/imagine

prompt

a futuristic and innovative research lab at Halmstad University in Sweden, filled with a dynamic and diverse team of researchers engaged in cutting-edge AI projects. In the foreground, a group of professionals are collaborating on an advanced neural network, symbolizing the breakthroughs in AI research achieved in 2023. The background is bustling with activity, featuring robots working alongside humans. Throughout the space, interactive displays and digital screens showcase key accomplishments and innovations from the CAISR research environment during the past year, including advancements in machine learning, robotics, ad AI etichs. The image convey a sense of progress, collaboration, and dedication to making a positive impact on society trough AI research. –style raw—ar 2:3

CAISR

Center for Applied Intelligent System Research

Annual Report 2023

HALMSTAD UNIVERSITY

Generative AI was one of MIT Technology Review's 10 Breakthrough Technologies of 2023. And in 2023, AI-generated images certainly got a lot of attention. The initial feeling was that this signaled the end for illustrators, and companies offering software for illustrators worked on providing generative AI plug-ins. Then, towards the second half of 2023, the discussion turned towards the ethical and sustainability aspects. Whose data are the models trained on? Do these people also own a part of the product? Generative AI consumes a lot of energy and has a significant environmental footprint, not least in all the freshwater used for cooling the computing hardware. We, therefore, opted to go for the most energy-efficient, sustainable, and creative generative model around – the human brain – to create the image for our cover. It is just the prompt, and we leave the rest to your imagination.

CAISR

Center for Applied Intelligent Systems Research

Annual Report 2023

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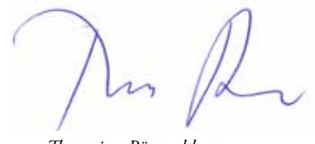
Introduction

2023 was a great year for Halmstad University. All performance indicators increased from 2022; publications, education volume, research volume, and scientific impact. The CAISR center contributed a lot to this. The number of scientific publications from CAISR in 2023 was almost doubled compared to 2022. Our share of the top 10% cited papers in the world again rose above 20%. Our research volume was almost a third larger than in 2022. In 2023, our research in machine learning predictive maintenance was reviewed with very good results. More and more students and professionals want to follow our education programs and online courses. In 2023, two of our Bachelor students were awarded the prestigious Wiman prize by the organization Sweden's Engineers. This is the second time in the past five years that the Wiman prize is awarded to students from Halmstad University, both times for thesis projects supervised by CAISR faculty.

Interest in AI and machine learning continued to grow fast in 2023. Gartner (gartner.com) estimates that Generative AI reached its "Peak of Inflated Expectations" in 2023, that there is a "Through of Disillusionment" coming soon, and that a plateau of steady productivity will be reached in 2-5 years. There are definitely signs that services like Stable Diffusion are not as "hot" anymore. However, Generative AI like ChatGPT is a technology that many have assimilated very quickly, not least students, and found useful. Or, as Will Douglas Heaven eloquently phrased it in MIT Technology Review (January 8, 2024): "Never has such radical new technology gone from experimental prototype to consumer product so fast and at such scale." The development of services in this field is extremely rapid, which indicates that we might see an approach to real and steady productivity very soon.

The rapidly growing interest in AI is also reflected in our researchers' activities. We have never before, in any year, done so many outreach activities (seminars, tutorials, podcasts, books, blogs, workshops, etc.) as in 2023. About one outreach activity was done each week all through 2023. This was to regional, national, and international audiences. We appeared in national television news, in several pod sessions, in panels in Halland Tech Week, in breakfast seminars for local companies, in seminars to professionals, and in international expertise panels.

In this report, we detail some highlights of 2023, describing our main research directions, our results in research, and new projects in education. 2023 was a great year, for Halmstad University and for CAISR.



Thorsteinn Rögnvaldsson

CAISR scientific agenda

The overall scientific agenda for CAISR is Aware Intelligent Systems Research. With this, we mean research on the design of systems that, as autonomously as possible, construct knowledge from real-life data, created through the interaction between a system and its environment. This means dealing with streaming data. It means constructing systems that can handle events that are unknown at the time of design. Our motivation for working with aware systems research is to approach the construction of intelligent systems that can do "life-long self-learning," i.e. that require less supervision and are capable of handling surprising situations.

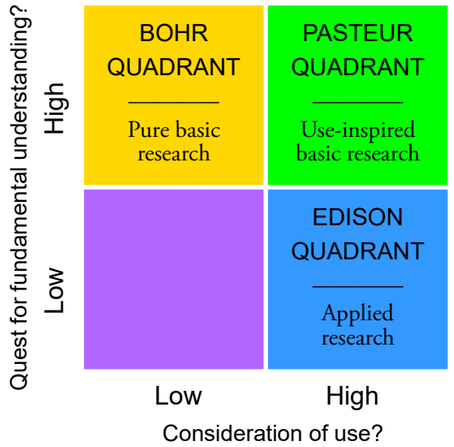
In order to do so, systems must become more "aware" and able to learn on their own. Our view on aware systems research builds on the knowledge pyramid, often referred to as the Data, Information, Knowledge, and Wisdom (DIKW) hierarchy[1] illustrated below.

The Data level is related to the collection and representation

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

of data. Open questions include how to autonomously select what data to collect, how to learn good data representations, and how to assess the present or future relevance of data streaming from all types of sources and with varying degrees of quality. The Information level is related to the creation of "events" from the data in the previous layer, answering questions such as "who," "what," "when," or "how many." This requires classification, sorting, aggregation, and selection.

Open questions in the information level are related to how to cluster and categorize events for current or later use, either autonomously or with limited interaction with a human, and in non-stationary changing environments. The Knowledge level relates to the creation of "rules" from the information; matching "events" (inputs) to correct responses (targets). This typically requires combining information from several sources. Open questions here are, e.g., how to efficiently incorporate humans in the process, combining human- and machine-generated knowledge, or how the knowledge should be represented. The Prevision and Understanding level (often referred to as the Wisdom level) is related to answering "what will happen" or "why." This deals with such concepts as explainable AI; reasoning forward through scenarios, or reasoning backward through a chain of events to explain them.



In CAISR research we focus on the Pasteur corner of the "Pasteur Quadrant", and work with relevant problem areas that fit the aware systems research framework in close cooperation with external stakeholders outside academia.

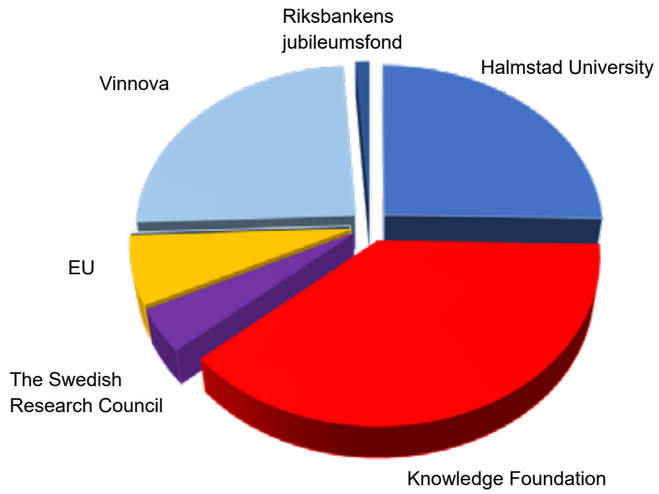
Our scientific agenda naturally leads to applied research on topics like feature learning, semi- and self-supervised learning, meta-learning, transfer learning, joint human-machine learning, and explainable AI.

1 Rowley, J. (2007), "The wisdom hierarchy: representations of the DIKW hierarchy", Journal of Information Science, 33, pp. 163-180.

Funding

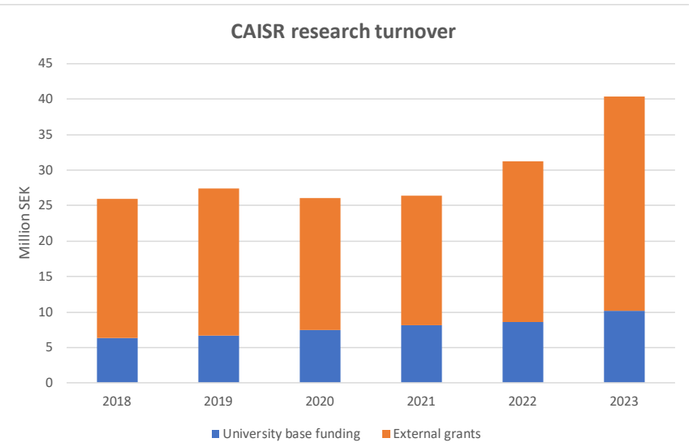
In 2023, the research turnover in CAISR was roughly 40 MSEK (million Swedish kronor) on the university side, i.e. not including in-kind efforts by our partners. This is almost a 30% increase from 2022 (31 MSEK). The external funding ratio increased (75% in 2023, cf. 73% in 2022). The sources of research funds to CAISR (on the Halmstad University side) are illustrated in the pie diagram to the right. The three largest sponsors were the Knowledge Foundation, Halmstad University, and Vinnova (Sweden's Innovation Agency). The fourth largest funder was the European Union. Both the Knowledge Foundation and Vinnova support projects that are done in very close collaboration between academics and industry (or the public sector). The Knowledge Foundation and Vinnova funding together contributed with more than half of the total research funding for CAISR in 2023.

Funding on the University side 2023



CAISR growth

CAISR research has expanded a lot over the last 2-3 years, as shown in the bar diagram to the right. This is probably due to the increased interest in AI and ML and the fact that CAISR and Halmstad University have become more known nationally in this field. The external funding ratio has remained high, in the range 70 – 75 % over the last six years. Most of the projects are conducted together with several external partners, with accompanying challenges of coordination, communication, and aligning goals.



Predictive Maintenance

In late 2023, we commissioned an external review of the CAISR Predictive Maintenance research; the reviewers' summary statement is on page 11. Below are excerpts from the self-evaluation and the material given to the reviewers, illustrating some aspects of the research in CAISR.

Predictive maintenance (PdM) is about predicting when a system needs to be maintained, based on the idea that systems can be monitored such that it is possible to estimate their health status and predict their remaining useful life or risk of failing. Predictive maintenance fits excellently with the CAISR scientific agenda and offers scientific challenges as well as the potential for significant cost and efficiency gains for industrial partners. The external funding comes mainly from The Swedish Knowledge Foundation and Sweden's Innovation Agency (Vinnova). Companies are collecting large amounts of data for the purpose of understanding better how their products are used, to improve their products, and to design more optimized maintenance programs, and we are witnessing a rapidly growing industrial interest in predictive maintenance with data and machine learning. Over the years, CAISR has collaborated successfully with many companies in this field, in projects on both low and high TRL (Technology Readiness Level).

In CAISR, we explore machine learning for knowledge creation from real data; this means data from companies' everyday operations, including all the real-world uncertainties, such as missing or strange values, and ambiguities in repair records. This is in contrast to most PdM research that is based on data obtained under lab-like experimental circumstances, sometimes even simulated, with annotations and known faults (a concrete example of the latter is the research on ball bearings, which make up almost 25% of the published PdM research worldwide). We chose this direction of "real problems, real data" in 2005 when we saw that many of the PdM challenges faced by our industrial partners are inherently connected with non-perfect data, with a lack of known ground truth. The non-perfect data challenge must be handled for solutions to be used in practice.

Main scientific contributions over the past years

Wisdom of the crowd. With numerous complex machines on the market, equipped with sensors that collect data continuously, it is not feasible for experts to create and manage rules to detect specific faults. We utilize the concept of "Wisdom of the Crowd", i.e., a group of similar individuals, to build algorithms that are able to learn in a self-organized way what constitutes normal and abnormal behavior. By discovering interesting patterns, Consensus Self-Organizing Models (COSMO) generate models for estimating the health status of the equipment by measuring how an individual deviates from the majority in the model space. This can be used to build up a knowledge base that accumulates over the lifetime of the systems. Moreover, detecting anomalies in streaming data has increased significantly in relevance, with broadly two categories of algorithms, namely general-purpose and ad hoc ones. The former assume a one-size-fits-all solution and strive to design a single "optimal" anomaly detector for any domain. A SAFARI framework abstracts and unifies the fundamental tasks within streaming anomaly detection, facilitating more flexible adaptation.

