2017 Halmstad University and Region Halland united and mobilized around going for a Vinnväxt initiative (a program funded by the Swedish Innovation Agency). The initiative as such aims at establishing a strong and sustainable innovation environment within Health Innovation in Halland, and further increasing integration between university, health and business.

Knowledge transfer between different applications has been central. Such disparate fields as intelligent vehicles and clinical decision support have much in common in their methodology, and CAISR strives to exploit these synergies. However, external knowledge is very valuable and Region Halland's collaboration with researchers affiliated with Harvard Medical School has contributed a lot to the knowledge in ongoing projects.

A development area that needs to be addressed is the integration of data from different sources. The development on the sensor side is swift, but it is necessary to integrate the information from many sources to get the overall picture of a person's or organization's current state. In order to meet the need for a more comprehensive picture, we will continue the work on infrastructure initiatives. The continued development of HCH's Test Environment Halland and the Halmstad Intelli-

gent Home (an initiative within CAISR) is central in this regard. Investing in test beds where companies, developers and public actors can meet is important to support the development and introduction of new digital products and services.

Wagner Ourique de Morais is demonstrating sensors in Halmstad Intelligent Home

We address the rapid digitization of society in a recently submitted application to the European Regional Development Fund (ERUF). The digitization leads to increased expectations for personalized solutions (services) with high quality and good accessibility. The rapid development we see in AI and the pressed resources means that a paradigm shift will take place in healthcare. When intelligent systems take over in areas such as prevention, detection, diagnosis and treatment, the flow in healthcare will change, as well as the professional roles. The way we prioritize care will change and home healthcare will develop and work methods will be streamlined. All signs indicate that more and more people will be cared for in their homes. Prevention services increase and people will gain (or will be expected to gain) greater influence over their health and care. The overall objective of our proposed project is to enable industry and the public sector to deliver the most competitive products and services for public and private care at home, with the individual at the center. A key part is to create a technical infrastructure that enables interoperability between different products and services, as well as enabling a transfer of information in the healthcare system. Among other things, the technical infrastructure will be evaluated and implemented in a private residential area – a test bed.

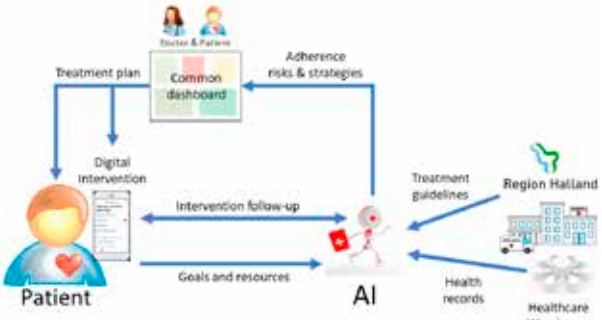
With these efforts we build a unique knowledge that gives us an opportunity to understand the complexity of healthcare and to prepare ourselves to understand the "new future". Connecting real-world needs and new technological advances, not least with AI, is a prerequisite for meeting the challenges that face healthcare.

New Project

IMedA

Improving Medication Adherence through Person Centered Care and Adaptive Interventions

The iMedA project will improve medication adherence for hypertensive patients through an AI agent that supports doctor and patient in collaboratively understanding key individual adherence risk factors and designing an appropriate intervention plan. iMedA will deliver the selected intervention through a mobile App and follow-up on its effectiveness improving the system over time. The combination of person-centered care and self-management interventions will lead to significantly improved health outcomes and reduced healthcare costs.

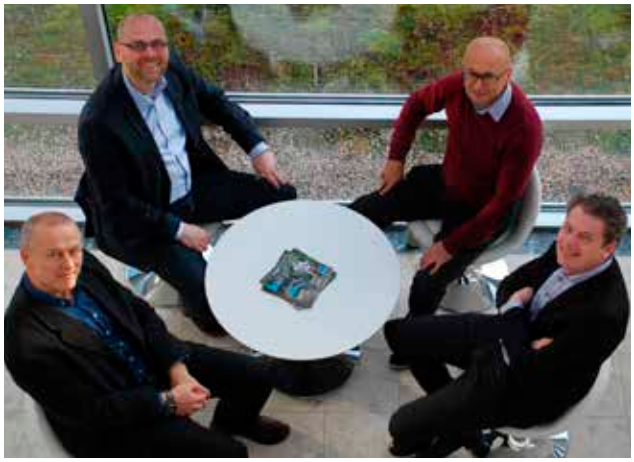


iMedA empowers hypertensive patients to take responsibility for their health through self-management, and provides doctors with information they need for person-centered care. To identify risks and intervention strategies, iMedA uses health records as well as self-reported input. The AI agent understands how both medical and personal factors interact with respect to medication adherence, and display this information on a "dashboard" that guides patient-doctor conversation. The AI monitors the effectiveness of interventions in order to improve over time. The iMedA agent will be built by combining three important AI techniques. First is to create a meaningful and comprehensive representation of each patient based on information fusion and representation learning. Second is to use peer group analysis and interpretable supervised machine learning methods to predict non-adherence for concrete patients. Finally, intervention strategies that are the most appropriate for a particular patient we will selected by combining data-driven and knowledge-driven approaches.

Organization

CAISR Management

CAISR is managed by the CAISR director with support from the academic management group, the industrial advisory board (IAB), the reference group (RG), and a project coordinator overseeing details regarding reporting, coproduction and information management. The academic management group consists of the three professors in CAISR and the head for the school of information technology. One of the professors also heads the department where CAISR is placed. This provides a very good overview of teaching, research, cooperation and coproduction. The two application areas, healthcare technology and intelligent vehicles, are discussed in two coordination groups on the School level. These two coordination groups are led by two professors (who come from outside of CAISR) and cover the two university-wide profile areas: health innovation and smart cities and communities.



The management group - Antanas Verikas, Thorsteinn Rögnvaldsson, Josef Bigun and Magnus Clarin

CAISR Reference Group

The CAISR reference group members serve a very important function in the development of the profile, serving as a sounding board for the CAISR management group. The group represents different important perspectives: international and national industry, as well as international and national academic research, related to intelligent systems. The reference group members meet and review the CAISR achievements and activities 1-2 times per year, providing advice and feedback on the progress. Each meeting is typically two days long.

Reference Group members (from left on photo above)

Christer Fernström	Director and consultant at Fernstrom et Associates in Grenoble, France and the CTO of CommuniTeams in Copenhagen, Denmark. Head of Reference group.
Robert Evans	Senior software engineer at Google, Mountainview, California.
Xin Yao	Chair Professor at Department of Computer Science and Engineering, Southern University of Science and Technology, Guangdong, China. Professor of Computer Science in the School of Computer Science at the University of Birmingham.
Birgitta Bergvall-Kåreborn	Professor in Information systems at Luleå University of Technology.
Charlotta Falvin	Chairman of the board for the Faculty of Engineering at Lund University and for the Lund research park Ideon. Member of the board for several companies.
Magnus Bergquist	Professor in Informatics. Leads the Knowledge Foundation-environment "Research for Innovation" at Halmstad University.

Terence Rogers, Toyota Material Handling, Thorsteinn Rögnvaldsson, Halmstad University, Mats Billenius, NEAT Electronics, David Lundqvist, Kollmorgen Automation and Siddhartha Khandelwal, Halmstad University on a visit in Fab Lab at Halmstad University. Fab Lab is part of a global network connected to MIT (Massachusetts Institute of Technology).

Industrial Advisory Board

The CAISR management is supported by the industrial advisory board (IAB), where each industrial partner in CAISR is represented, and a reference group. A key contribution of the industrial partners to CAISR is their involvement in the strategic planning. During 2017 we organized a workshop on the scientific agenda, the research questions and how they relate to industrial goals and strategies. All the partners were active in this workshop, in formulating relevant questions and setting these in relation to market development. It was clear from this workshop that it is not difficult to map high level research questions to very concrete and even short-term industrial goals. As such, CAISR is not just an industry co-funded research center; it is an industry-guided research center.

The IAB further give advice on the progress and activities from the industrial partners' perspective and take decisions when new industrial partners want to enter or partners need to leave. David Johansson from Tappa Service was the chairman during 2017 for the CAISR IAB. The IAB meet approximately semiannually in relation to the reference group meetings.

