CAISR

Center for Applied Intelligent Systems Research

Annual report 2013

HALMSTAD UNIVERSITY

Cover Photo. Some of CAISR PhD students: Yuantao Fan, Siddhartha Khandelwal, Anna Mikaelyan, Jens Lundström, Saeed Shahbandi Gholami and Iulian Carpatorea.

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Research Profile
Annual Report 2013

HALMSTAD UNIVERSITY

Knowledge Foundation

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Introduction

CAISR: a KK-profile for excellent research and coproduction

The Knowledge Foundation supports young Swedish universities to build up profiled and strong research in close collaboration with industry. One of the key tools for this is the "KK-profile"; a long-term funding intended for a systematic establishment of an internationally competitive research environment within a limited, well defined area relevant for industry. The research environment shall contribute to the University's strategic research and education development, and to the industrial partners' development and competitiveness.

A requirement for the "KK-profile" is that the industrial partners contribute with at least as much in effort (in-kind or in cash) to build up the profile competence and produce the research results. Coproduction is the key word. The purpose is to achieve research results that are relevant, with a higher probability for generating value, when industrial partners and academic partners cooperate around problem formulations, discussions on solution methods, and in the dissemination and implementation of results. Industrial development can be more long term when both industrial partners and researchers participate in discussions on strategies and the choice of solutions. Both academia and industry have something to gain from thinking outside their respective boxes.

CAISR (The Center for Applied Intelligent Systems Research) is such a KK-profile. We receive 36 million SEK from KK during the period 2012-2019, which are matched by industrial efforts. The effort is complemented by Halmstad University internal funding and projects that are funded by other research agencies.

Thorsteinn Rögnvaldsson
Director of CAISR

The Halmstad University goal with CAISR is to build up a strong research, education and innovation environment in intelligent systems, with strong national and international networks and with research projects funded by a variety of research agencies. CAISR should be an environment that is attractive for students, on all levels, with excellent education and close connections to the work market. CAISR is a central part in the university's master program in embedded and intelligent systems, and in the new "civilingenjör" education (a Master of Science in Engineering, cf. the German Diplom-Ingenieur) that starts 2014. Furthermore, the CAISR environment is the hub for the university's PhD education in Signals and System Engineering with a significant volume of PhD students, some of whom are active and employed in the industry.

CAISR is already a long way towards being an internationally competitive research center. An external assessment of all the research at the university during 2013 (Assessment of Research and Coproduction: ARC13) showed this. However, a few things need to be improved before we are there (more on this later in this report).

Aware intelligent systems at our service

The CAISR research focus is on "aware" intelligent systems: human aware, situation aware, and self-aware. Aware intelligent systems will become even more important in the "ubiquitous future" with data, sensors and embedded computers everywhere (the "internet of things"). Aware intelligent systems will be important in applications areas of societal importance, like health care and vehicles.

Awareness themes

Human aware systems know where humans are, what the humans are doing, and can possibly find out what the humans want. They can plan their actions in relation to humans. They can establish a communication between a human and themselves. Human aware systems acquire sensor data, extract human-related information from the environment, engage in decision making, and act to make human lives more safe, comfortable and engaging.

Situation awareness is about having the "big-picture" and not just sensor readings. A situation aware system can react to an otherwise normal event if it happens concurrently with something else that is not supposed to happen. A self-aware system can be a self-monitoring system; a system that is able to learn and describe what it does and flag when things go wrong. A self-monitoring system has a model (possibly built by itself) of its own operation. It can evaluate its own operation and notify someone else when operation is not "normal".

Scientific areas

CAISR is built around research groups in three scientific areas: Signal Analysis, Mechatronics and Machine Learning.

Signal analysis is the extraction of meaningful information from signals. This is often digital images but it can also be signals from other sensor modalities (sound, lasers, radars, accelerometers, etc.). The purpose can, e.g., be to identify an object or a person, understand what a person is doing, evaluate how she/he is doing it, or localize an object or a person in an environment.