Domain adaptation. Predictive Maintenance often relies on generalizing the knowledge acquired in controlled lab experiments, prior to the deployment. Automating this step is difficult since future field data rarely has a similar distribution, as complex machines operate under dynamic environmental conditions and are used in many different ways. Over the years, we have explored many techniques that aim to help with this issue. One is the Transfer Learning method, based on transferable features capturing how a particular equipment differs from its peers, for predicting the Remaining Useful Life under previously unseen conditions and the labels available only for the source domain. Another is the Multi-Domain Adaptation for Regression under Conditional shift (DARC) approach facilitating cross-domain learning by minimizing the marginal (conditional) distribution shift between domains by constructing a shared feature space. This space aligns different domains using a novel Pairwise Similarity Preserver loss function incentivizing distance between any two samples, regardless of their domain(s), in the constructed space to match the differences of their outcomes. A multi-task ensemble was used to transfer knowledge from high-resolution data to enable vehicle behavior based on low-resolution data (aggregated over time onboard the vehicles). We also developed, together with Volvo, an approach to turbocharger failure prediction combining multi-task learning with recurrent neural networks, handling the severe data imbalance challenge (very few turbochargers fail in the field).

Meta learning. In Meta-Learning, or learning to learn, we relaxed an implicit assumption that the distribution over tasks is unimodal. In real-world applications, tasks are often very diverse and come from multiple different domains. A method that learns multiple sets of meta-parameters and uses a task encoder to select the best initialization to finetune for a new task is shown as superior compared to state-of-the-art meta-learning approaches.

Joint human-machine learning. AI solutions with human-in-the-loop remain an important challenge that we aim to address. We have completed a literature survey on interactive clustering, reviewing state-of-the-art solutions according to the level of interaction, the operations involved, how user feedback is incorporated, as well as the evaluation, data, and methods used. We also proposed a new active learning method that handles label noise without relying on crowdsourcing, or multiple oracles. The strategy selects instances with a high influence on the learned model, i.e., those that, if trained on, would result in a model that greatly disagrees with the current model on labeling other instances.

Machine activity recognition (MAR). This is about characterizing the use of machines, and we approach it using streaming (onboard) data in the controller area network. Past research on MAR has almost exclusively used sensors external to the machine, e.g., cameras or accelerometers. A serious shortcoming in the past research is the use of the "boilerplate" supervised learning paradigm, which requires labeled data. Labeled data is very expensive and difficult to produce, whereas unlabeled data is available in large quantities (and relatively easy to collect more of). So far, it is only our group that has dealt with this issue and, e.g., used semi-supervised learning and domain adaptation methods to extract valuable information from unlabeled data. Here, representation learning with recurrent deep neural networks has proven helpful.

National position

The CAISR centers national position in PdM was estimated by extracting all scientific papers from Swedish universities in Web of Science over the years 2018-2023 (until September), with keywords like "anomaly detection", "maintenance", "diagnosis", "prognostics", and "remaining useful life", and then reading all abstracts and selecting the papers that dealt with data-driven predictive maintenance. This resulted in a total of 376 papers, where the affiliation-fractionalized citations and number of papers were computed for each university. Figure X shows the results of the analysis: Luleå University of Technology is, by a wide margin, the most productive in this field. The Royal Institute of Technology (KTH), Chalmers Technical University, and Linköping University are as a group in second place. CAISR (Halmstad) comes in third place together with Mälardalen University.

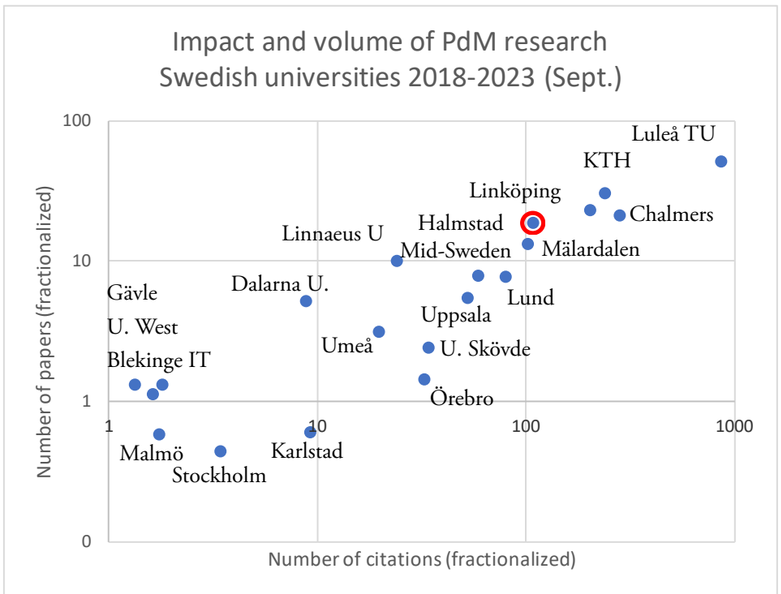


Table 1: Positioning of Swedish universities in data-driven predictive maintenance. Note the logarithmic axes.

Impact examples -PdM

The HEALTH project (2017-2019). Predictive maintenance services were deployed and demonstrated in VOSP (Volvo Service Planning), for prediction of vehicle component status and breakdown prognosis of trucks. Alerts were implemented for four markets: Sweden, Switzerland, Finland, and Denmark. The selected target components included air compressor, turbocharger, front and rear air bellows, and the alternator. The system produced warning messages that informed the dealer of an increased risk of failure for a specific component on a specific truck. The system also recommended actions to the dealer; like planning an earlier visit for the customer to check the component or to consider repairing or replacing the component during the next workshop visit.

The PRIME project (2016-2022). In PRIME, failures were predicted in fleets of Getinge sterilizers deployed in hospitals all over the world. It resulted in an in-house implementation set up in Getinge for predicting the health of certain components.

The EVE project (2019-2023). The focus here was to extend the lifespan of electric vehicles using data analysis and machine learning. We significantly improved the predictions of Battery State of Health, and some of the findings and developments in electric component status monitoring were integrated into Volvo Monitoring Systems.

The CAISR+ project (2020-2023). Two demonstrators came out of this project. One on turbocharger failure prediction, and one on forklift truck activity monitoring. The cooperation on turbochargers led to the deployment of a survival model in an inhouse dashboard that was implemented at Volvo GTT in early fall 2023, for monitoring how well the turbocharger survivability agreed with real cases in the field. The machine activity recognition was adapted and implemented on board a forklift truck for demonstration. The implementation was done by Stream Analyze, using SA Engine implemented on Toyota forklifts and demonstrated in 2022. The implementation showcased real-time analysis and processing of data directly on the forklifts.

Review -PdM

Following the on-site visitation of CAISR Predictive Maintenance research group, Halmstad University, that took place on 14 th -15 th December 2023, the group of independent reviewers consisting of Dr. Olga Fink (Assistant Professor - Intelligent Maintenance and Operations Systems, EPFL, Switzerland), Dr. Javier Diaz-Rozo (CTO, Aingura IIoT S.L., Spain), and Dr. Mihaela Mitici (Assistant Professor - Algorithmic Data Analysis, Utrecht University, the Netherlands), reached the following evaluation.

CAISR is leading innovation in data-driven AI algorithms for predictive maintenance. This is evidenced by the multiple publications in leading scientific journals, the increasing number of national and international research projects, and the long-term, effective collaborations with major industrial partners. CAISR's research focuses on major, relevant research lines for AI for predictive maintenance such as anomaly detection, federated learning, meta learning, domain adaptation and explainable AI. These research areas are highly relevant and position CAISR to capitalize on them in the coming years.

The extensive experience of CAISR in working with realistic datasets and implementing innovative AI solutions, in collaboration with industrial partners, uniquely illustrates the relevance of CAISR's research for industry. The ongoing collaboration with the main industrial partner (Volvo) serves as evidence of the impactful research they provide.

CAISR exhibits notable strengths that distinguish it within the research landscape. Its primary advantage lies in its profound industry focus, emphasizing a clear problem statement and well-defined research questions. The center is adept at channeling its efforts towards solving tangible industrial challenges, addressing associated complexities, and thereby contributing meaningfully to practical applications. CAISR faces a challenge in the form of relatively low visibility in a sector dominated by larger competitors, suggesting a need for increased outreach.

While the national network is already robust, further improvement could be achieved by diversifying the research partners. Additionally, collaboration with national universities has the potential to further enhance the research network. Collaborative efforts with other research groups can also bolster the center's standing, creating opportunities for knowledge exchange and mutual growth. It is recommended to expand international collaborations and actively work towards improving international recognition through research visits, exchange programs, joint research proposals, organizing joint special issues and sessions, as well as hosting international conferences in Halmstad.

Moreover, it is advisable for CAISR to enhance its industry relations across different sectors, fostering diversification and broadening its impact. To capitalize on niche research lines with direct or potential industry impact, CAISR should prioritize areas such as XAI, human-in-the-loop technologies, and advancements in AI/ML.

Dr. Javier Diaz-Rozo, Universidad Politécnica de Madrid

Dr. Olga Fink, École polytechnique fédérale de Lausanne

Dr. Mihaela Mitici, Utrecht University

Information Driven Care

A unique pilot on patient trajectories

In 2023, the research program Information Driven Care (IDC) started as one of the Vice-Chancellor's appointed strategic, multidisciplinary initiatives on profiling Halmstad University research, with strategic support from the Vice chancellor and the schools. IDC is large, with more than 70 people engaged in the program. One core part is the Knowledge Foundation funded profile CAISR Health and developing AI and machine learning models for improved healthcare. Several researchers from CAISR participate in the IDC program.

Information Driven Care is about meeting healthcare challenges with data, by extracting information from data to better advise decisions in healthcare. Today, we collect loads of data that can be used for advice. This can be data that comes from the individual, e.g., subjective opinions about well-being, or sensor data from activity monitoring. It can be data or information from the healthcare system, e.g., a doctor's note, a blood test, the result of a gene analysis, or an x-ray image.

This means that we need to analyze and process information from several different sources and for different purposes. One purpose may be to provide care that is individualized, where all aspects of a person's health are weighed together to provide the best possible care. Another purpose is to innovate healthcare, e.g., to understand how patients in a certain disease group are doing and the quality of their treatment in general, to find patterns that provide information on how to improve the quality or remove activities that do not contribute to good quality.

In 2023, Carl Bennet AB decided to support an international PhD student program in Information Driven Care. Carl Bennet supported professors at Halmstad University connected to Health Innovation over the period 2013-2022, and the international PhD student program is the next step in strengthening the Health Innovation area.

The IDC program is described in detail on Halmstad University web.

Information Driven Care is about meeting healthcare challenges with data, by extracting information from data to better advise decisions in healthcare.

The CAISR Health profile

The CAISR Health profile project involves Halmstad University, public healthcare providers, and several private companies, with the common ambition to develop and improve healthcare with information driven care. The partners in CAISR Health are Region Halland, Brigham and Women's Hospital, Cambio, Capio, Inter Systems, Mölnlycke, Novartis, Hallandia V, and Visiba Care. The research projects in CAISR Health cover topics such as cardiovascular health, automated anamnesis and triage in primary care, heart failure readmission prediction, AI for better mental health in young people, validating AI-assisted triage and diagnostic tools, and wound care.

In addition to running research projects, the CAISR Health researchers give master classes and provide tutorials on information driven care. In 2023, the CAISR Health researchers had a large presence at Vitalis, the leading annual Nordic fair and exhibition on healthcare and health. For example, at Vitalis, Farzaneh Etminani talked together with staff from Hallandia V about "Increasing quality of care by using AI, visual patient trajectories and synthetic data generation"; a journal paper about the graph technology behind this work was also published in 2023 in npj digital medicine.

Docent Farzaneh Etminani is employed both with Halmstad University and Region Halland. In 2023, she was employed as an AI Strategist at Region Halland.

One paper from CAISR that ended up in Scopus' list of top 10% cited papers worldwide 2023 described the work on readmission prediction of heart failure patients, which is presented in this annual report.

The CAISR Health profile is described in more detail on Halmstad University web: https://www.hh.se/caisr-health/

CAISR Health Partners
Brigham and Women's Hospital
Cambio
Capio
Inter Systems
Mölnlycke
Novartis
Hallandia V
Region Halland
Visiba Care

Healthcare in Sweden is decentralized. Responsibility for healthcare lies with the regional councils for primary and secondary care, and local or municipal councils for homecare. Every regional council, local authority or municipality is responsible for managing and prioritizing its own healthcare resources. They are silos and are unaware of each others' care and resources allocated for their common patients. At the same time, integrating information/data from multiple caregivers and analyzing the complete care chain for a patient (a.k.a. the patient trajectory) is considered vital to achieve the national goal of a person-centered care.