IAB Members

Emil Hällstig	Fotonic AB
David Lundqvist	Kollmorgen Automation AB
Mats Billenius	NEAT Electronics AB
Per-Arne Viberg	Swedish Adrenaline AB
David Johansson	Tappa Service AB
Jacob Arvidson Klint	Toyota Material Handling Europe AB
Petter Wirfält Andreas Jonsson	Volvo Technology AB/ Volvo Group Trucks Technology
Ervin Omerspahic	Volvo Bus Corporation

Below: Industrial Advisory Board and CAISR staff at a coffee break during a workshop held at Digital Laboratory Center at Halmstad University on March 31.

Meet Anita Sant'Anna

An Engineer with a Passion for Health

In all honesty, Anita Sant'Anna was considering becoming a medical doctor. However, after some time contemplating, she decided to study electrical engineering. Today she has managed to combine both her interests. Her research on health technology is about improving patients' health, in close collaboration with companies, hospitals and patients.

In her research, Anita Sant'Anna takes care of sensors, such as mobile phones and activity trackers

Anita says, "I like to help people. When I find out what the needs and problems are in the health sector, it motivates me to continue researching. This means that I want to find the solutions to the problems."

In her research, Anita Sant'Anna makes use of sensors, such as mobile phones and activity trackers, to collect or record patient health data. This can help doctors to get a clearer picture of how a patient feels or what the patient´s everyday life looks like. This can give forehand knowledge to help avoid an emergency situation developing. Furthermore, it gives the patient the opportunity to better healthcare through more careful monitoring and, therefore, better knowledge of his/her condition.

"The challenge is how the patient will get suggestions for better choices in their everyday life through their activity tracker, in both a positive and motivating way" - Anita Sant'Anna

Wants to Improve the Health Care

The basis of Anita Sant'Anna's research is about, togethe with several collaboration partners, improving the nursin and health of people. This is what drives her to continue t research, because it really does make a difference. Howeve the choice of becoming a researcher was not so clear-cut i the beginning for Anita Sant'Anna. She comes from a famil where most work as engineers, and in fact, she chose to be come an engineer herself, but with a focus on biomedicin At the same time, she wanted to do something different. Wit an interest in both study and travel, she combined her studies with discovering new places. Finally, she ended up at Halmstad University, following a tip from a friend concerning a doctoral position that suited her perfectly: a combination of technology and health.

During her doctoral studies, Anita Sant'Anna researched on how to monitor motion patterns by using sensors. She studied how patients walked with the help of sensors that were attached to the patients´ legs. By comparing how much deviation in the patient's gait (style of walking) had to a healthy person´s way of walking, people working within the health care system could get a clearer picture of a patient's illness or rehabilitation after, for example, an operation. Anita Sant'Anna has not only researched patients who have had hip replacements but she has also used sensors in research concerning people who suffer from Parkinson's disease.

An activity tracker used for collecting patient health data. Photo: Fitbit, Inc

“Doctors do examine how well the patient walks, but often by using a rather “crude” basic scale. By studying how the patient walks with help of sensors, you get more knowledge that you may not be able to see by the naked eye alone. This can help create a clearer picture of the patient's condition,” says Anita.

Health technique in focus

Anita Sant'Anna is still at Halmstad University. Her research is still about health technology. She is now researching how, with the help of technology, to help people suffering with osteoarthritis make healthier choices in their everyday lives. In her research, she uses the Fitbit activity tracker.

"The challenge is how the patient will get suggestions for better choices in their everyday life through their activity tracker, in both a positive and motivating way. The goal is that it will happen at the right time, for example, proposing a ten-minute longer walk when the patient is already out walking,” she says.

One of the main challenges in health technology research is the huge amount of data that is collected or which is possible to collect.

"It offers incredible opportunities. Nevertheless, at the same time, it is part of the challenge, because we need to find out what information we need, and then how to sort it out and be able to use it in the correct way,” say Anita.

According to Anita Sant'Anna, one of the main challenges in health technology research is the huge amount of data collected.

Collaboration is important

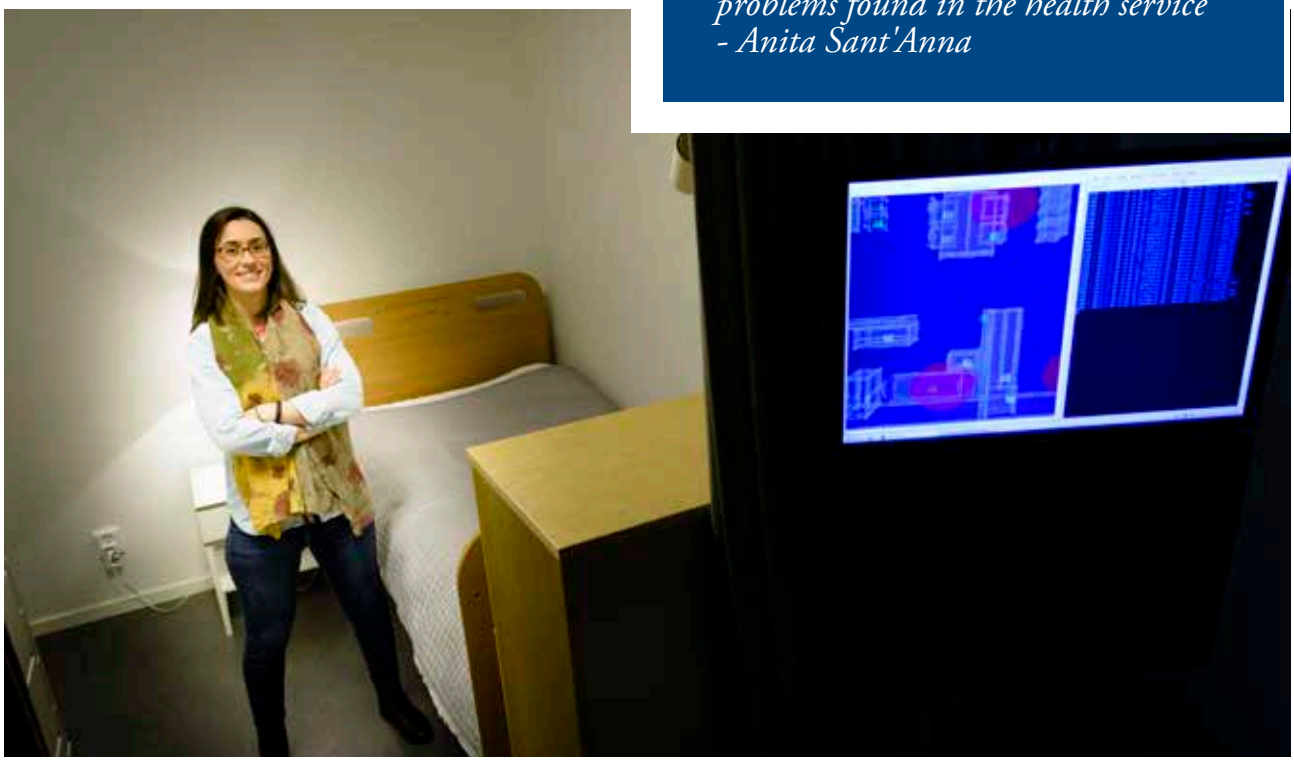
Anita Sant'Anna wants to continue researching, in collaboration with both industry and other institutions. She believes it is important that research is not only undertaken in the lab but also with different collaborators; i.e. working together with patients in the hospital and also with contacts with industry, so that they can see the potential of new products.

"The more we work together with industry, companies and institutions, the better we will be to solve healthcare problems.

Anita Pinheiro Sant'Anna

Born 1983 in Florianópolis, Brazil
Title: PhD in Signals and Systems from Halmstad University
Topics: Health Technology, machine learning, decision support

"The more we work together with industry, companies and institutions, the better we will be able to solve the problems found in the health service" - Anita Sant'Anna



Anita in Halmstad Intelligent Home, a realistic apartment for research and experiments for improved care

Meet the founder & director of CAISR
Thorsteinn Rögnvaldsson

Thorsteinn Rögnvaldsson has worked within the sphere of computer science at Halmstad University since 1996. His interest in artificial intelligence and machine learning was, however, established much earlier in life.