Mechatronics is the joint disciplinary subject in the intersection between machine engineering, electronics, computer and systems engineering. Mechatronics includes, e.g., control theory, computer science, signal processing and sensor technology. Today's vehicles and robots are excellent examples of modern complex mechatronic systems. Cyber-physical systems are also examples of mechatronic systems.

Machine learning is about designing algorithms that can be used to enable machines to develop knowledge from data and from interaction with humans. Key parts in machine learning are the analysis and recognition of patterns and how "intelligent" decisions can be made from this.

Application areas

The industrial partners come from two application areas: intelligent vehicles and health care technology. These are two application areas where aware systems will be important and have a large societal importance.

Health care technology. The health of the elderly and a growing elderly population is one of the major societal challenges in the years to come. Overweight, an inactive population and poorer health is another. Aware intelligent systems is one of the key technologies to meet this challenge, e.g. through social (aware) robots and smart (aware) environments that support people in their life. Aware systems can be used to motivate and coach not so old people to live a healthier and more active life, so that their life quality later is improved, e.g. through "life logging" apps or smart exercise equipment. Technology development in this sector is creating new business opportunities.

Intelligent vehicles. More efficient and safer transportation and logistics opens up new opportunities for trade and business. Efficient and reliable transportation means opportunities for people to work and live a rewarding life. Smarter cars allow persons with disabilities to have a more mobile life. Aware intelligent systems is a key technology to achieve this.

David Johansson, Tappa Service AB, together with Mats Billenius and Lars Nyström, both from Neat Electronics AB

Academic management group
Thorsteinn Rögnvaldsson, Professor computer science
Director of CAISR
Antanas Verikas, Professor pattern recognition
Vice Director of CAISR
Josef Bigun, Professor signal analysis
Magnus Hållander, Head of school

The Academic management group: Josef Bigun, Thorsteinn Rögnvaldsson, Magnus Hållander and Antanas Verikas

Industrial advisory board

Industrial partners	**Representatives (ordinary members)**
Kollmorgen Särö	Jonas Rahm (chairman)
NEAT Electronics AB	Lars Nyström
Optronic AB	Emil Hällstig
Swedish Adrenaline	Per-Arne Viberg
Tappa Service AB	David Johansson
Toyota Material Handling Europe AB	Henrik Eriksson
Volvo Group Advanced Technology & Research	Joakim Svensson

Jonas Rahm
Chairman of IAB

Poster session together with the Industrial Advisory Board and the CAISR Reference Group, August 2013

Funding and goals for 2013

The original plan we made (back in 2011) was to reach a gross research turnover of about 15 million Swedish kronor (SEK) on the university side (excluding the company in-kind contributions) in 2013. We ended up reaching 15.9 million. We were successful with winning new research contracts in 2013, most of which start fully in 2014. We therefore expect to grow faster than anticipated from 2014. The full economy is summarized below. The company in-kind contribution was larger than planned, which shows that some of the ideas we lined up in 2011 developed better than expected.

We aim to have a significant contribution of research grants from other research agencies. In 2013 the CAISR funding from the Knowledge Foundation constituted about 40% of the total external research funding for the center. About 25% of our external grants came from VR (Vetenskapsrådet) and the EU (part of the EU funding came through Tillväxtverket).

For 2012 and 2013 we used about 2 million SEK less than planned from the KK-foundation funds for salaries. This was due to two things: initial problems with recruiting PhD students and a lower research percentage than planned from some seniors due to other duties at the university or sick leaves. The PhD student costs will catch up (we now have the PhD students in place). We hired a young assistant professor in 2013, one year earlier than planned, to fill the need for more senior research staff. We will also hire a postdoctoral researcher early in 2014 for some of the unused funds to further increase the research production.

We have now exceeded our goals regarding new PhD students. The total number of PhD students in CAISR at the end of 2013 was 10. Four more are starting in the beginning of 2014. Three are in the newly started EISIGS industrial graduate school.