In 2021, Region Kronoberg and Ljungby municipality received funding from Kampradstiftelsen to invest in a pioneering and cross-border collaboration; a joint analysis of data from the region and municipality to shed light into the understandings over the care chain and ensuring that the individuals do not fall between the organizational chairs.

Martin Myrskog and Jennie Vidal winning the prize Årets Välfärdsinspiratör 2023

CAISR researchers and the company Hallandia V framed the project scope and research plan in discussions with Region Kronoberg and Ljungby municipality. Halmstad University was granted the ethical approval for the project. The data analysis platform SHARPEEC by Hallandia V proved to be an effective tool for analyzing the healthcare data.

Thomas Davidsson CEO at Hallandia V, provider of the Sharpeec data analysis platform

One of the most intriguing findings was the identification of three distinct patient groups (high, medium, and low) based on their consumption of care services. The disparity in average consumption of care services among these groups is striking, with the high consumption group exceeding the medium group's average consumption by a factor of 10 or more. This underscores the potential for significant cost savings if proactive measures can be implemented to decrease the transition rate into the high consumption group.
Our analysis challenges the common assumption that patients exhibit a gradual increase in care consumption over time. Instead, it appears that specific incidents trigger their entry into the high-consumption group. Through careful examination, we have pinpointed the diagnoses associated with these incidents and have determined that both chronic and non-chronic conditions present opportunities for preventive intervention.

Findings show that 20% who are high consumers in care account for approximately 80% of the total cost and 20% of older high consumers account for approximately 40% of the total cost for high consumers. The average cost increases as the need for nursing homes, home care, home health care and inpatient care arises. Nursing homes, home care, home health care, specialist care (outpatient care) and inpatient care cost the most, overall. The total cost for high consumers consists largely of housing for the elderly, home care, home health care, and inpatient care. The most common diagnosis groups are hypertension diseases, second heart diseases, diabetes, metabolic diseases, and general symptoms and signs of disease.

Farzaneh Etminani, Halmstad University researcher in the project

The project also pinpointed the overlap of patients between regions and municipalities, highlighting the necessity for enhanced interactions between these entities. Preliminary findings indicate a promising avenue for streamlining communication and collaboration between organizations, offering benefits not only for patients but also for the efficiency and effectiveness of the involved entities.

The results showed that it is possible to achieve individually tailored care that both saves public resources and increases quality for the individual. The project received national attention and led to Region Kronoberg and Ljungby municipality winning the prize for *Årets Välfärdsinspiratör 2023.*

New research may prevent hospital readmission after heart failure

Heart failure is serious and causes many deaths. It is also a disease that affects many and for which much of the resources in healthcare are used. New studies at Halmstad University show that one in three patients who have been hospitalized with heart failure is admitted again within 100 days. The researchers can also contribute with knowledge about how many of these unplanned admissions can be predicted and prevented.

In heart failure, the risk of further cardiovascular problems is greatest within 100 days, such as new heart failure, angina, heart attack, stroke, and irregular heartbeat. A new study at Halmstad University shows which factors could be considered already at discharge, as these can be linked to an increased risk of new, unplanned hospital admission within 100 days. Being a woman reduces the risk, as does elevated blood pressure. Other factors that can be linked to an increased risk of readmission are age, certain hormone levels and other diseases such as Chronic obstructive pulmonary disease (COPD).

Farzaneh Etminani, Associate Professor of Information Technology at Halmstad University.

> *"The idea is that patients will receive better care at a lower cost."*
>
> *Farzaneh Kobra Etminani*

"These factors are examples of clear indicators for readmission," says Farzaneh Kobra Etminani, Associate Professor of Information Technology at Halmstad University and one of the researchers behind the current research.

Health data

The studies is an example of Halmstad University's research on information-driven care, where AI and data analysis are used to draw conclusions from health data.

There is a difference between planned and unplanned hospitalizations, Farzaneh Etminani points out. The researchers have therefore begun to develop an algorithm to predict which people are statistically at greater risk of being hospitalized.

"This knowledge contributes to a clinical decision support system that can support healthcare professionals while they still have the patient with them. The system can "flag" a high risk of readmission, and then it is up to the doctor not to discharge the patient at all or to discharge the patient with, for example, more support measures and planned follow-up visits."

The knowledge becomes a decision support that is part of the doctor's overall knowledge of the patient, combined with test results, the patient's history, experience and so on. In addition to the emotional aspects for the patient linked to being admitted to hospital, the decision support is about saving resources and directing resources correctly.

"The idea is that patients will receive better care at a lower cost. Unplanned admissions cost more than planned ones. It's not about avoiding patients being re-admitted, but about being able to focus on those who really need to be admitted. Who needs the care and resources the most?"

The decision support system is currently being implemented in healthcare together with a company that makes medical record systems.

"It's important that we find ways that the clinics think are best, so that new knowledge can be integrated into the care chain. At the end of the day, it's all for the patient's benefit," says Farzaneh Kobra Etminani.

Work preventively

Markus Lingman, Chief Physician and Strategist at Region Halland and Adjunct Professor of Medicine at Halmstad University, believes that it is extremely important for healthcare to understand what will happen to a patient to be able to work preventively and take preventive measures in time.

"In addition, understanding what increases the risk, in this case of rehospitalization, means that we can target the preventive measures and become more accurate," says Markus Lingman and continues:

"Some factors can be influenced, while others, such as age, cannot be done much about. Knowing which factors are most important and possible to influence can make planning for patients much better so that the need for hospitalization might not be necessary."

More about the research

The study is based on 7500 patients over the age of 40 who were admitted with heart failure during the years 2017-2020 in Region Halland. Of the patients, 12 percent died and one in three patients was readmitted to hospital within 100 days of discharge.

Research on information-driven care at Halmstad University is often conducted in close collaboration with Region Halland.

Read the article Clinical characteristics at hospital discharge that predict cardiovascular readmission within 100 days in heart failure patients – An observational study in International Journal of Cardiology: Cardiovascular Risk and Prevention (IJCCRP)

The researchers behind the study are Jason Davidge, PhD student in Family Medicine, Lund University, Anders Halling, Professor of Family Medicine, Lund University, Awais Ashfaq, Postdoctoral Researcher in Signal and Systems Engineering, Halmstad University, Farzanhe Kobra Etminani, Associate Professor of Information Technology, Halmstad University, Björn Agvall, Specialist in Family Medicine and R&D supervisor, Region Halland.

Read the article The Price of Explainabitlity in Machine Learning Models for 100-Day Readmission Predicition in Heart Failure: Retrospective, Comparative, Machince Learning Study in Journal of Medical Internet Research.

The researchers behind the study are Amira Soliman, Senior Lecturer, Halmstad University, Björn Agvall, Specialist in General Practice and R&D Supervisor, Region Halland, Kobra Farazaneh Etminani, Associate Professor in Information Technology, Halmstad University, Omar Hamed, Research Engineer, Halmstad University, Markus Lingman, Chief Physician and Strategist at Region Halland.

Computer Vision

The main research directions in the computer vision group in CAISR are applications for biometrics and autonomous driving. Professor Josef Bigun is the top Swedish researcher in Biometrics, an IEEE Fellow, Fellow of IAPR, and Halmstad University's first full professor. The group is highly cited and has a strong scientific position, with a track record of several consecutive projects funded by the prestigious Swedish Research Council.

The group members are very active in teaching in Halmstad University's popular IT-forensics program. Several of the thesis projects supervised in the group have been nationally noticed and awarded, e.g., the Wiman prize and the Swedish AI Society's prize for best master thesis in AI.

One of the top cited papers from Halmstad University in 2023 is "FaceDancer: Pose- and Occlusion-Aware High Fidelity Face Swapping," presented by the computer vision group at the 2023 *IEEE Winter Conference on Applications of Computer Vision.* In this paper, the researchers introduce a single-stage method for subject agnostic face swapping and identity transfer. The publication is connected to the research project GUARD (Guarding Anonymization Procedures) that started in 2023, funded by Vinnova, where the aim is to investigate and fix vulnerabilities in anonymization methods based on facial manipulation. These can be used to create anonymous (GDPR compliant) data for training autonomous vehicles. The GUARD project is coordinated by the Swedish Research Institute RISE with partners Halmstad University and Engage Studios. The GUARD project is a continuation of the project MIDAS (Anonymizing Data Collection for Traffic Safety) that ended in early 2023.

Another project that started in 2023, also funded by Vinnova, is SMILE-IV. Autonomous vehicles heavily rely on deep learning (DL) algorithms to function effectively, but it is still an open research question on how to implement DL methods in safety-critical applications. The SMILE (safety analysis and verification/validation of machine learning based systems) research program has studied and developed methods and processes that allow DL-based functions to be included in safety-critical applications. For example, the SMILE III project developed an experimental pedestrian emergency braking Advanced Driver Assistance System (ADAS) called SMIRK (https://github.com/RI-SE/smirk) with the first full application of the Assurance of Machine Learning for use in Autonomous Systems (AMLAS) safety assurance process (https://www.assuringautonomy.com/amlas). In SMILE IV we further develop these enabling technologies and implement a safety assurance framework for the new types of transport services enabled by small autonomous vehicles: transport robots in factory settings and delivery robots in public spaces. The SMILE-IV project is coordinated by RISE with partners Halmstad University, Infotiv, Dyno Robotics, and the Volvo Group companies.

Authors of top cited paper

Felix Rosberg

Eren Erdal Aksoy

Fernando Alonso-Fernandez

Cristofer Englund

Other ongoing externally funded projects in computer vision

DIFFUSE (Disentanglement of Features For Utilization in Systematic Evaluation)

Training and validating machine learning based methods commonly require large datasets. A challenge that remains in generation of datasets is to create a good combination of realism, control, and variation. In the DIFFUSE project we propose an improvement of current algorithms for data generation by developing their ability to disentangle features in the input. That is to say, a specific part of the input should control a specific and understandable part of the output data. This has applications in increasing the understanding of what a generated dataset contains, to give a clearer picture of in what situations a network trained on it could be expected to work.

The project is co-funded by Vinnova.

AI-Powered Crime Scene Analysis

The project is about automatic analysis of indoor crime scenes, using AI technologies for environment mapping, segmentation, and classification of objects and traces found at such scenarios. We explore vision technologies like visible, IR, thermal, and non-vision depth sensors like LIDAR. The use of nanodrones is explored to ensure minimum contamination. This is a challenge, since existing drones equipped with the required sensors are big and unsuitable, e.g., for small flats. We also investigate the use of smartphones or bodycams worn by first responders.

The project is co-funded by Vinnova.

Mixing household surveys, satellite imagery, and machine learning in human development studies

The project aims to enhance our understanding of the pace of agricultural and rural transformation in contemporary sub-Saharan Africa, its poverty and distributional impacts and drivers. This is done by mixing methods – household surveys, satellite imagery, and machine learning – in human development studies. It is a collaborative project between CAISR at Halmstad University and the Department of Human Geography at Lund University.

Using transfer learning, deep CNNs can, from daytime satellite images, estimate poverty in villages with a precision similar to that achieved with traditional household questionnaires. This has sparked interest in the policy community and even suggestions to abandon surveys as the workhorse of development research. In the project, we study how accurate this estimation is c.f. human experts, and how to explain what the CNNs base their estimates on.

The project is co-funded by Riksbankens Jubileumsfond.

Facial Analysis in the Era of Mobile Devices and Face Masks

This project addresses the challenge of reliable analysis of facial images when the ocular region – the area around the eyes – is the only visible part. Solutions must be capable to operate on devices with hardware restrictions, a necessity if they are to be employed on devices such as smartphones or assistive robots in home or healthcare environments.

One goal is to provide reliable methods to detect the face. Impressive performance is shown by Convolutional Neural Networks (CNNs), which are infeasible in smartphones or robots. Instead, we use complex symmetry filters as attention mechanism to facilitate detection, coupled with CNNs with complex coefficients. Another goal is the estimation of soft biometrics indicators (gender, age, ethnicity). These indicators can complement a non-conclusive result of a hard modality (iris or face). They have other applications as well, such as customized advertising, enhanced HCI, age-dependent access, location of specific individuals in video streams, or child pornography detection.