–It started already at upper secondary school. I was intrigued by the human brain and imagined building an artificial model on how it works. Later, when I saw the chance to do a PhD with a focus on neural networks and machine learning, it was the clear choice for me.

Even if his interest in the function of the brain has lasted throughout his academic career, Thorsteinn Rögnvaldsson's predominant research focus has been on applied intelligent systems, particularly in vehicles and health technology products.

He earned his PhD in theoretical physics at Lund University and switched to computer science during his postdoctoral studies at the Oregon Graduate Institute in the United States. Here, he discovered several things that were new to him – less locked positions between subjects than he had experienced in Sweden for example.

–People looked more at what you actually did than what topic background you had. Also, I saw a great interest in the USA in machine learning, it was something completely different from Sweden.

While in the United States, he had the opportunity to attend, present and publish at the NIPS[1] conference, which is considered to be the leading conference in machine learning.

–We also worked extensively with external parties there, both from the financial industry and from the American defence. In addition, we offered training courses in machine learning for professionals.

Between 2006 and 2010, Thorsteinn Rögnvaldsson was a professor of mechatronics at Örebro University, simultaneously working at Volvo Technology for two years, in a so-called "strategic mobility" project funded by the Swedish Foundation for Strategic Research.

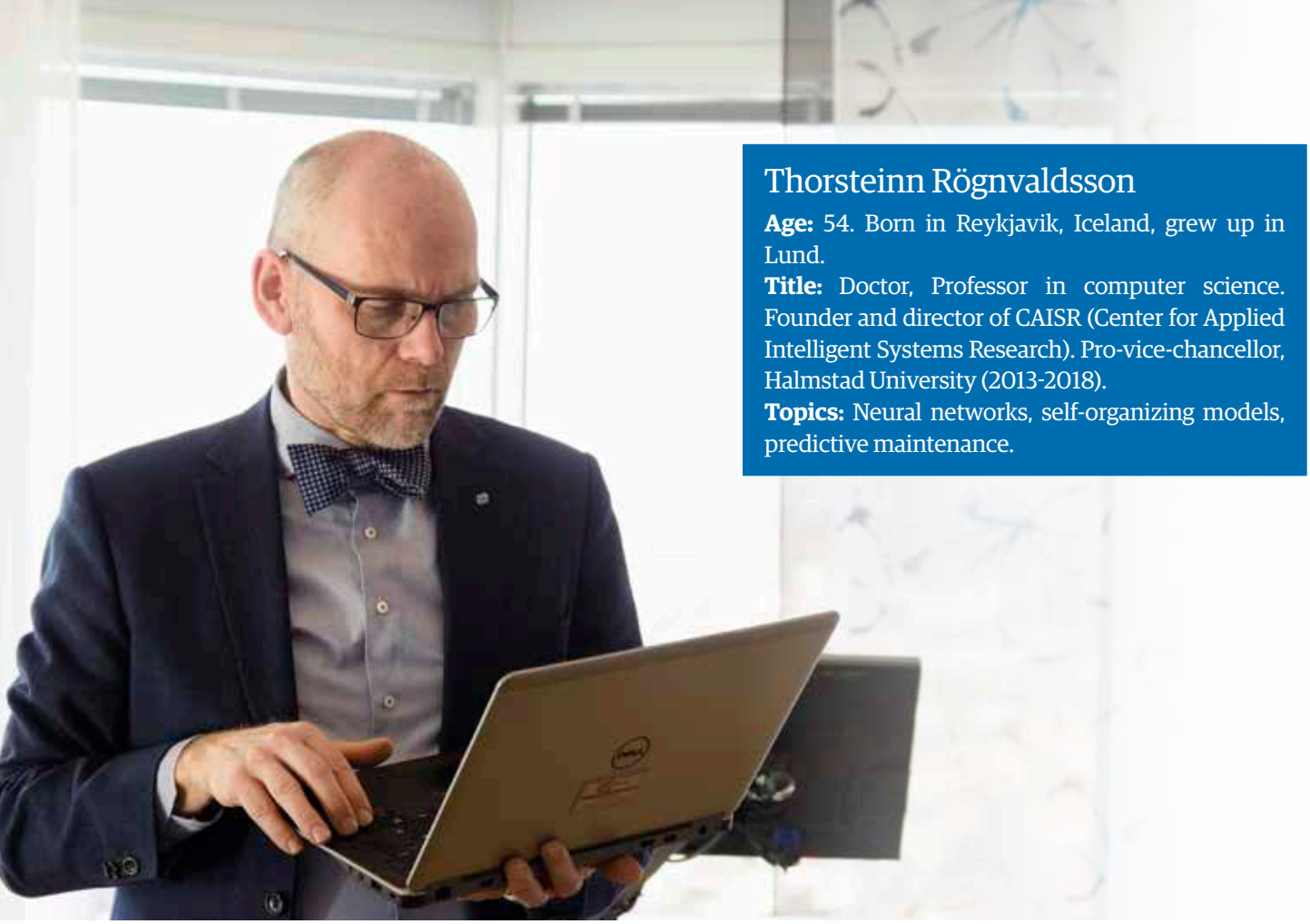
–I worked mainly with R&D and strategy, which was enriching in many ways. Being a part of (and understanding) the big organisation that is Volvo, created a lot of the foundation to what is today the core of the research carried out at CAISR, he says and continues:
–I am grateful that Volvo gave us the confidence to apply our ideas to the maintenance problem, using a machine learning approach. Our approach was conceptually quite different from the control theory approach, which was the dominant paradigm within diagnosis. Volvo invited us to test our machine learning and "wisdom of the crowd" approach already in 2005 and we managed to show that there were some gold nuggets in this. Today, machine learning is the hottest thing, but at the time it was not as popular. Volvo has really been a good partner for us here.

"Our grand aim is to build systems that can learn independently on their own, from their own experiences, and create knowledge from this."

In 2012, Thorsteinn Rögnvaldsson established the CAISR research center, where he is also the manager.

–I have always had a drive to contribute with something bigger. In 2004-2005, we discussed how to start a larger academic centre. The process took a few years, with some rejected proposals on the way, but we persevered and from January 1st, 2012, we were granted financing from the Knowledge Foundation.

1 NIPS - Annual Conference on Neural Information Processing Systems.



Thorsteinn Rögnvaldsson

Age: 54. Born in Reykjavik, Iceland, grew up in Lund.
Title: Doctor, Professor in computer science. Founder and director of CAISR (Center for Applied Intelligent Systems Research). Pro-vice-chancellor, Halmstad University (2013-2018).
Topics: Neural networks, self-organizing models, predictive maintenance.

The interest in artificial intelligence has exploded since the start six years ago. According to Thorsteinn Rögnvaldsson, CAISR's role is to aid Swedish industry as well as the public sector in becoming more efficient and competitive with the use of artificial intelligence and machine learning.
–Our grand aim is to build systems that can learn independently on their own, from their own experiences, and create knowledge from this, he says and continues:

–What we see now is that machine learning is appearing all over. The demand for more opportunities to use data and images for making better decisions is steadily increasing in all parts of society.

One apparent demand, according to Thorsteinn Rögnvaldsson, is within health care, where better decision making can be facilitated by using data mining and machine learning.

–We have a well-established collaboration with Region Halland. Region Halland have built up an excellent, even unique, data resource that unifies all their data and we can use this to extract lots of useful relationships; relationships that were largely unknown before. We have several interesting projects going on here.

During the past few years, Thorsteinn Rögnvaldsson hasn't had much time to commit to his own research. As director of CAISR and pro-vice-chancellor for Halmstad University, he primarily works with management on different levels, looking at for example the strategic development of the center. However, there is some time left to tutor doctoral students.

–My assignment as pro-vice-chancellor expires this summer, hopefully giving me the possibility to return somewhat to my own research while managing the research center and continuing with the tutoring. I will be taking on the responsibility as program manager for the university's KK-environment Research for Innovation. That will also take considerable time so I may be overly optimistic about time for my own research.

Thorsteinn Rögnvaldsson thinks he will stay with Halmstad University for a long time.