We fell short of our publication goals. Our plan was to publish 12 scientific Journal papers and 12 conference papers. We ended up publishing only 7 Journal papers and 10 conference papers, which is even less than 2012 (8 Journal papers and 13 conference papers). We are now keeping a special focus on scientific production during 2014 to lift our output to the desired level.

Two important goals are to increase the staff's amount of teaching and supervise many Master theses. We aim to have a teaching volume equal to 6 full time positions by the end of 2014 (and 7 full time positions by 2019) and to supervise 10-15 Master theses each year. In 2013 we had a teaching volume of 5.5 full time positions, which is an increase from 2012 (4.5 full time positions), and we supervised 12 thesis projects (in 2012 we supervised 9). Furthermore, our ambition is that many Master thesis projects should lead to a publication at a conference. None of the 2013 Master projects have resulted in a publication but three are planning to write papers (one Master thesis project in 2012 resulted in a conference publication).

In 2013 we increased the internationalization of CAISR. We intend for our PhD students to have longer (more than one week) stays at international research institutions during their education. During 2013, one of our PhD students visited the Netherlands Forensic Institute for two weeks in June and the Finnish National Bureau of Investigation for a month in October. One of our industrial PhD students spent the second half of 2013 at the Volvo GTT R&D office in Lyon, France. In 2013 we continued, together with CERES, the Halmstad Colloqium series, presented later in this report. Karl Iagnemma, director of the robotic mobility group at MIT (Massachussetts Institute of Technology), started a visiting professorship with us that will continue at least into 2015. The development here is so good that we foresee that his stay with us will be even longer than that.

During 2013, Halmstad University conducted a full research assessment exercise, ARC13 (Assessment of Research and Coproduction)[1]. The panel that reviewed the research in embedded and intelligent systems considered the research quality in intelligent systems to be very good and gave the following five specific statements regarding the intelligent systems (IS) research (i.e. CAISR):

"The research is organized into three research groups: (i) Mechatronics/robotics, (ii) machine learning and (iii) signal processing. All of these three groups have critical mass in terms of senior researchers and junior researchers. However the current number of PhD students seems to be too low. The research is well aligned with the teaching responsibilities of the lab. The quality of research is very good within these research areas and there is a potential for further growth. It would, however, be good for the research environment to increase the number of PhD students and strengthen existing senior/junior researchers in terms of journal publications, increased cooperation and support for writing research proposals. The three research groups are thematically quite close to each other, although there seems to be more focus on applied questions within robotics/mechatronics and machine learning as compared to the signal processing group. Some of these research results have been deployed in real-world applications and/or compared by means of international competitions to the other state-of-the-art approaches developed elsewhere. This makes the industrial and social impact of the conducted research in the aforementioned areas significant."

"The scientific publications in these areas of research are of the highest or very high quality (as measured by the impact factors of the journals in which the work has been published as well as by the number of citations), clearly indicating the significance of the impact that this work had on the scientific community."

"The IS researchers have a good track record of publishing at both conferences and in journals. Nevertheless, the group recommends a continued push for publishing in high-impact journals. It seems that IS is already competitive on the national scale although as a whole not yet in the world-class. This is largely explained by the strong emphasis on applied and innovation research, often in collaboration with the impressive number of local and national companies. While this is well motivated by the mission of IS (to provide knowledge and competence relevant to the creation of innovative IT products and services), a balance of fundamental, basic research and applied research should be sought."

[1] A description of ARC13 and the full report is available at http://www.hh.se/arc13_en