The project is funded by the Research Council

AI-based face analysis can be used for anything from unlocking your phone to making self-driving vehicles recognise pedestrians in traffic. But the selfie filters on social media and in your phone can make it a lot harder to recognise your identity or even detect the face. As a part of a bigger project initiated by the Swedish Research Council, a group of master's students and researchers at Halmstad University has developed a method to reverse unwanted effects of these filters.

How do selfie filters affect AI-based face identification?

When it was time for students Pontus Hedman and Vasilios Skepetzis to write their master's thesis at Halmstad University, they wanted to explore how selfie filters affect AI-based face detection and recognition. They were redirected to a group of researchers within the field who became their supervisors, and together with PhD student Kevin Hernandez-Diaz and Professor Josef Bigun, they have now written a paper called 'On the effect of selfie beautification filters on face detection and recognition'.

'It all comes down to legislation, and in this case, privacy legislation. We have to create trust. People have to be able to place their trust in these systems.'

Fernando Alonso Fernandez,

'The idea of targeting social media filters came from the realisation that people very publicly provide their images on social media platforms. Many times, these images are augmented in some way with the tools provided by the platforms, or occluded due to the nature of how the images are captured', says Pontus Hedman, who is now working at Orange Cyberdefense as a security analyst.

'It was interesting to discuss a scenario resembling the funny and fabled "enhance the image" trope seen in fictional crime dramas', adds Vasilios Skepetzis, who is also working as a security analyst at Orange Cyberdefense.

Filters negatively impact identity recognition

One of Pontus Hedman and Vasilios Skepetzis' supervisors was Fernando Alonso Fernandez, PhD and senior lecturer in computer vision and image analysis at Halmstad University.

'This research is about face analysis when it's captured in the wild, meaning that we don't control the circumstances. Due to the different filters that are available on social media and video conference applications, the images can be partially occluded, so that you don't see the entire face. For example, users put on these fancy glasses or animal noses. What happens is that when these parts of the face are occluded, it can impact the functionality of regular algorithms that are not expecting this to happen', says Fernando Alonso Fernandez.

Fernando Alonso Fernandez, PhD and senior lecturer in computer vision and image analysis.

he filters especially impact face detection and identity recognition negatively if they cover the eyes, and to some extent the nose.

'There are different problems at work here', Fernando Alonso Fernandez explains. 'When you get an image, you don't know if there are artificial glasses or not, for example, and so you have to detect the face to be able to figure this out. But if the face is partly covered, it might not be possible to detect it.'

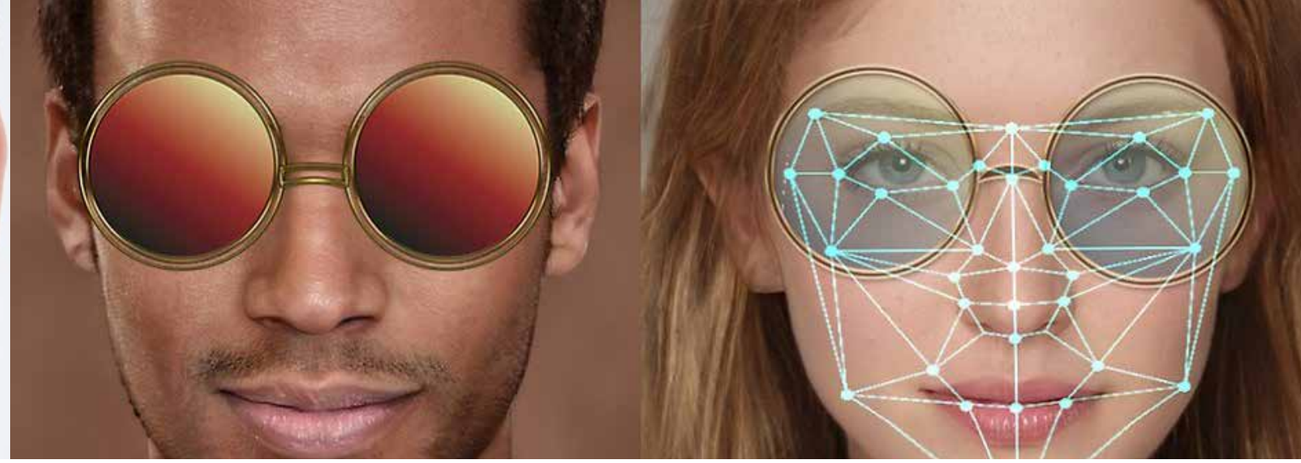
Developed a method to revert the filters

As a solution to this problem, Pontus Hedman and Vasilios Skepetzis developed a method that reverses the manipulation caused by the filters, which contributes to better face detection and recognition accuracy. Using filtered images from a database, they trained the system to revert some of these modifications, like artificial glasses, with varying degrees of success.

'The results were not successful when the original glasses were completely black. But with glasses that are kind of transparent, they were more successful in recovering face detection and recreating the eyes', says Fernando Alonso Fernandez.

'A picture has a limited amount of information, as was proved by the poor results of the entirely occluded eyes, but given a few breadcrumbs we were able to help through generative algorithms', explains Vasilios Skepetzis.

On top of this, Pontus Hedman and Vasilios Skepetzis used images with filters to train the algorithm to recognise the face. What they could see was that these approaches could help make it easier to recognise faces that were partly covered with selfie filters.



The results were not successful when the glasses completely covered the eyes, but with transparent glasses it was easier for the algorithm to recognise faces and recreate the eyes.

Results could lead to more efficient face identification

The results of the study were published in Pattern Recognition Letters, a well-respected peer-reviewed scientific journal that is in the top 20 in the field, and the paper has been cited by several other researchers.

'We all think it's very nice that our students have been generating a thesis that is worthy of public attraction, and after they graduated, they were both able to quickly find jobs in the field', says Fernando Alonso Fernandez.

Fernando Alonso Fernandez hopes that these results can lead to more efficient face-analysis based identification, something that has become a lot more attractive after the pandemic, given that you don't have to touch any sensors to be identified.

'Face identification is already in use in many airports, for example, but it requires the face not to be occluded', Fernando Alonso Fernandez explains. 'Currently, when you are about to cross the automatic gates and have your face scanned, you first need to remove anything that covers the face, such as glasses. There is also the case of automatic vehicles and robots working in healthcare needing to be able to recognise and interact with people. For this to work, they need to be able to correctly identify people who are wearing glasses or face masks, for example.'

We all think it's very nice that our students have been generating a thesis that is worthy of public attraction, and after they graduated, they were both able to quickly find jobs in the field'

Can you trust the technology?

The group is aware of concerns about the negative consequences of developing this kind of technology – questions of the sort are usually the first to come up when they mention their work.

'Such concerns are fair. For example, machines can become biased based on their training dataset – as can humans. That's why these tools need to be understood and used with caution given the sensitivity of their application', says Vasilios Skepetzis.

Fernando Alonso Fernandez agrees, saying 'Of course, if there is misuse of these technologies, it could lead to negative consequences – it's the same with many other technologies that can be used for both good and bad. It all comes down to legislation, and in this case, privacy legislation. We have to create trust. People have to be able to place their trust in these systems.'

While being able to trust these technologies is vital, Pontus Hedman also thinks it is important to remain critical.

'In the future, we will see face recognition and digital identity play a larger role in society. People would do well to consider what type of data they provide freely and publicly', says Hedman.

Endless possibilities with the right funding

While Pontus Hedman and Vasilios Skepetzis are now working in the cyber security industry, Fernando Alonso Fernandez and his group of fellow researchers at Halmstad University continue to carry out research in the field of face recognition, with the help of different funders interested in the subject – in June, for example, he and his colleagues met with a foundation hoping that this kind of technology can help prevent child abuse.

They are also a part of a group of people from universities all around Sweden trying to create a national centre for digital forensics research.

'The possibilities with this kind of research are endless – it all just comes down to companies and politicians finding out about it, and deciding to fund it', Fernando Alonso Fernandez concludes.

Professor portrait

Stefan Byttner

Stefan Byttner, newly appointed Professor of Information Technology, has been deep diving into the subject of intelligence and learning since childhood. In addition to building algorithms and increasing knowledge about artificial intelligence (AI) among small businesses, his research has led to two patents that AB Volvo now manages.

Stefan Byttner has been interested in understanding how intelligence and learning work ever since he was a child. What does it really mean that a machine can think?

"Computers offer many different ways to investigate this, and today's great accessibility to data and computational power makes the situation even better for conducting research in the field", says Stefan Byttner.

"It is rewarding and feels important to be part of developing the education so that Halmstad University can become more accessible and reach people throughout their lives for lifelong learning. We hope to raise the competence in AI among professionals who do not have the opportunity to follow traditional courses at a university."

Stefan Byttner

Stefan Byttner's early interest determined his career choice. Today, a large part of his research is centred around building efficient algorithms based on data enabling us humans to understand more of the surrounding world. This may involve, for example, building algorithms to detect a leakage in a heat pump or for a system to itself detect a broken compressor in a bus.

"For instance, I have investigated how to achieve self-organised monitoring of large groups of heterogeneous systems, such as a fleet of tens of buses or a city with hundreds of district heating substations", says Stefan Byttner and continues:

"In this context, self-organised monitoring means that a system can automatically find an appropriate representation of itself and detect if there are deviations compared to other systems in the group. It can then indicate that something is not right and can be linked to errors noted previously as a way to explain the deviation."

Patented research results

Stefan Byttner's research is closely linked to the industry. Such collaboration has, among other things, led to two patents on new methods of error detection. AB Volvo now manages the patents. He has also been involved in building a national data science portal for the energy industry.

"The goal of the portal was to develop an industry-wide work approach to show and spread examples of energy-related problems and how different algorithms can be used to find solutions to these problems. The idea is that different actors will be able to share information about problems that may arise in the energy systems and compare different algorithms that handle these problems in a good way as inspiration for the development of future tools for fault detection."

In addition to doing research, Stefan Byttner leads a large educational project in artificial intelligence and service innovation for professionals called MAISTR. MAISTR contains 26 short courses that give credits at an advanced level. The courses are given together with the University of Skövde, RISE and Blekinge Institute of Technology.

"It is rewarding and feels important to be part of developing the education so that Halmstad University can become more accessible and reach people throughout their lives for lifelong learning. We hope to raise the competence in AI among professionals who do not have the opportunity to follow traditional courses at a university. I am also very proud that we have developed the podcast Eliza and the Beyond AI podcast, which opens up for the public to listen to different perspectives on the topics that the courses address without having to go through the process of being admitted to a course," says Stefan Byttner.
Stefan Byttner also leads, together with colleagues at the University and the business incubator High Five, an innovation support called AI.m aimed at small and medium sized enterprises in Halland that want to develop AI-based services.

"We have recently received a new funding from the European Regional Development Fund for a researchproject called 'Innovation Platform AI Halland' as well as a large endorsement from Region Halland, which means that we will be able to continue to develop this work. It is great fun to support companies in Halland and to connect researchers with companies that usually have had no previous contact with the University. In the future, one of the goals is to develop a demonstrator on how generative AI can strengthen the competitiveness of businesses in the region", says Stefan Byttner.

Footnote: Generative AI technology is about tools and applications that can generate lifelike content from texts or images using machine learning algorithms.

About Stefan Byttner

Stefan Byttner earned his computer science bachelor's degree at Blekinge University of Technology in 1998. He received his doctorate at Chalmers in 2005 with his thesis "Real-time control of an SI engine using ion current based algorithms". In 2015, he became a docent in Information Technology at Halmstad University and was promoted to Professor of Information Technology in 2023. During his years at Halmstad University, Stefan Byttner held the position of Acting Head of School at the School of Information Technology from August 2022 to February 2023. He has been Head of the Department for Intelligent Systems and Digital Design since 2018.

MAISTR

MAISTR is an education program directed at professionals who want to get continued education in Artifical Intelligence (AI) technologies, specifically Machine Learning (ML), and business and service development techniques. The program is on the advanced level and comprises 26 courses with a flexible format that is suitable for professionals. The program has unique aspects by combining courses on both AI technology, management and courses on service design with AI. The academic partners are Halmstad University, Blekinge Institute of Technology, University of Skövde and RISE which work towards offering a distributed education environment for industry. The initiative is supported by more than a dozen industrial partners, both from Swedish production industry and Swedish service industry.