–I really enjoy being a part of the multicultural environment in CAISR. Here, people with different cultural backgrounds and experiences meet, with a common interest in intelligent systems. We also work together, and not just individually, and in close cooperation with industry in order to make an important contribution.

"What we see now is that machine learning is appearing all over. The demand for more opportunities to use data and images for making better decisions is steadily increasing in all parts of society."

Funding

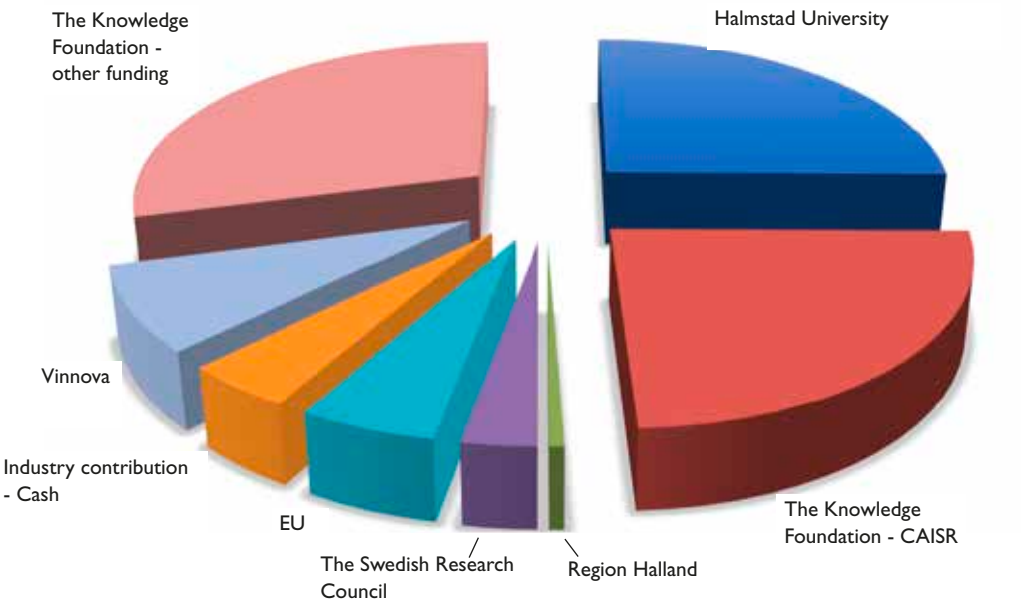
The annual research revenue in CAISR has now reached the level 20-25 MSEK (million Swedish kronor) on the university side (i.e. not including industrial in-kind efforts). The revenue growth has been well in line with our plan described in our proposal 2011. The industrial matching effort during 2017 equaled 3.8 MSEK. The total industrial matching to CAISR during the period 2012-2017 has exceeded 40 MSEK.

For 2017, about 5.1 MSEK were direct research funds from Halmstad University; the rest were external funds. Thus, CAISR had an external funding ratio of about 75%. This is also in line with the expected development we outlined in our proposal in 2011 (we predicted 70-80%). In 2016, however, the CAISR reference group pointed out that "maintaining a level of about 70-75% is very challenging". The major part of the external funding comes from the Knowledge Foundation: 5.3 MSEK directly for the CAISR profile and about equally much for other projects funded by the Knowledge Foundation.

Since the society demands for (and expectations from) AI and ML competence have skyrocketed, we expect that there will be more external funds available for the AI and ML fields. For example the Swedish Innovation Agency is increasing the calls with AI and ML directions. We also hope that the allocation of direct university research funds to CAISR will increase in the near future.

Financer	Budget 2017	Actual 2017
The Knowledge Foundation	6 549 596	5 372 632
CAISR Industrial partners (in kind)[1]	6 956 000	3 824 482
Other external funding[2]	11 000 000	11 062 454
Halmstad University	5 319 766	5 126 513
Sum total	**29 825 362**	**25 386 081**

1. All in kind contribution have been computed using the standard tariff of 800 SEK per hour (the actual company costs are sometimes larger than this and sometimes less).
2. Funding from other sources (VR, EU, Vinnova, companies...) not matching the Knowledge Foundation CAISR funding



Funding for CAISR research on the Halmstad University side 2017

Research for Innovation and CAISR

Halmstad University has a ten-year contract with The Knowledge Foundation to develop as a *Foundation Research Center*. The name for this venture is *Research for Innovation*, and it stretches between 2012 and 2021. Research for Innovation has a major influence on the development and profiling of the entire university. The goals of Research for Innovation are expressed in terms of four dimensions: positioning, branding/profiling, quality and relevance.

Positioning means to position Research for Innovation scientifically with respect to impact and specialization, and with respect to applied and fundamental research. The aim is to have both high consideration of use and high contribution to understanding (the Pasteur position in Pasteur's quadrant). *Branding/positioning* means that the university's profile as "The innovation driving University" shall be well known and recognized regionally, nationally and internationally. *Quality* means to further enhance the high quality in research and education, for students, for faculty and staff. *Relevance* means that Halmstad University shall be a strategically important partner for industry and public-sector organizations to maintain and develop their quality and regional, national and international competitiveness.

CAISR is a substantial part of Research for Innovation; about 25% of the Knowledge Foundation funds to Halmstad University are directed to CAISR. This means that CAISR is expected to be a major contributor to meeting the goals for Research for Innovation.

The strong scientific position for CAISR is described earlier in this report. We work to create innovations from our research, either through our partner companies or by researchers creating spin-offs. We monitor carefully our education and research quality. In 2017 was one of our Master theses awarded the best Swedish AI thesis by the Swedish AI Society. In 2017 were 93% of the courses given by CAISR staff rated "good" or "very good" by the students. The scientific impact, in bibliometric terms, of our publications is described earlier in this report. We establish and maintain strategic and relevance driving partnerships with our external partners.

Knowledge Foundation

The Knowledge Foundation is the research financier for universities with the task of strengthening Sweden's competitiveness and ability to create value.

The Foundation supports research that is conducted at Sweden's new universities, provided that industry provides a matching amount and actively participates in order to achieve development there as well.

The Knowledge Foundation was established in 1994 and since then it has invested close to 10 billion in more than 2,500 projects.

The Knowledge Foundation strives to help Sweden's new universities create internationally competitive research environments, work long-term on strategic profiling and increase cooperation between academia, industry, institutes and society. Universities are responsible for a significant portion of knowledge development and research. Many are leaders in their own special areas, cooperate extensively with industry and contribute to strengthening Sweden's competitiveness and creating growth.

Meet Antanas Verikas
Professor
From punch cards to artificial intelligence – from east to west

Antanas Verikas has seen the birth of artificial intelligence. Since his university studies in electronics in the early 1970's, the technology that enables artificial intelligence (AI) has evolved rapidly. The computer that back then occupied an entire room can now fit in a mobile phone. Meet the professor who has done research on behalf of the Soviet military, who climbs mountains in his spare time, and has developed Halmstad University's outstanding research within AI.

– When I studied at Kaunas University of Technology in Lithuania in the 1970s, there was only one computer in the entire university, and it took up the space of a large room. I had access to the computer once a week for two hours. That meant that I had to test the program in my head in advance. I learned to predict what would happen in each step of the program, says Antanas Verikas, Professor of Image Processing with focus on artificial neural network technology at Halmstad University.

The idea that a computer can mimic the human nervous system, and thus learn to make the right decision, was launched in the 1950's. In the mid-1980's, Antanas Verikas, who at the time was studying character and pattern recognition, was fascinated by this area called artificial neural network (neuron = nerve cell). A neural network is a structure that is trained to solve a particular problem. For example, it can recognise patterns in a large amount of data or it can create predictions. This can for instance be used to estimate whether a person is healthy or ill. Input is a set of health parameters, such as pulse and blood pressure. Output can in this case be an answer to if the person is healthy – a yes or a no. However, neural networks must be trained to provide the correct output, i.e. make the right decision.

– Today, artificial neural network models can be very complex and handle thousands of input variables. In my research, I have developed methods for assessing and selecting these variables, says Antanas Verikas.