MAISTR combines courses in

- Machine Learning
- Human-Centered Design
- Innovation Management

MAISTR numbers 2023

- 851 course registrations
- 287 registered students that passed courses

Professor portrait

Cristofer Englund

Cristofer Englund has a genuine interest in traffic safety and has dedicated many years researching the field. It was his master's thesis in computer systems engineering that laid the foundation for his continued research in machine learning and traffic safety. Now, as Professor of Information Technology at Halmstad University, he wants to use his knowledge and research to contribute to creating a safer and more sustainable society.

Cristofer Englund's research has primarily focused on traffic safety. The focus has been on how vehicles can interact with each other to create better traffic flow, as well as how self-driving vehicles can interact with humans in a safe manner. He has particularly focused on behaviours, such as how people and vehicles move and relate to each other in traffic.

"Through my research I want to create results that contribute to a sustainable society. Improved traffic safety is one such thing. Traffic accidents are a far too common cause of death, and therefore, it feels good to be able to contribute to features in vehicles and infrastructure that can save lives," says Cristofer Englund.

AI for increased traffic safety

Artificial intelligence (AI) is an essential part of accelerating innovation and development, and one of the most evident examples is found within the automotive and transportation industry. One of the research projects that Cristofer Englund has been involved in focuses on how cameras and sensors in traffic can collect data through movement patterns of road users, and through machine learning predict what will happen next – all in order to avoid accidents. This technology is useful in environments where there are many moving objects, such as in high-traffic areas or on a construction site.

"My interest lies in understanding which variables most influence the model and thus provide the ability to create an explanatory model for the scenario, the model, or the data," Cristofer Englund explains.

Another research project that Cristofer Englund has worked on involves predictive maintenance of roads, where data on road structure is combined with traffic volume, traffic type, and climate data to build models that can predict when the road needs new surfacing.
"In this project, we also created explanatory models using machine learning to show which variables were important for making good predictions. This type of model is intended to be used as decision support for the client to improve road maintenance work."

Professor and Dean with focus on smart technology

Cristofer Englund is currently Dean at the School of Information Technology, Halmstad University, a strong research and education environment, focusing on smart technology. He has worked with research in the industry section for several years and has a background as Research Director at the research institute RISE.

"The research areas that I have worked with mostly revolve around the interaction between humans and technology. With more perspectives and more expertise, the ways of looking at a more complex problem increase, which often enhances the ability to solve the problem."

Cristofer Englund teaches classes at the University as well as various yoga classes.

"As a professor, I have the opportunity to meet many students, and I want to contribute to the education of future problem solvers and to continue making Halmstad University known for educating innovative, curious, and competent students."

Cristofer Englund, Professor of Information Technology

Multitasker finding balance through yoga

Cristofer Englund describes himself as curious and persistent, and this is reflected in his many interests. In his spare time, he enjoys skiing in the Alps, playing jazz on his saxophone, or surfing with a SUP board in the ocean.

"Halmstad is situated in a fantastic location, and there are several beaches with waves suitable for almost every wind direction," says Cristofer Englund with great enthusiasm.

In recent years, a specific interest has taken over more and more.

"In the summer of 2020, my colleague and I started a yoga studio, which my colleague runs today. However, I still teach yoga a few times a week. There are plenty of yoga styles, and my favourite is Ashtanga yoga, which I practice almost every day."

Yoga is not the only area in which Cristofer Englund teaches. For the past eight years, he has been teaching courses in the programmes for Electrical, Computer, and Mechatronics Engineering, as well as in the master's programme in Intelligent Systems at Halmstad University. Additionally, he supervises several bachelor's and master's theses each year. In his role as professor, Cristofer Englund wants to contribute to education and teaching with the purpose to support and shape the next generation of students.

"As a professor, I will have the opportunity to meet many students, and I want to contribute to the education of future problem solvers and to continue making Halmstad University known for educating innovative, curious, and competent students."

About Cristofer Englund

Cristofer Englund moved to Halmstad in 1998 to study Electrical Engineering at Halmstad University. After his graduation, he continued his studies at the master's programme in Computer Systems Engineering. After a term as an exchange student at the University of Technology in Sydney, Australia, he returned to Sweden to do his thesis, which laid the foundation for his research in Machine Learning.

In 2007, Cristofer Englund got his Ph.D. in Data Mining from Chalmers University of Technology with the doctoral thesis "Modelling and controlling an offset lithographic printing process."

He was Research Manager at RISE (Research Institutes of Sweden) 2010–2023.

Cristofer Englund became an associate professor in 2018, an adjunct professor in 2020, and a professor of information technology at Halmstad University in 2023.

PhD Alumni

In 2010, Halmstad University was granted the right to award PhD degrees in Information Technology. Between 2011 and 2023, 32 students finished a PhD degree in Information Technology, of which 14 were supervised within the CAISR environment. In addition, three PhD students in CAISR did a Licentiate degree and then went on to a career in industry, one finished with a PhD at another university. Of the 14 PhDs, eight went for a career in industry after graduation, six are in academic research.

On the right, we list our 18 alumni PhD students 2012-2023, plus two PhD students who recently presented their Licentiate theses and plan to graduate as PhDs in 2024. One out of four is a woman and we try to improve the balance between women and men.

However, "a PhD is not enough" (as Peter J. Feibelman titled his book with advice to newly graduated PhDs) and the PhD dissertation is followed by a fascinating journey. It is great fun to follow our former students' paths into their postdoctoral career and see the great things they do after graduation. Today, eight of our PhD alumni work with health innovation R&D, and eight work with intelligent vehicle R&D.

To illustrate a PhD students' life after graduation, we present interviews with three of our PhD alumni who describe their PhD studies, what they did after the dissertation, and what they do today.

Dissertations 2012-2023

2012	
Anita Sant'Anna	Dr
2014	
Jens Lundström	Dr
Klas Hedenberg	Lic
Rune Prytz	Lic
2015	
Anna Mikaelyan	Dr
Peter Mühlfellner	Dr
Wagner Ourique de Morais	Dr
2017	
Iulian Carpatorea	Lic
2018	
Siddharta Khandelwal	Dr
Saeed Gholami Shahbandi	Dr
2019	
Hassan Mashad Nemati	Dr
2020	
Yuantao Fan	Dr
2022	
Rebeen Ali Hamad	Lic
Zahra Taghiyarrenani	Lic
Kunru Chen	Lic
Awais Asfaq	Dr
Ece Calikus	Dr
Shiraz Farouq	Dr
Pablo Del Moral	Dr
2023	
Alexander Galozy	Dr

Rune Prytz 2014

Anna Mikaelyan 2015

Yuantao Fan 2016

Siddharta Khandelwal, 2018

Anita Sant'Anna

Now she's taking Halmstad's innovation ideas to Canada

She was the first PhD student to graduate from CAISR and stayed for 12 years, studying everything from health technology to electrical systems and smart homes. Now Anita Sant'Anna is on her way to Canada, bringing with her an innovation model from Halmstad.

Anita Sant'Anna has just left a part-time job at HighFive, Halmstad Municipality's innovation arena. She is now in the middle of preparing for a move to Canada.

- My husband is from there. We are moving to his hometown in New Brunswick to be closer to his family. There is an incubator there that is quite similar to HighFive - maybe I will do the same thing there and spread our innovation model.

Anita Sant'Anna explains that HighFive's focus is on "human-centered AI". The model, which blends business strategy with design and AI, was created by Anna Pettersson, Head of the Innovation Arena, together with Pontus Wärnestål and Stefan Byttner from Halmstad University.

- In AI development, it is easy to become technology-driven, but what makes AI really create benefits for a company is everything else, how the technology is used, when and why. Therefore, we have tried to support companies by bringing together people with different roles, discussing the overall need for AI, and then guiding them step by step to what they could do.

The final step is usually for HighFive to create a visual prototype to show what the intended service would look like.

Small university meant more freedom

Anita Sant'Anna grew up in Brazil where she started her education. She wanted to travel and a colleague from her alma mater, who was in Stockholm at the time, told her that Sweden was a good country. She had never heard of Halmstad, but ended up applying for a PhD position there. She came to Halmstad with a strong interest in health technology, a field that at the time barely existed at the university.

- My supervisors had worked with cars, but I wanted to work with people... And they were also interested in a move towards health technology.

At a small university, it is more challenging to find research funding, but there are also major advantages.

At CAISR, which was formed shortly afterwards, Anita Sant'Anna stayed on from 2007 to 2019. She earned her PhD with a thesis on using wearable sensors to study the movement patterns of patients to monitor rehabilitation or identify early signs of disease. As a postdoc, she worked on electrical systems, cyberphysical systems and modeling. She participated in projects on smart homes, district heating systems and many others.

- At a small university, it is more challenging to find research funding, but there are also major advantages. There were many international doctoral students in Halmstad and I liked the environment very much. The fact that the university was small meant greater freedom and independence, I felt that I was a bigger part of the whole than I would have been at a larger university.

Own company to help healthcare researchers

During her research, Halmstad University developed a collaboration with Region Halland and Halmstad Municipality. The healthcare innovation center, now called Leap for Life, began to take shape.

- It was very interesting to be part of. The connection to the hospital and the doctors meant that the technology we developed could really be applied in the healthcare sector.

But eventually Anita Sant'Anna felt done with academia and left to start her own company, Research on the Go. The idea was to develop a system for data collection in healthcare-related research, something she wished had existed during her own research career. Her system is currently used in two projects at the Sahlgrenska Academy at the University of Gothenburg. She will continue to run the company from Canada.

- Of course! You can't stop in the middle of a research study, and what I do can be done remotely. It's so wonderful in Sweden that you can get everything digitally - from the Swedish Tax Agency, Bolagsverket.... No need for paper correspondence, everything comes via Kivra. So there will be no problem, I will continue.

Peter Mühlfellner

"I was lucky to get to spend a lot of time on my research"

As an industrial doctoral student at Volkswagen, Peter Mühlfellner developed technology for automated parking. The support from Halmstad University helped give him plenty of time for his research.

If you ask Peter Mühlfellner about his job, he won't tell you anything. He laughs a little.

- It is a very secretive company.

Shortly after his PhD, he was recruited to Apple in Zurich and had to "disappear down a rabbit hole". But he enjoys it.

- For me, this was an incredible opportunity, almost intoxicating at first. It's such an exciting company and it was my previous research that opened the door here.

Peter Mühlfellner is from Austria and studied engineering at FH Salzburg. FH Salzburg had an exchange program with Halmstad University and he wanted to spend his final year abroad. As a master's student in Halmstad, he got an internship at Volkswagen and eventually a position as an industrial doctoral student with one foot in Halmstad and one in Germany.

Automated parking

The doctoral research was EU-funded and focused on automated driving at low speeds, such as when parking cars in a parking garage.

- What I did, worked well and led to some patents. Mainly it was about more robust methods for vehicle navigation in changing environments.

A parking garage may not sound very changeable, but it is if the navigation is based on a map of the environment based on visual features. Many visual features are in practice on parked vehicles - which come and go and the features change. Other examples might be a trash can that has been moved, or lights and shadows that change.

Peter Mühlfellner developed ways to determine which parts of the visual environment were permanent and use them to determine the vehicle position. After his PhD, researchers at ETH Zurich have further developed these methods using machine learning.

- I was lucky to get to spend a lot of time on my research. This was not the case for everyone.

But I am aware of the huge impact these technologies will have, and I would like to help democratize AI.

According to Peter Mühlfellner, a crucial factor was how much support the doctoral students received from their universities. He had very good support from his supervisor at Volkswagen. He himself had weekly discussions with his supervisor in Halmstad.

- We could discuss everything and he was genuinely interested. He helped me identify what I needed to do and set clear goals. Other industrial PhD students did not have such close communication with their universities and perhaps it was not so clear to them what requirements they needed to meet.

Get help from your institution

His main advice to other industrial PhD students is not to be consumed by what others want from you, but to make sure your main priority is your own well-being and goals. Make it clear to your institution what you need to succeed and enlist their help in lobbying for your research in the workplace. Ensure that there is a clear agreement between the university and the company about what you will do.

- It is also important to remember that work is not life. You may or may not succeed, and it depends a lot on circumstances beyond your control, says Peter Mühlfellner.

Personally, he simply hopes to continue solving challenging problems. Machine learning is an area he's drawn to right now, although he thinks the main hype around it will die down in time.

- But I am aware of the huge impact these technologies will have, and I would like to help democratize AI. Make it available in a way that enables people, rather than just in a way that generates even more profit for a few companies.

Hassan Mashad Nemati

From a dream to become a medical doctor to AI in medical technology

Working at CAISR brought Hassan Nemati into contact with many different areas of research, from automotive to healthcare. Today, he is happy to work with AI in the field of healthcare, where his work can directly benefit patients.

In 2008, Hassan Nemati came to Halmstad University from Iran. His brother was studying at Chalmers and had told him how good Swedish education was, which made Hassan practice his English more and apply to several Swedish universities. The only thing he knew about Halmstad was that it was close to Gothenburg, and he had seen pictures of the beautiful beach. In Iran, he had studied electrical engineering, but what attracted him to Halmstad was a master's degree in embedded and intelligent systems.

- My first course in Sweden was on artificial intelligence, and the lecturers were Stefan Byttner and Thorsteinn Rögnvaldsson. It was absolutely fantastic for me, I am so proud to have had two lecturers who currently hold important positions at the university.

The early days were challenging. Having never read academic literature in English before, Hassan Nemati stayed up until midnight with his books, day after day. There were written tests, laboratory sessions and finally an oral exam. When it was over, Thorsteinn Rögnvaldsson stood up and shook Hassan Nemati's hand and announced that he had passed the course with the highest grade.

- I still remember that moment so clearly, that feeling. It encouraged me to work even harder.

Contact with other fields broadened perspectives

During his master studies, Hassan Nemati took courses in computer vision, robotics, and mechatronics, and remembers how other teachers were called in by his teacher to see the end results.

- I was very stressed, but it was a good experience. The advantage of a small university is that you have a personal connection with the teacher and you get feedback directly.

He went on to a PhD position with a focus on data mining. The project was about distributed electricity grids, "smart grids", and was done in collaboration with Halmstad Energi och Miljö (HEM). The goal was to find patterns in disturbance data that showed where in the grid the risk of damage was greatest.

- To do research at CAISR meant working closely with many different groups, in machine learning, intelligent vehicles, healthcare, data mining... I felt that it broadened my perspective a lot.

I really enjoy working on something where I can directly see people being helped.

Wanting to help people

Today, Hassan Nemati is head of technical research at Ortoma, a Gothenburg-based medical technology company focused on advancing orthopaedic surgery through its innovative AI platform, Ortoma Treatment Solution. It is currently being adapted for total hip replacement, in collaboration with corporate giant Johnson & Johnson, which will launch it in the US. AI algorithms and machine learning models are employed on different imaging modalities, including X-ray, MRI and CT, to detect the patient's bone structure.

- Thanks to the system, the surgeon can more accurately familiarize themselves with the anatomy before surgery and decide more precisely on the size of the prosthesis. They can also see if a particular region exhibits lower bone quality which means there is a need to be extra careful, and it is possible to simulate the movement of the joint, says Hassan Nemati.

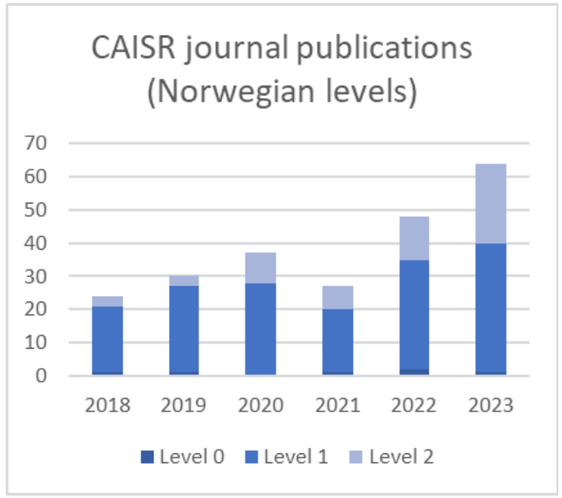
More information and greater precision reduce surgery time. Ortoma Treatment Solution also assists surgeons during surgery and analyzes the follow-up scans, including calculating when a prosthesis is misplaced or misaligned and there is a need for revision.

Hassan Nemati's mother, a former teacher and principal, owns two private schools where she still works at the age of 74. She was an important motivator for him and his brother on their path to higher education. Initially, Hassan Nemati wanted to become a doctor, but chose engineering to improve his job prospects.

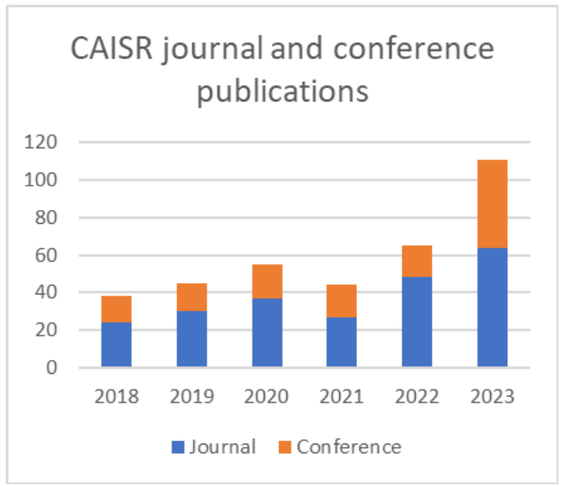
- My current job is like a bridge between engineering and healthcare. I really enjoy working on something where I can directly see people being helped. It's so exciting.

Scientific publication and impact

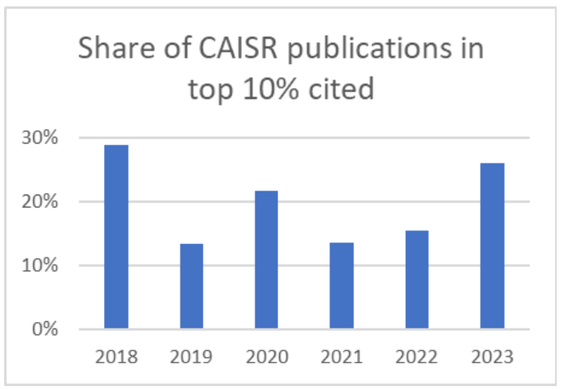
2023 was a very good year for CAISR in terms of scientific publications. CAISR researchers published an all-time high number of scientific papers in 2023: in total 111 papers, of which 64 were journal publications. Of the journal publications, 38% were published in level 2 journals in the Norwegian ranking system (i.e. of the highest prestige according to the Norwegian Science Council). This was very good, and also an all-time high for CAISR. The figure to the right shows the development of publications from CAISR over the last six years, split up on the three Norwegian levels 0, 1, and 2 (where level 1 means a good review process and a good scientific publication, and level 2 means a publication in a channel among the 20% most prestigious). Over the last six years, the annual publication output from CAISR has almost tripled, as shown in the figure below it.



CAISR researchers also publish quite a lot together with external partners from industry and public sector. In the period 2018-2023, CAISR researchers published 30 papers in Scopus with "both academic and corporate affiliation". This is almost one third of all such publications in Scopus from Halmstad University over this period.



The CAISR publication results are also strong in terms of scientific impact, as measured by citations. A quite high share of the CAISR papers end up among the top 10% cited worldwide, as measured by Scopus in their SciVal tool. In total 74 papers from CAISR published 2018-2023 are ranked by SciVal to belong to the 10% most cited papers worldwide. This corresponds to one-third of all papers published from Halmstad University in that period that are ranked to be among the top 10% cited worldwide (subject normalized). It also corresponds to roughly 20% of all CAISR papers published 2018-2023 (358 papers). The figure on the right shows the share of papers from CAISR published each year 2018-2023 that have ended up in the category top 10% cited worldwide.'



The figure also shows that it is not only in the latter years that CAISR papers get high citations.

Outreach

Long-term commitment to collaboration awarded with the Prize for Collaboration and Innovation

Magnus Clarin, Research and Education Manager at Region Halland and Project Manager at the University, has for a long time worked on developing the healthcare organisation of the future, where he has had a strong focus on collaboration and innovation.

"It's a lot about trying to get all the different parts – business, academia and the public sector – to understand each other and to find what jointly creates added value. It is both about understanding the important issues and that the individuals who will work together have an understanding and trust in each other," says Magnus Clarin.

Among other things, Magnus Clarin has been in charge of the former Hälsoteknikcentrum, now Leap for Life, where he led development projects in collaboration with the University and private and public actors. During his time as Dean at the School of Information Technology, Magnus Clarin paved the way for the long-term investment in the research project CAISR Health and the research programme IDC – Information Driven Care.

"Magnus Clarin has had a crucial significance for the successful collaboration that the University has built within health technology and health innovation together with regions, municipalities and businesses, both nationally and internationally," says Anders Nelson, Deputy Vice-Chancellor in 2023 with responsibility for collaboration, internationalization, and innovation.

Magnus Clarin, Research and Education Manager at Region Halland

Outreach activities to non-academics by CAISR staff during 2023,

- Ten episodes of Eliza – the beyond AI podcast. About 1400 downloads.
- Halmstad professionals event on When Explainability Meets Privacy on the Support Vector Machine
- AI Sweden podcast on AI-driven services
- Talk for IEEE Canada on AI in Healthcare, Steps Toward Proactive Care
- Podcast on AI and LLMs in healthcare
- Lunch seminar on AI at AI Sweden
- Podcast on AI and healthcare
- Short segment on SVT (Swedish Television) about the Applied AI Bachelor program
- Short segment on SVT (Swedish Television) about AI.m
- Presentation on LLMs and healthcare at SoftHouse in Malmö
- Presentation on generative AI at the Swedish-German AI Colloqium
- Presentation on AI, and LLMs at the Australian Water School
- youTube movie on predictive maintenance for turbochargers
- Presentation on information driven care at the annual conference for the Swedish Association for Nursing Informatics
- Seminar at Linköping Science Park on AI-driven services
- Podcast on AI as a design material
- Participation in the EU event sustainable AI and AI for sustainability in Gothenburg
- Several presentations on information drive care at Vitalis
- Article in Hallandsposten (local newspaper) on autonomous driving
- Blog on Unlocking the Future of AI: A Creative Framework for AI-Powered Services
- Panel discussion at HighFive "AI breakfast" on generative AI
- Participation in round table on AI to prevent child sexual abuse in Stockholm, organized by World Childhood Foundation
- Seminar on information driven care for Carl Bennet
- Participation in WHO expert panel on medication adherence for non-communicable diseases
- Talk at RISE on domain adaptation and transfer learning
- Talk about information driven care for orthopedic technicians in Stockholm
- youTube movie on forklift activity recognition with machine learning
- Talk for pensioners in Halmstad on AI
- Presentations and panel discussion at Halland tech week.
- Article in Hallandsposten (local newspaper) on AI
- Talk to Volvo retirees about AI and predictive maintenance
- Podcast on AI and lifelong learning
- Article in the Conversation on XAI, machine learning, and poverty estimation
- RISE blog on AI and circularity
- Two episodes on the podcast Paths, Puddles, Products about AI, service design, learning and regulation

From AI.m to AI2.m and beyond

The AI.m inititive started with a few peoples' vision of how to give hands-on support to local companies on the possibilities with AI technologies. The first step was a small pilot in late 2018, collaboratively funded by Halmstad University, Region Halland, HighFive, and ALMI. The goal was to increase the competitiveness of companies in Halland by disseminating knowledge and competence in AI and service design from university researchers and students to the region's companies. Three companies participated in the pilot, where university researchers collaborated closely with company staff on short and well-defined challenges. The pilot was very successful and developed into a larger effort involving many more local companies (SMEs), which in turn developed into an even larger project with more companies. So far, more than 60 companies have participated in AI.m processes. Now it has developed into an ambitious AI innovation platform for Halland, co-funded by the European Union.

...and now Innovation Platform AI Halland...

Halmstad University and HighFive Innovation Arena continue to develop a one-of-a-kind innovation centre for human-centred AI, which both organisations have developed together in the past few years. The goal of this new major investment, called Innovation Platform AI Halland, is to further strengthen the innovation capacity of companies in the region by offering them knowledge, tools, and processes for how to apply AI, service design and data-driven innovation to create new business opportunities and competitive solutions.