A specific example of when these models can be used is in predicting muscle fatigue during exercise. Antanas Verikas and his colleagues at the Center for Applied Intelligent Systems Research (CAISR) measured in a research project cyclists' EMG signals, blood lactate concentration levels and oxygen uptake. The data was used to create models to evaluate the cyclists' physical ability under increased strain.

– This can, for instance, be used by an elite cyclist when setting up his or her training. The models provide important information about when a potential muscle fatigue occurs, says Antanas Verikas.

Research on behalf of the Soviet military

Antanas Verikas interest in hiking and climbing was stirred in young years. Every summer was spent in the Pamir, Tian Shan or Caucasus mountain ranges.

He grew up in Lithuania when the country was occupied by the Soviet Union. Soviet controlled large parts of the society – as well as the university's research.

– Most research projects at Kaunas Technical University were at that time commissioned by the Soviet military. During my time as a PhD student, we developed the navy's database for submarines. They wanted to transfer text on paper about the submarines to their database. Our mission was to create hardware and software for this, equivalent to today's scanner.

"Today, artificial neural network models can be very complex and handle thousands of input variables. In my research, I have developed methods for assessing and selecting these variables".

Antanas Verikas developed the software algorithms. Unlike today, all programming was done by hand, on paper. Paper strips were used to transfer programs to a computer, with holes representing the program code of ones and zeros. The strips, that could be over 30 meters long, were replaced by punch cards with the equivalent hole coding in the late 1970's.
– We had to write very effective programs because the memory of the computer was so limited at that time. The programs could not exceed 25 kb, if I remember correctly.

The application of the research results was classified. As a PhD student, Antanas Verikas went to Leningrad twice a year to report to the military what the research group had achieved.

– I was reviewed by a group of senior military personnel. I had to keep my head cool to answer, defend and explain our research, says Antanas Verikas and chuckles at the memory.

As an active researcher, you could not talk to fellow scholars outside of the Soviet Union. And you were not permitted to travel westward.

– I tried to go to Italy as a guest researcher in 1985, but the leaders in Moscow did not allow it. In 1991, the Soviet Union dissolved and the borders were opened. It felt amazing!

From paper and print quality to health innovation

Through one of his doctoral students at Kaunas University of Technology, Antanas Verikas established a contact with researchers at Halmstad University. And through a scholarship from the Swedish Institute, Antanas Verikas came to Halmstad in October 1992.

– I planned to stay for nine months, but 26 years have passed, he says with a smile.

"I planned to stay for nine months, but 26 years have passed".

Antanas Verikas

Age: 66. Born in Moletai, Lithuania
Title: Professor in pattern recognition
Topics in focus: Classification committees, feature selection; semi-supervised learning, fuzzy logic, analysis of pathological speech.

"I was reviewed by a group of senior military personnel. I had to keep my head cool to answer, defend and explain our research".

Antanas Verikas and his research team started a collaboration with several of Sweden's paper mills. They were interested in knowing which variables resulted in the best paper and print quality.

– As a spin-off, we also worked with banknotes. We developed hardware and software to assess the quality of the details on the banknote. The purpose was to determine if the printed notes were of sufficient quality to prevent copies. We delivered ready-made systems for this to, for example, the Bank of England in the early 2000's.

When CAISR was initiated in 2010, two application areas were defined: health technology and intelligent vehicles.

– A year later, we received funding from the KK Foundation. Since then our research center has grown every year, says Antanas Verikas.

2018 is Antanas Verikas final year as a researcher. When he retires by the end of the year, he wants to focus on his hobbies: hiking and mountain climbing. A certain longing for home can also be discerned:

– I want to travel! To visit Burma, Cambodia and Vietnam. Madeira is also fascinating. And I want to spend more time in Lithuania.

Meet **Josef Bigun**

The professor who wants to teach machines to see

When will we be able to teach robots to see like humans do? That means, to really interpret the surroundings and then make rational decisions. Today, research has not got that far. But Joseph Bigun, Professor of Signal Analysis, wants to be involved in the development of the first visually intelligent machine.

Perhaps vision is a human's most important sense. We can manage without it, but it's with our eyes most of us see and interpret the world.

– Our vision uses a great deal of our brain's capacity. We need to process all the visual data and then put them into context. It really applies to anything we want to do. Our vision is so essential to our lives that we hardly think about what we would do without it, says Josef Bigun.

Josef Bigun is a professor of signal analysis and intelligent systems. His research is about biometrics, i.e. technical means for computers to identify and collect information about us and our characteristics. It could be eye scanning, DNA, fingerprints or recognizing a walking style. This involves teaching computers visual intelligence, and eventually teaching a robot to recognize images or patterns.

– We already have computers with different types of intelligence, but it's not sophisticated. Currently, there are no robots with a visual intelligence so well developed that they can draw conclusions like we humans do.

Human vision is still largely superior to that of robots, but to succeed in making a robot copy the way we see the world is what fascinates and motivates Josef Bigun.

– It's a big challenge to teach a robot to do what we've learnt since we were children, he says.

It was a bit of coincidence that Joseph Bigun ended up at the University of Halmstad. After graduating with a MSc in engineering at Linköping University, he continued with a doctorate in computer science at the same university. After ten years as a researcher at the Swiss Federal Institute of Technology, he returned to Sweden and received a position at Halmstad University, which has become one of the premier institutions in Sweden for research in visual intelligence and in particular, biometric identification. The collaboration within the CAISR research group is important. The researchers discuss results and share ideas, and collaborate with many international colleagues. In 2016, CAISR organized the International Conference on Biometrics, with over 200 participants from around the world. It's one of the oldest and most respected conference regarding current research in biometric identification.

The research field in artificial intelligence is very active. It has also attracted much attention in media in recent years. While challenging, it's primarily a lot of fun, Josef Bigun thinks.

– There's a constant stream of new results published and things happening all the time. It has been like that for the past 40 years.

Josef Bigun's goal as a researcher is clear. He would like to leave a better world, he says, and as a researcher he wants to contribute to continually improving both the environment and our lives.

> *"Currently, there are no robots with a visual intelligence so well developed that they can draw conclusions like we humans do."*

– I don't try to solve all the problems myself, but in my niche, I try to see how we can contribute. For example, by cameras that help to recycle and make environmental benefits, or to improve future transport with autonomous vehicles. I believe in the role of knowledge; new knowledge will help solve several problems.

He also hopes that his research will be useful for the robots of the future.

– Robots will need to help with different things in the future, where we won't have enough human resources. Our society is still becoming more and more automated; what's left to automate is often linked to visual intelligence, he says.

For example, robots can help in healthcare, but the technology can also be used with other types of services.

– As an example, cameras and sensors could become intelligent and beep if you haven't turned off the stove. Or they could be used to check if a passenger has shown his ticket in a bus.

But it is not always easy to work with issues related to visual intelligence and intelligent computers. Sometimes the research is met with criticism and skepticism - or fear. Josef Bigun, on the other hand, argues that a future with visually intelligent robots is a bright future.

– Everything can be used for good or bad purposes. But I think intelligent systems really will be able to help us in the future. I think it's legitimate to be skeptical, that is why we should have better technology, make laws about using personal data and have good education about computers and artificial intelligence. It's much like cars: Traffic rules, better vehicles and infrastructure and driving license training make traffic safer. We don't ban the cars, the same goes for technology - by looking at the benefits and acting on several fronts we can minimize the risks.

The best thing about working as a researcher is producing new knowledge, Josef Bigun thinks; and it's something he can always do working in the research-group CAISR.

– We are constantly developing new knowledge. It's difficult to point to something that was particularly important in 2017. However, 2017 was better than all previous years because we are constantly building on our knowledge - it's like an artist who keeps working on a piece of art, he says.

Josef Bigun

Born: 1961
Title: Professor
Topics in focus: Computer and human Vision, Biometrics, Visual Intelligence
Freetime: Family, Walks, Human Languages & Weekend Cooking

"Everything can be used for good or bad purposes. But I think intelligent systems really will be able to help us in the future."

Licentiate exam

Iulian Carpatorea

Methods to quantify and qualify truck driver performance

Abstract

Fuel consumption is a major economical component of vehicles, particularly for heavy-duty vehicles. It is dependent on many factors, such as driver and environment, and control over some factors is present, e.g. route, and we can try to optimize others, e.g. driver. The driver is responsible for around 30% of the operational cost for the fleet operator and is therefore important to have efficient drivers as they also inuence fuel consumption which is another major cost, amounting to around 40% of vehicle operation. The difference between good and bad drivers can be substantial, depending on the environment, experience and other factors.

In this thesis, two methods are proposed that aim at quantifying and qualifying driver performance of heavy duty vehicles with respect to fuel consumption. The first method, Fuel under Predefined Conditions (FPC), makes use of domain knowledge in order to incorporate effect of factors which are not measured. Due to the complexity of the vehicles, many factors cannot be quantified precisely or even measured, e.g. wind speed and direction, tire pressure. For FPC to be feasible, several assumptions need to be made regarding unmeasured variables. The effect of said unmeasured variables has to be quantified, which is done by defining specific conditions that enable their estimation. Having calculated the effect of unmeasured variables, the contribution of measured variables can be estimated. All the steps are required to be able to calculate the influence of the driver. The second method, Accelerator Pedal Position - Engine Speed (APPES) seeks to qualify driver performance irrespective of the external factors by analyzing driver intention. APPES is a 2D histogram build from the two mentioned signals. Driver performance is expressed, in this case, using features calculated from APPES.

The focus of first method is to quantify fuel consumption, giving us the possibility to estimate driver performance. The second method is more skewed towards qualitative analysis allowing a better understanding of driver decisions and how they affect fuel consumption. Both methods have the ability to give transferable knowledge that can be used to improve driver's performance or automatic driving systems.

Throughout the thesis and attached articles we show that both methods are able to operate within the specified conditions and achieve the set goal.

Main supervisor:	Associate Professor Sławomir Nowaczyk, Halmstad University
Co-supervisor:	Prof.Thorsteinn Rögnvaldsson, Halmstad University
Discussion leader:	Prof. Mattias Wahde Chalmers University of Technology
Examiner:	Prof. Josef Bigun Halmstad University

Optimized driving for reduced fuel consumtion

Could less fuel have been used? That is a question asked in new research from Halmstad University. Since both the environment and company finances benefit from lower fuel consumption, it is important to investigate driver responsibility irrespective of load or weather conditions.

– My research thesis is about estimating how good a truck driver is in optimising fuel consumption. In other words, I want to be able to say whether less fuel could have been used in a specific situation if the driver had driven differently, says Iulian Carpatorea, PhD student in Signal and Systems Engineering at Halmstad University.

40 percent of costs

In his licentiate thesis "Methods to Quantify and Qualify Truck Performance", fuel consumption accounts for about 40 percent of vehicle operation costs. To reduce costs, it is for that reason important that the drivers are efficient in their driving. Since most of the goods within Europe are transported by truck, lower fuel consumption would also have a positive impact on the environment.

The methods used for calculating truck fuel consumption today are based on statistical averages, like percent of driving time used for breaking and time spent accelerating, which in these methods give different 'scores' for the driver. Iulian Carpatorea introduces two new methods to measure how the driver is acting in real driving situations.

– My methods also give the driver a score, but also aim to explain the behind the score, to say where, and why, during a stretch of driving the driver acted in one way or the other, says Iulian Carpatorea, and adds that one more important factor is being able to do that assessment even if important data is missing.

Reduce variations

One example of a driving situation is when the driver enters an area predisposed to heavy traffic. One type of behaviour is alternating between accelerating and braking, which is not very efficient from a fuel consumption point of view. A better way would be to lower the average speed to reduce variations.

Another example would be going up a hill, when the speed a vehicle has at the start of the climb affects the fuel use all the way over the hill.

– However, the most common reason for sub-optimal driving is the lack of anticipation, i.e. the sudden use of braking.

Iulian Carpatorea's first method quantifies fuel consumption and gives the possibility to estimate driver performance. The second method looks more at quality analysis, allowing a better understanding of driver decisions and how they affect fuel consumption.

– It is desirable to measure the driving without weather or vehicle load interfering with the result, or a driver in a truck with a light load, for example, would always have better performance than a driver in a heavily loaded vehicle.

Feedback in real-time

There is much work to be done in this field, concludes Iulian Carpatorea. The methods he has introduced can be further expanded.

– At the moment, my colleagues and I do our work offline, i.e. data is recorded with help of sensors, and is delivered to us for analysis. But there is also potential for adapting our work to an online environment and give the driver feedback in real-time.

Two methods are used

FPC (Fuel and Predefined Conditions) makes use of already known facts in order to incorporate the effect of factors that are not being measured. These could include wind speed and direction or tire pressure. Based on a set of assumptions, these unmeasured effects can be calculated, and the contribution to the influence of these variables can be estimated. This is required to be able to calculate the influence of the driver.

APPES (Accelerator Pedal Position – Engine Speed) seeks to qualify driver performance irrespective of the external factors by analysing driver intention with different decisions during the drive.

Licentiate exam

Hassan Nemati

Data-Driven Methods for Reliability Evaluation of Power Cables in Smart Distribution Grids

Abstract

This research aims to develop data-driven methods that automatically exploit historicaldata in smart distribution grids for reliability evaluation, i.e., analyzing frequency of failures, and modeling components' lifetime. The results enable power distribution companies to change from reactive maintenance to predictive maintenance by deriving benefits from historical data. In particular, the data is exploited for two purposes: (a) failure pattern discovery, and (b) reliability of power cables.

To analyze failure characteristics it is important to discover which failures share common features, e.g., if there are any types of failures that happen mostly in certain parts of the grid or at certain times. This analysis provides information about correlation between different features and identifying the most vulnerable components. In this case, we applied statistical analysis and association rules to discover failure patterns. Furthermore, we propose an easy-to-understand visualization of the correlations between different factors representing failures by using an approximated Bayesian network. We show that the Bayesian Network constructed based on the interesting rules of two items is a good approximation of the real dataset.

The main focus of reliability is on failure rate estimation and reliability ranking. In case of power cables, the limited amount of recorded events makes it difficult to perform failure rate modeling, i.e., estimating the function that describes changes in the rate of failure depending on age. Therefore, we propose a method for interpreting the results of goodness-of-fit measures with confidence intervals, estimated using synthetic data.

To perform reliability ranking of power cables, in addition to the age of cables, we consider other factors. Then, we use the Cox proportional hazard model (PHM) to assess the impact of the factors and calculate the failure rate of each individual cable. In reliability , it is important to consider the fact that power cables are repairable components. We show that the conclusions about different factors in PHM and cables' ranking will be misleading if one considers the cables as non-repairable components.

The developed methods of (a) are applied on data from Halmstad Energi och Miljö (HEM Nät), Öresundskraft, Göteborg Energy, and Växjö Energy, four different distribution system operators in Sweden. The developed methods of (b) are applied on data from HEM Nät.

Main supervisor:	Associate Professor Sławomir Nowaczyk, Halmstad University
Co-supervisor:	Dr. Anita Sant'Anna Professor Antanas Verikas Halmstad University
Discussion leader:	Niklas Lavesson, Professor Blekinge Institute of Technology
Examiner:	Tomas Nordström, Professor Halmstad University

Mining historical data enables power companies to predict and prevent power outages

Since 2014 Hassan Nemati's research focus has been on estimating the reliability of underground power cables by using historical data. This means, estimating how reliable a cable is without installing additional sensors in a power grid. On September 29, Hassan Nemati will present the research during his licentiate seminar at Halmstad University.

– My research project is a collaborative work with Halmstad Energi och Miljö AB (HEM Nät), the electricity distribution company which operates in and around Halmstad city. The aim of this project is to reduce the number and duration of electricity outages at HEM's electricity grid. We investigate and implement data mining techniques to discover patterns in previous outages, and model power cables' lifetime, says Hassan Nemati.

Hassan Nemati is a doctoral student at the Embedded and Intelligent Systems Industrial Graduate School (EISIGS) at Halmstad University. As an EISIGS-student, he works both at the University and at the industrial research partner – in this case HEM Nät.

– I spend one day per week at the company but this will probably be increased in the future. This collaborative work is very efficient for my research since I get the chance to meet and discuss with experts at the company regularly, says Hassan Nemati.