"This is a fantastic opportunity for all companies in the region who are interested in exploring the potential of AI. The platform has already helped many companies to integrate AI-technologies in their businesses and this new investment will make it possible for many more companies to take advantage of the latest developments in AI", says Stefan Byttner, Professor in Information Technology at Halmstad University.

The investment strengthens Halmstad University and HighFive's position as national pioneers in the field of human-centered AI, connecting researchers, experts, and small and medium-sized enterprises. This is particularly important for a region like Halland, home to many small and medium-sized companies that often have a low degree of research and innovation.

"The platform has already helped many companies to integrate AI-technologies in their businesses and this new investment will make it possible for many more companies to take advantage of the latest developments in AI."

Stefan Byttner, Professor in Information Technology

Anna Peterson, Head of Innovation at HighFive, "The possibilities with AI are multiplying at an astounding rate and it is more important than ever to focus on human-centeredAI specifically. How should companies address all these opportunities and how do we build reliable, user-friendly systems that enhance human capabilities rather than replace them? We are tackling these issues by identifying, conceptualizing and creating prototypes of value-adding AI solutions with a focus on human-centered design in collaboration with researchers and test environments at Halmstad University."

13 million SEK investment allows companies to explore AI

One of the projects that will continue thanks to this new investment is AI.m, which gives companies a unique opportunity to explore the possibilities of AI.

"AI.m is a great opportunity to explore synergies between AI and human-centred design in a series of effective workshops, where we explore sustainable and meaningful value-adding solutions for each company. Always focusing on customers' needs and realistic positive outcomes", says Pontus Wärnestål, Deputy Professor in Information Technology at Halmstad University.

The investment totals 13 million SEK and is financed by the The Swedish Agency for Economic and Regional Growth (Regionalfonden), Region Halland, Halmstad University and HighFive. HighFive is responsible for the management and coordination of the project.

Pontus Wärnestål, Anna Petersson, and Stefan Byttner wants to strengthen the innovation capacity of companies in the region.

AI.m case #1 (Ensolution)

Ensolution entered the AI.m program in the fall of 2020. They help businesses to deliver individualized cost-effective welfare services. With this aim, various concepts are offered, for example cost calculations, process mapping, management systems, resource distribution systems, business reviews, and needs assessment. In the AI.m process, the business design, the availability of data, and the design of the service were explored. The team included innovation leaders and business designers from HighFive, Human-centered design and AI researchers from Halmstad University, UX designers, and people from Ensolution.

The data analysis was based on data in Ensolution's Kuben Analytics service, a mobile interface for collecting data for needs assessment. Two main directions were explored: analysis of assessments and risk stratification and predict future needs and resource assessment. Both directions showed positive results, and the UX prototype provided an image of the service. This gave Ensolution the insights needed for the next step; an application to support home care businesses to make more informed decisions.

A mapping of soft financing was also done, and in 2021 a project funded by Vinnova started together with the City of Helsingborg. The project was recognized internationally in 2022 as the winner in the Technology Award category at the European Social Service Award. In 2023, Ensolution bought the design agency that built the prototype to increase its ability to further develop the solution and expand its operation.

AI.m case #2 (Byhmgard)

Byhmgard is a company that supplies battery storage to the Swedish market to help balance the electricity grid and maintain an even frequency as well as installations of solar cells. They went through the AI.m process in the spring of 2022, at the same time as they started HighFive's incubator program, where they simultaneously received help with business development, financing, growth strategies, etc. From the time the company was started in the fall of 2021 until it closed its first fiscal year, it went from 0 to 110 million SEK in turnover and believes themselves that the digital, intelligent infrastructure that was laid the foundation for in AI.m has been one of the keys to their rapid growth journey. A team of researchers from the University in AI/ML and service design as well as business developers from HighFive and an external design agency participated in the AI.m process. The foundation that was laid and the prototypes the company brought with it have since functioned as a client basis for developers who have then built the platform that is used today.

About HighFive

HighFive is an innovation arena that supports entrepreneurship, the development of people and companies with ambitions. Where new ideas and experiences meet, innovative entrepreneurship and sustainable development are created. HighFive makes people think new, be creative and develop through inspiring meetings, committed teams, efficient processes and valuable networks. Their passion is to make a difference for our and the next generation's future through entrepreneurship and innovation.

HighFive are owned and part of Halmstad municipality and is located at the Halmstad University campus.

Collaborating with CAISR

2018 ● ● ● ● 2023 ● ● ● ● ● ● ● ● ●

Five years ago, in 2018, we did an interview study with CAISR's industrial and public sector collaborators, to gauge the quality in our collaboration and identify areas for development and improvement. In 2023, we commissioned a follow-up study. In total, 20 collaborating companies or organizations were interviewed.

Overall, the interviewees are satisfied with the collaboration with CAISR. Even if proposals for development and changes are put forward, it is more about minor adjustments than major changes of collaboration activities or research orientation. We summarize here the main findings and conclusions from the interviews.

Value creation

In the 2018 survey, several respondents stated that participation in CAISR created value in the form of concrete results, for example development of new products and services, patents, and decision-making basis for the development of their own operations. In 2023, there are few who highlight such concrete result, and the parties talk more about gaining understanding and insights together with competence development. The benefit that CAISR creates for companies is overall on a different level today.

What is mainly highlighted in the answers is connected to use of and access to data. Several companies highlight increased knowledge and understanding of what they can do with their own data and not least what the requirements are for collecting data so that it becomes useful for the development of products and services. When it comes to access, collection, and use of data, companies have reached a higher level of maturity.

Another important value that CAISR creates is competence development, which is highlighted by most respondents. The collaboration has increased the companies' competence and provided individual employees with personal development, partly through participation in projects and partly through the professional education offered by the academic environment around CAISR. For employees with an academic background, participation in CAISR has offered an opportunity for them to also participate in research activities and publications. Overall, this increases companies' attractiveness as employers. Participation in CAISR also gives companies access to competence that they can recruit, in the form of students and PhD students.

The companies also point to the value in terms of access to domain expertise and opportunities to test new approaches. They also say Halmstad University acts as their eyes on the world, contributes with a global outlook and knows where in the world you can find good groups in various areas connected to AI and ML. The companies highlight new networks as very valuable and through the collaboration the companies have been able to get inspiration and feedback from both other companies and researchers on their own approaches. This has led to discussions that the companies otherwise did not have internally, and collaboration has thereby provided new insights and offered opportunities to test new ideas.

The companies also point to the value in terms of access to domain expertise and opportunities to test new approaches.

Specifically valuable activities

Workshops and meetings are something that many highlight as good activities. A few companies lift collaboration with named researchers as very appreciated and valuable. One company specifies a joint presentation at a national conference, where researchers showed the scientific results and the company could place it in the company's perspective. Another company points to the help they received with the ML-models, where the collaboration with CAISR really made a difference because the company would not have solved this themselves. A couple of companies highlight a transfer learning project that showed how to match privacy sensitive data with not sensitive data and that way extract valuable information without using privacy sensitive data.

For the business incubator HighFive, the collaboration within the MAISTR program, training for professionals, is particularly valuable. Through HighFive's participation in the program, connections are created between start-ups, established companies and researchers.

The companies' most valuable contributions

Most companies consider their main contribution to the collaboration to be access to real world problems and environment. The researchers get the opportunity to work with real data from the companies' processes and products, the companies share the challenges they have and where they need to apply new solutions, as well as what requirements are set for solutions to be implemented. In many cases, the companies also offer access to real products and platforms that the researchers can use for development and testing.

Among the companies that work with information-driven care, the companies mention that they also share knowledge about therapeutic areas and clinical challenges that also exist in other regions and globally. Furthermore, that the companies contribute with knowledge about the layout of different types of clinical studies and how these should be planned and structured. Some companies also mention that they contribute by challenging the pace of development that exists within academia, where companies need clearer deliverables and milestones

What is great and what could be changed?

Most of the collaboration companies express appreciation for that the researchers are accessible; it is easy to contact expertise and there is a genuine interest in collaborating with industry.

The companies within CAISR+ are also very satisfied with the collaboration design; smaller projects combine to form larger programs, which means that the project scope is fairly flexible and can be adapted to changing conditions.

The companies within CAISR Health highlight the importance of all three parts, the triple helix: academia, industry and the public sector. Also, both Halmstad University and Region Halland are relatively small organizations, why it is possible to achieve close cooperation with short decision-making paths. It is familial and entrepreneurial at the same time.

The parties within CAISR+ think that the collaboration has worked very well and do not have any specific changes to propose, only that there is a wish to find more long-term funding and bring a few more partners with similar challenges into the collaboration.

Within CAISR Health, the parties wish for more exchange and openness between the projects, and preferably, if possible, to gather projects into more comprehensive programs. Several interviewed also point to the problem that companies and academia move at different paces. To motivate the investments required to participate in CAISR Health internally within the companies, the companies need ongoing information on how the projects are progressing. CAISR Health would gain from finding a better and more structured way of communication. More frequent information is also requested by Region Halland, e.g., a newsletter every six months to the healthcare organizations/clinics/persons who have been involved in projects. Healthcare personnel who have been engaged often feel a bit forgotten afterwards, as they receive no feedback on the results, and that makes it more difficult to get people to re-engage.

Anna Aspgren

Among the companies that are not part of either of these two large programs, there are several that for many years have had a relationship with the university. They request meetings for exchange of experience or theme-based workshops/meetings in the way that was done before the pandemic. This is particularly emphasized by the companies that primarily work with a single researcher. Possible workshop themes that are highlighted are for example AI and ethics, handling GDPR and privacy issues, synthetic data, and cyber security.

Points for future collaboration

In general, the companies express that a collaboration must create value for them, address real needs and opportunities, and lead to something that can be implemented.

Several of the companies in information-driven care point out that CAISR has succeeded in positioning itself well and has access to data sets that few others have. They would like to see CAISR use this position and create more visibility and communicate what is being done. They also want Halmstad University to benefit even more from these data sets by looking at how the big universities work to really maximize the outcome of their databases. Region Halland wishes CAISR to also develop working methods to capture the driving forces from the healthcare and not just the needs of the companies.

Another suggestion is to support the companies' development projects by involving students more. Today there is something called FabLab at the university where companies can come and meet experts and get help from students to do tests, for example. Can CAISR do something similar, an AI lab, where students can help with AI solutions.

More cooperation with HighFive and AI Sweden is also desired by some companies. HighFive is a node for AI Sweden, HighFive is also a suitable actor to involve in creating an AI lab and they could also have a clearer role in the commercialization of new results.

Areas for development

Strategic outlook and foresight: AI is a booming area where major investments are made, and almost all universities and research institutes have research and education in the field. So even if funding is increasing, competition also grows. Research collaboration of the type conducted in CAISR, where academia and companies work together, is dependent on public research funding that supports such research. Vinnova is an important Swedish financier in the field and for this type of collaborations, and they tend to have relatively short time cycles between calls for proposals being announced and the deadline for submission. Those who are most successful in obtaining funding for collaborative projects often already have cooperation at a strategic level, the parties know each other's development needs and strengths, and there is a preparedness to monitor suitable calls for proposals, and to be able to quickly produce an application when an announcement in the right area is opened. This type of collaboration around strategies that create preparedness is asked for by the companies.

The companies within CAISR+ are also very satisfied with the collaboration design; smaller projects combine to form larger programs,

Impact and implementation: Several companies address different aspects of implementation and dissemination of results. For the manufacturing companies, it is established that even when project results are successful and demonstrated, there is a long way to go before results are implemented in products as there must be internal sponsors for the next development stage. It is therefore far from certain that successful project results will be implemented, why the most important result for the companies is new knowledge. Often, it is dependent on a service being developed and implemented, something that some companies point out can be difficult to do in a collaboration as service development is also business development.

For the companies in the healthcare sector, many are dependent on results being spread more widely within healthcare for them to be implemented. Here, there is a desire for CAISR to work in a more structured manner with the dissemination and communication of results. Developing a more structured way of working for impact and implementation in CAISR can further strengthen the environment, attract funding and partners.

Fora for knowledge exchange: Specifically, the companies outside the major projects within CAISR express that they lack the type of network meetings that were held before the pandemic. These companies have good experience of the previous cooperation and interest in developing the cooperation further. It should be important for CAISR to regain closer contact and listen to what type of meetings, content, format, and frequency are desired. As many have become accustomed to digital meetings, it is more difficult today to gather people for physical meetings, while physical meetings are usually more rewarding when it comes to creating networks or jointly developing ideas.