The method is spreading to other Swedish power companies

When we met Hassan the project team was having a monthly meeting in a modern office building at HEM. Advisors from HEM, and supervisors from Halmstad University were gathered to see the latest results in Hassan Nemati's research. On September 29, Hassan Nemati will present his licentiate thesis which is based on the research that he started in 2014.

In his licentiate thesis "Data-Driven Methods for Reliability of Power Cables in Smart Distribution Grids", historical data is used for failure pattern discovery and reliability of power cables. The method he proposed for failure pattern discovery got attention from other electricity distribution companies in Sweden such as Öresundskraft, Göteborg Energy, and Växjö Energy. These companies asked if their data also could be analysed by Hassan and, after receiving the outcomes, the companies claim that the results were very beneficial.

The method that Hassan Nemati has proposed for reliability of power cables is currently being evaluated by HEM Nät as a method to prevent failures of cables. According to the method, the reliability is estimated based on different factors such as previous failures, number of cable joint, and geographical position. The cables are then ranked for prioritising maintenance actions.

Research that will improve services for the customers

Alexander Örning and Peter Addicksson, both Electrical Engineering alumni from Halmstad University, are Hassan's supervisors at HEM. They believe that the research collaboration is good for both the company and their customers.

– We could clearly see that this work, now and in the future, can help us in the maintenance work, says Alexander Örning, manager and engineer at HEM Nät.

The future work of this project focuses on deviation detection of power components by using data collected from smart meters.

– Since 2009 we use smart meters that give us different types of data, such as power quality, active and reactive power, and alarms. We receive a huge amount of data and now, through the collaboration with Halmstad University, we can use it and try to predict problems before they occur, says Alexander Örning.

– We have several ongoing collaborations with Halmstad University, using research to increase sustainability and improve services for our customers. We can´t sit and wait for others to come up with the innovations that we need. Hopefully we, in our turn, can spread Hassan's knowledge, and also give him all the help he needs to reach great results, says Alexander Örning.

Hassan Nemati will continue his research towards a PhD:

– My goal for the coming years is to investigate smart meters' data. Mining and analysing these data can provide valuable information which could be used to improve reliability and increase efficiency.

Some Highlights

Wouter De Mol, master student from Katholieke Universiteit Leuven, Belgium, has just passed the exam with his master thesis "Comparison and evaluation of the accuracy of accelerometers and gyroscopes for detecting gait events in a real life setting".

PhD student Siddhartha Khandelwal and the master students Lohith and Wouter, calibrating shimmer sensors for data collection. The work was done for comparing the performance of accelerometers vs gyroscopes for doing real-world gait analysis.

Running athlete performing a maximal lactate test on a treadmill. Data of lactate, oxygen consumption, muscle activity, acceleration and feet pressure is captured during an incremental running test. The data analysis aims to predict fatigue from indirect measurements.

PhD students Iulian Carpatorea and Ece Calikus on CAISR workshop, June 14, preparing for Reference group meeting. The workshop took place on Digital Laboratory Centre at Halmstad university..

Autonomous Driving, a round table discussion with Melissa Cefkin. Principal Scientist and Design Anthropologist in Nissan's Silicon Valley research center. The discussion gathered researchers and company representatives from companies related to the automotive industry.

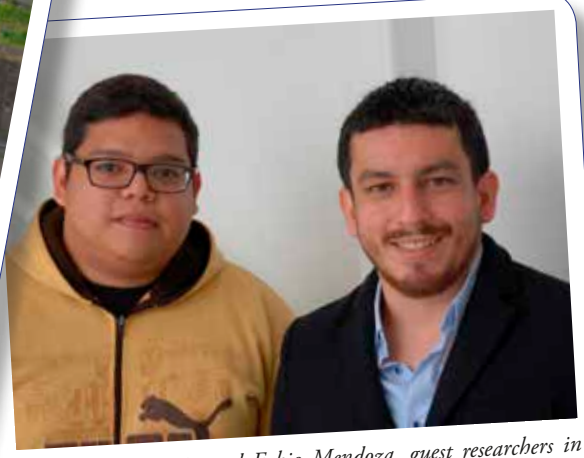
Melissa Cefkin, Nissan Silicon Valley Research Center.

Researchers and company representatives for the Synergi project "Self-Monitoring for Innovation (SEMI) – Meta-Framework for group-based self-monitoring, gathered for a project meeting on March 30.

Bendik Bygstad, professor of Informatics at the University of Oslo, and international guest professor at Halmstad university, gave a talk on May 23. The talk was entitled "Process innovation with light-weight IT" and explained a successful case of digitalization of a Norwegian hospital.

Dr Grzegorz Koczyk from Institute of Plant Genetics at Polish Academy of Sciences visited us for some days in March. Among other things he gave a seminar on "Phylogenomics, tree reconciliation and secret histories of fungal chemical warfare".

The CAISR Reference group gathered for meeting in June, Christer Fernström, Robert Evans, Xin Yao, Birgitta Bergvall-Kåreborn, Charlotta Falvin and Magnus Bergquist.



Miguel Angel Ortiz and Fabio Mendoza, guest researchers in the REMIND project from Universidad de la Costa, Colombia. Miguel and Fabio worked together with CAISR researchers on improving models for activity recognition in smart homes and emotion recognition from EEG signals respectively. The photo is from the beginning of October, when both of our guest were here at the same time.

Ece Calikus (to the right) is explaining the ideas behind the synergi project SeMI, in which three projects are working together to solve a comprehensive research question. Charlotta Falvin from the reference group to the left.

The master student Thomas Rosenstatter (to the right) wrote the thesis Modelling the Level of Trust in a Cooperative Automated Vehicle Control System. The thesis resulted in a publication in EIII Transactions on Intelligent Transportation Systems. This thesis also received the 2017 Best AI Master Thesis Award from the Swedish AI Society. The supervisor Cristofer Englund to the left.

Simon Thelin and Oskar Svensson, former students at Halmstad University, won the first prize for the best bachelor thesis work within the engineering programmes at the School of Information Technology. HMS presents the best thesis project with The HMS Scholarship of 20,000 SEK. The students were also rewarded 50.000 SEK from Sparbanksstiftelsen Kronan. Simon and Oskar wrote a conference paper "Indirect Tire Monitoring System - Machine Learning Approach", that they presented at a conference in Romania. CAISR staff were supervisors.
Photo: HMS Networks

The cooperation with Region Halland and Hallands hospital Halmstad opens interesting possibilities for promising students. Alexander Galozy, master student within the programme embedded and intelligent systems, presents results from his ongoing thesis work "Data-mining medical records to predict primary medication adherence for hypertensive patients"

A study on Parkinsonian gait using smart wearable sensors and PAMM-II robotic walker. The study was conducted at Donald Gordon Medical Center in Johannesburg, South Africa, in collaboration with the University of Witwatersrand. The aim was to develop an intelligent aware system that monitors Parkinson's symptoms using wearable sensors in a natural environment.

New Project

Active at Work

Optimizing physical activity at work with personalized decision support among individuals with osteoarthritis

The aim of Active@Work is to explore if mobile technology including a personalized decision support system, can have any effect on physical activity level, health, work ability, quality of life, work productivity or sick leave among individuals with osteoarthritis (OA). We also aim to study if there is any difference in effect between using mobile technology and activity monitoring alone or when continuous feedback concerning physical activity is added. Participants will be allocated through a patient education program for OA and randomized into either (A) Patient education program and physical activity monitoring, (B) Intervention A plus continuous feedback concerning physical activity or (C) Patient education program (control). The intervention will be performed during three months, with measurements at baseline, and follow-ups after 3, 6 and 12 months. Patient-reported outcomes, outcomes from technical devices and register data will be evaluated. Lund University is responsible for the randomized controlled trial and Halmstad University is responsible for developing the mobile technology and activity support in the project. Inclusion of patients in the project is expected to start in spring 2017 and to continue until 2019. Analyses and manuscript writing will be performed during 2019. This project will show how technological solutions can be used to develop evidence-based treatment models to improve health and work ability which can be effective as first line treatment of OA.

Tommy Salomonsson lecturer at CAISR driving a virtual excavator. The simulator is created by six students, two from each: computer-, electrotechnical- and mechatronics engineering. Tommy was their supervisor in the project. The simulator connects a virtual environment to a platform that moves and reacts according to the excavator work. Patrick Karlsson that worked with the gamification software is supervising the work.

Maria Lindén, professor in health technology from Mälardalen University, gave a talk about embedded sensor systems at the event "Smarter Electronic Components & Systems" at Halmstad University, October 25.

PRIME

Predictive Intelligent Maintenance Enabler

New Project

The goal of this project is predicting failures in a fleet of sterilizers deployed in hospitals all over the world. The characteristics of this problem are general to the field of predictive maintenance for different application fields. Companies are interested in predictive maintenance to reduce the down time of their machines. In general the list of critical components, whose unexpected breakdowns would result in stopping the machine, is long. Therefore, the scope of a predictive maintenance system should be predicting failures in a big number of different components. For several years, systems such as cars, sterilizers or industrial equipment have been equipped with a significant amount of sensors. Which signals to record is in general not decided based on the predictive maintenance needs, but on the requirements of security or controllers among other reasons. The sensors mounted usually don't describe the particular behavior of the components of interest, but measure physical quantities that can be influenced by the different behavior of several components. Predicting what component will fail when requires historic data about the operation of the machines, but also needs to be linked to the occurrence of failures, so that we can label the recorded data. In general, companies have access and store data coming from their machines, but don't necessary have access to the whole history of repairs. The owner of the machines can decide whether to perform maintenance and repairs with the official service or any other unofficial service. The main research goal of this project is to build a framework that allows predicting all type of failures that can happen in a machine.

Getinge Disinfection Washer. Photo: Getinge AB

The Embedded and Intelligent Systems Industrial Graduate School (EISIGS) made a study tour to the Netherlands in late October. Here's the group gathered outside one of ASML's plants in Veldhoven. The company have more than 16500 employees worldwide. On the photo (from left): Maytheewat Aramrattana, Stella Erlandsson, Magnus Jonsson, Hassan Nemati, Harold Weffers (Technische Universiteit Eindhoven), Richard Bunk (Combitech AB), Dulce Goncalves (Combitech AB), Benjamin Vedder (Research Institutes of Sweden AB), Hawar Ramazanali (SAAB AB) and Yuantao Fan.

For the second year in a row, Halmstad University won the Cross-Spectrum Iris/Periocular Recognition COMPETITION, in the periocular modality. Results presented at the International Joint Conference on Biometrics, IJCB 2017 in October. Fernando Alonso-Fernandez receivied the diploma.

Another stop at the EISIGS study tour where at Philips Lightning Research. Hassan Nemati is trying a demonstrator of Philips indoor positioning systems. The light from the luminaires sends a unique code to a mobile device and pinpoint the location on a map.

On December 7 Halmstad University and CAISR, including the Reference Group and Industrial Advisory Board, were visited by a group from SAFER. The research at Halmstad University within the automotive area was presented on a poster session. SAFER is a competence centre where partners from the Swedish automotive industry, academia and authorities cooperate to create a centre of excellence within traffic safety research and safe mobility. Halmstad University is a member in SAFER.

Amer Mohammed (sitting in fron), head of digital innovation at Stena Line, met with (from left) Antanas Verikas, Magnus Bergquist and Slawomir Nowaczyk on November 1.

Marlena Nowaczyk, guest lecturer from AGH University of Science and Technology, Cracow, Poland. During her visit at CAISR, she gave the course 'Advanced mathematics tools 3 ECTS' for PhD students.

OCULAR

New Project

Ocular Biometrics in Unconstrained Sensing Environments

This is a four-years project financed the Swedish Research Council. The project is concerned with ocular biometrics in unconstrained sensing environments. Attention will be paid to the periocular modality (the part of the face surrounding the eye), which has shown a surprisingly high discrimination ability, and is the facial-ocular modality requiring the least constrained acquisition. One goal is to contribute with methods for efficient ocular detection and segmentation. This is still a challenge, with most works relying on manual image annotation, or on detecting the full face, which may not be reliable for example under occlusion. We will continue initiated work with symmetry filters, and will explore deep learning algorithms too, which are giving promising results in many computer vision tasks. Low resolution is another limitation. Thus, another goal will be super-resolution (SR) reconstruction of ocular images. With few works focused on iris, and none on periocular, adaptation of the many available SR methods to the particularities of ocular images is a promising avenue yet to be explored. Ubiquitous biometrics has emerged as critical not only in light of current security threats (e.g. identifying terrorists in surveillance videos), but also due to the proliferation of consumer electronics (e.g. smartphones) in need of continuous personal authentication for a wide variety of applications. By our contributions, we expect to be able to handle a wide range of variations in biometric imaging from these scenarios.

Anna Mikaelyan, former PhD student at CAISR, who graduated 2015, conferred a doctor's degree at the Academic Ceremonial on November 17.

In Dec. 2017, Eric Aislan Antonelo gave a short PhD course on Echo State Networks (ESNs) and held a number of practical sessions, collaborating with PhD students on applying ESNs to model complex processes and solve problems in the industrial domain.

Eric received his PhD from Ghent University on the topic of reinforcement learning of robot behaviour for navigation tasks. He is now a research associate at Service and Data Management in Distributed Systems group (SEDAN), University of Luxembourg, and his research interests include reservoir computing, machine learning, fraud/anomaly detection, robot behavior learning, and system identification.

Cristofer Englund is adjunct senior lecturer within CAISR. His main occupation is research manager at RISE Viktoria where he leads a group of researchers that work on cooperative and automated vehicles. His research concerns behavior modeling of humans and vehicles to improve traffic safety, efficiency and comfort. Cristofer is now in the final stage of becoming Docent at Halmstad University.

Sepideh, Ece, Anita, Rebeen, Naveed, Yuantao, Parivash and Martin on the annual November workshop.

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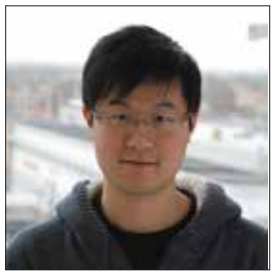

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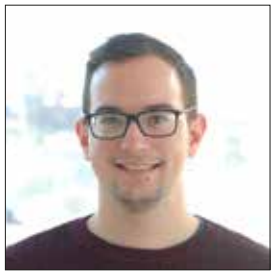

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CAISR Publications 2012–2017

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2013

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Thanks to:

Our main funder

The Knowledge Foundation

Our Industrial partners in CAISR:

Fotonic AB
Kollmorgen Automation AB
NEAT Electronics AB
Swedish Adrenaline AB
Tappa Service AB
Toyota Material Handling Europe AB
Volvo Technology AB/ Volvo Group Trucks Technology
Volvo Bus Corporation

And partners in projects supported with other funding than the Knowledge Foundation CAISR funding:

Affecto Sweden AB
Alfa Laval AB
EasyServ Sweden AB
Fysiotest Europa AB
Getinge AB
Halmstad municipality
HEM - Halmstad Energi och Miljö AB
HMS Industrial Networks AB
HotSwap Norden AB
Region Halland
SWATAB
Sydpumpen AB
Öresundskraft AB

CAISR

CAISR, the Center for Applied Intelligent Systems Research, is a long-term research program on intelligent systems established by Halmstad University. The program is funded by the University and the Knowledge Foundation with support from Swedish Industry.

The subject expertize in the center is in signal analysis, machine learning and mechatronics. The center also has an emphasis on cooperating systems, in line with the research focus for the larger EIS environment. Several industrial partners are collaborating with researchers from the University in joint projects, and take an active part in the development of CAISR. The key application areas that the center does research in are intelligent vehicles and health technology. The industrial partners include multinational companies as well as research-based growing companies.

The mission of CAISR is to serve and promote the development of industry and society. It is a center for industrially motivated research on the future technologies for and application opportunities with aware intelligent systems. CAISR will serve as a partner for industry´s own research and development, as a recruitment base for those who seek staff with state-of-the-art knowledge in intelligent systems technologies, and as a competence resource for industry and society. All research is conducted within different research projects.

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Halmstad University, School of Information Technology, March 2018