CAISR Health meeting at Mölnlycke

The CAISR brand: The name CAISR only has meaning for the organizations involved in either of the large CAISR+ or CAISR Health profile projects. The other companies say that they collaborate with Halmstad University. Even the companies active in CAISR+ and CAISR Health have very limited knowledge of each other, and many companies do not know that CAISR includes both these projects and even less which companies are included. There is a risk that the name is losing importance. For the companies, this probably has limited significance, but for CAISR as an environment, a more structured use of the brand can contribute to a clearer profile in e.g. applications and communication. It may be appropriate to discuss within the academic grouping how the name CAISR is viewed, what benefit it is considered to create (or has created) and if it is desirable to build more clarity in the brand.

The camera sees if you are safe enough for the job[1]

Jonathan Karlsson and Fredrik Strand are awarded the Wiman prize 2023 for Sweden's best degree project in Bachelor of Science in Engineering.They receive the award for their work in making workplaces safer with computer vision and machine learning.

In many workplaces, safety equipment is required to gain access. Helmet, special gloves, safety vest, safety glasses and hearing protection are some examples. Only those wearing the correct protection should be admitted. The students tackled the safety issue by trying to visually identify protective equipment by combining computer vision and machine learning. The starting point is a camera image that is used to determine whether an employee should be allowed into a security-classified area. The camera sees if you are safe enough for the job.

The system they created - after being trained on the different parts of the protective equipment - became very accurate. The hit rate was 99 percent at a distance of three meters. The award winners believe that the system could be even better if it was trained on exactly the protective equipment used in a specific workplace.

Jonathan Karlsson and Fredrik Strand graduated from Halmstad University in 2022 on the Bachelor of Science in Engineering program with a specialization in computer engineering.

From the award committee's motivation

In addition to the technical aspects of the thesis, the prize winners address ethical and legal issues surrounding the developed technology. They demonstrate that they can apply academic knowledge and methods to a relevant practical problem with great skill and not least how technology can be used to make the world a little safer.

1. This article was first published at Sveriges Ingenjörer website (in Swedish: sverigesingenjorer.se).

Fredrik Strand on the left and Jonathan Karlsson on the right.

About the Wiman prize

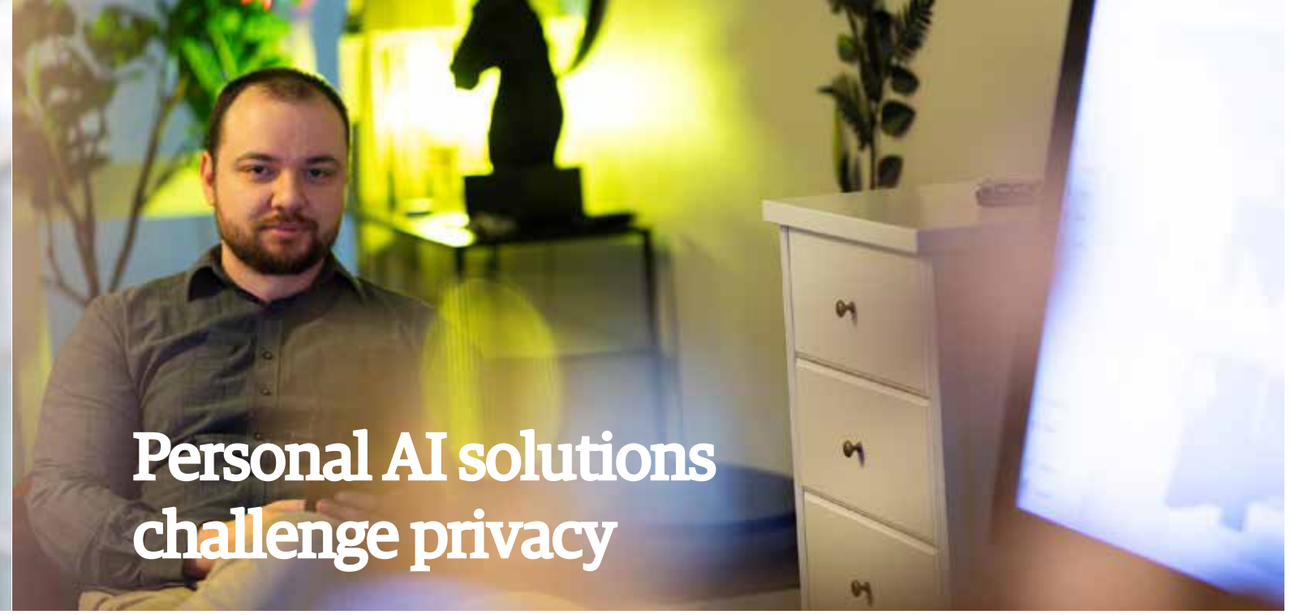
The Wiman prize is awarded every year by a committee appointed by Sweden's Engineers for the best degree project in Bachelor of science in engineering. The Bachelor of science in engineering comprises 180 higher education credits, which corresponds to three years and is a professional qualification. As a university engineer, you work with various forms of technical development and construction.

Sveriges Ingenjörer

PhD Graduation

Alexander Galozy

Mobile Health Interventions through Reinforcement Learning



Personal AI solutions challenge privacy

Alexander Galozy i den intelligenta lägenheten HINT på Högskolan i Halmstad. Det är en realistisk hemmiljö där forskning och experiment utvecklar innovationer för vård och omsorg.

Abstract

This thesis presents work conducted in the domain of sequential decision-making in general and Bandit problems in particular, tackling challenges from a practical and theoretical perspective, framed in the contexts of mobile Health. The early stages of this work have been conducted in the context of the project ``improving Medication Adherence through Person-Centred Care and Adaptive Interventions" (iMedA) which aims to provide personalized adaptive interventions to hypertensive patients, supporting them in managing their medication regimen. The focus lies on inadequate medication adherence (MA), a pervasive issue where patients do not take their medication as instructed by their physician. The selection of individuals for intervention through secondary database analysis on Electronic Health Records (EHRs) was a key challenge and is addressed through in-depth analysis of common adherence measures, development of prediction models for MA, and discussions on limitations of such approaches for analyzing MA. Providing personalized adaptive interventions is framed in several bandit settings and addresses the challenge of delivering relevant interventions in environments where contextual information is unreliable and full of noise. Furthermore, the need for good initial policies is explored and improved in the latent-bandits setting, utilizing prior collected data to optimal selection the best intervention at every decision point. As the final concluding work, this thesis elaborates on the need for privacy and explores different privatization techniques in the form of noise-additive strategies using a realistic recommendation scenario.

The contributions of the thesis can be summarised as follows: (1) Highlighting the issues encountered in measuring MA through secondary database analysis and providing recommendations to address these issues, (2) Investigating machine learning models developed using EHRs for MA prediction and extraction of common refilling patterns through EHRs, (3) formal problem definition for a novel contextual bandit setting with context uncertainty commonly encountered in Mobile Health and development of an algorithm designed for such environments. (4) Algorithmic improvements, equipping the agent with information-gathering capabilities for active action selection in the latent bandit setting, and (5) exploring important privacy aspects using a realistic recommender scenario.

PhD Defense facts

Title:
Mobile Health Interventions through Reinforcement Learning

Author
Alexander Galozy

Supervisors at Halmstad University
Professor Slawomir Nowaczyk

Chairman of the defence:
Associate Professor, Eren Erdal Aksoy, Halmstad University

Opponent:
Senior Lecturer, Allan Tucker, Brunel University London

Examination Board:
Professor, Myra Spiliopoulou, Otto von Guericke Universität Magdeburg
Professor, Panagiotis Papapetrou, Stockholm University
Professor, Janna Hastings, University of Zurich

A few years ago, Alexander Galozy, a doctoral student in information technology, presented his licentiate thesis on how AI can support healthcare by reducing workload, lowering costs and empowering patients' autonomy. As Alexander Galozy now defends his doctoral dissertation, he shares insights into progress and developments since then.

When Alexander Galozy wrote his licentiate thesis, it was part of the iMedA project, where the research group developed a mobile application with customised reminders and personalised information. To assist patients in adhering to their treatment and medication plans, the mobile application needs more information to understand the patient group better. Therefore, large amounts of existing electronic health records (EHR) are analysed using machine learning models. Since the licentiate thesis, Alexander Galozy has, among other things, worked on improving the learning speed of the algorithms.

"We have tested increasing the speed at which our algorithms more efficiently utilise previously collected data and intelligently analyse patterns. This has reduced the number of interactions required to offer customised solutions in the mobile application. This not only enhances user engagement but also strengthens the ability to provide patients with more effective and personalised interventions," says Alexander Galozy.

Imbalance between performance and privacy

With his fellow researchers, Alexander Galozy has also investigated privacy concerns regarding user data by analysing how effective simple noise-additive schemes are at preserving user data privacy in a recommender system. A recommender system is an IT-support system that uses AI algorithms on big data to make suggestions and recommendations to the end-user, for example, a doctor. By adding noise, the researchers hoped to mask and preserve private data about individual patients.

"The recommender system is not unlike something you would use in mobile health (mHealth) setting to provide digital interventions", Alexander Galozy says. He continues, "We have found that these noise-additive schemes, unfortunately, are insufficient for preserving privacy or destroying too much of the information. There is an interesting avenue for further research to find a better performance-privacy trade-off."

AI solutions for personalised care

Alexander Galozy believes that mHealth will become more and more important in the future as the population ages. He hopes his research will make it easier to apply probability methods when developing algorithms and applications, more specifically Bandit methods, that can help make suggestions, estimations and choices. Alexander Galozy thinks that this will be useful not only in the mHealth domain but also in other domains.

"It will allow patients to receive good interventions which are more tailored to their needs – right when they need it", Alexander Galozy says. He continues, "Also, I think the topic of privacy and how it affects performance in the Bandit research is just emerging, and we do not know a lot yet. With my research, I provided a little step forward to address the issue of privacy in this domain, as it will become, and certainly is, very relevant today and in the future."

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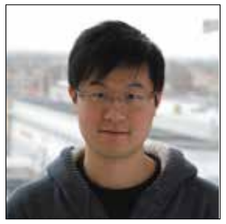

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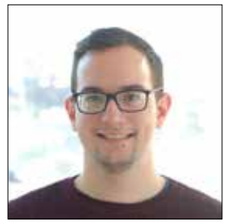

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JOURNAL PAPERS

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VINNOVA

Knowledge Foundation

The Knowledge Foundation funds research and competence development at Sweden's new universities. The Foundation was established by the Swedish government in 1994, and the Foundation's overall mission is to strengthen Sweden's competitiveness.
The Knowledge Foundation has the following objectives:

- to support the exchange of knowledge and skills between the business sector on one hand, and universities, higher education institutions (HEIs), and research institutes on the other.
- to fund research at smaller and mid-sized HEIs and Sweden's new universities (founded after the foundation was formed) in special profile areas.
- to promote information technology.

The Knowledge Foundation achieves these objectives by helping young universities build internationally competitive research environments, work long-term on strategic profiling and increase the cooperation between academia, industry and institutes. The Foundation funding programs are all characterized by a long-term perspective and requirements for co-production with industrial partners.

VINNOVA
Sweden's Innovation Agency

Vinnova is Sweden's innovation agency. Vinnova is a government agency under the Ministry of Trade and Industry and the national liaison authority for the EU Framework Program for Research and Innovation.

Vinnova's task is to promote sustainable growth by financing needs-motivated research and the development of effective innovation systems. "Innovation systems" refer to networks of public and private actors where innovations and new knowledge are developed, disseminated, and used. In order to achieve sustainable growth and strengthen Sweden's competitiveness, the authority must, from a challenge-driven perspective, work for the utilization of research and the promotion of innovation.

Every year, Vinnova invests approximately SEK 3 billion in research and innovation. This is done in many forms, typically cooperative projects between partners with complementing competencies. For CAISR one particularly important funding program is FFI, the Vehicle Strategic Research and Innovation program, which is a collaboration between the government (Vinnova, the Swedish Transport Administration and the Swedish Energy Agency) and the Swedish automotive industry (Scania CV AB, AB Volvo, Volvo Car Group and FKG - Vehicle Component Group).

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CAISR

CAISR, the Center for Applied Intelligent Systems Research, is a long-term research program on intelligent systems established by Halmstad University. The subject expertize in the center is in signal analysis, machine learning and mechatronics. 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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