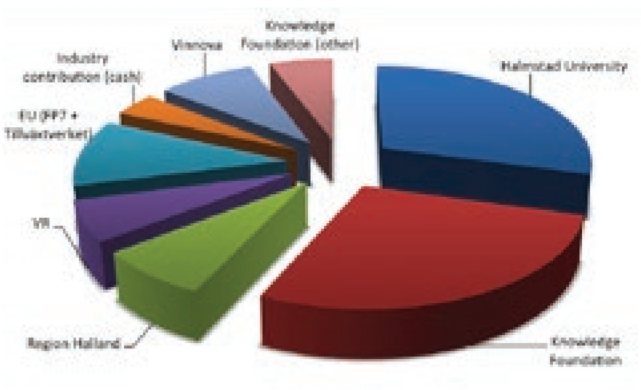
"The robotics lab houses several mobile robots for from small humanoid robots, quadcopters and a wide variety of autonomous guided vehicles .Through collaborative projects with Kollmorgen, the lab has access to state of the art AGV localization for projects. The robotics lab also has classroom sets of robots used for teaching and project work. The Centre for Health Technology Halland, a meeting place for industry, the municipality, the county and Halmstad University, is an excellent breeding ground for new projects. It has resulted in numerous collaborative projects and several demonstrators."

"The presentations given by the leaders of MPE and IS groups, indicated the novelty of the conducted research, thus demonstrating excellence in basic research…A strategy and plan to enhance the collaboration between various EIS groups needs development. Even within a single lab, such as IS, the inter-group collaborations seem to be under-exploited, which indicates that there is room for capitalization on existing expertise."

The expert panel's comments confirm our choice to establish CAISR as a high quality research center where we improve the research output by combining the three groups. We are on a good international level but there is potential for becoming very good, which requires collaboration.

To summarize, 2013 was a very positive year. The downside is that we did not meet our publication goals. Our efforts are definitely leading forward and the number of PhD students has reached a good level. We expect 2014 to be the year when our first two years' work with building strength begins to bear fruit.

Funder	Budget 2013 (SEK)	Result 2013 (SEK)
Knowledge Foundation	5 270 101	4 398 156
CAISR industrial partners[2]	4 624 980	9 610 475
Other external funding[3]	7 000 000	6 263 663
Halmstad University	3 134 067	4 694 345
Sum	20 029 148	24 966 639



[2]All in kind contribution have been computed using the standard tariff of 800 SEK per hour (the actual company costs are sometimes larger than this and sometimes less).
[3]VR, EU, Vinnova, companies et cetera

Industrial partners

The CAISR research environment consists of Halmstad University and seven companies. The companies are presented below and how they express their own aims for being a partner.

Kollmorgen Särö AB
Innovation defines our future and by combining expertise in CAISR with our business focus and experience in the development of autonomous vehicles, this collaboration increase our ability to develop new features that will benefit our customers.
http://www.danahermotion.com

Neat Electronic
Neat Electronics AB develops and sells advanced alarm systems for elderly care on the world wide market.
The global approach of the project is to increase efficiency in the care of elderly people, and at the same time enable them to live independently longer, with an increased sense of security and less intrusion in their privacy. The idea is to achieve this by monitoring behavior with passive sensors and by applying algorithms and alert staff at various predefined conditions and events.
The project is progressing well, apart from that the number of data collecting sites are fewer than anticipated.
Valuable knowledge is gathered in terms of profile of potential users, issues in terms of "selling the idea of the solution" to the users and installation issues.
Basic knowledge is gathered in terms of how to interpret collected data. Fruitful discussions and brain storming is held on how to overcome the complexity of properly detecting deviant behavior calling for actions.
In general, the project is making good headway in finding solutions to this very complex set of problems. Neat look forward to a continued work bringing the ideas and visions into commercial products.
http://www.neatelectronics.se

Optronic AB
Optronic is a leading service provider in the field of optical sensors and is continuously looking for new application fields for these sensors. Within the CAISR project several interesting applications within logistics are discussed. This provide Optronic with a better understanding of how the sensors can be used in combination with state of the art algorithms provided by the researchers. The project is also a good meeting place to together with other companies in the field discuss different technical topics. The opportunity to get all this information is very important to Optronic.
http://www.optronic.se

Swedish Adrenaline AB
Swedish Adrenaline is a young company with an experienced team. The company develops and markets innovative products, based on the company's technical expertise in sensor technology and wireless communication. Our two profiles are sports and industrial communication.
Within the sports area we are focusing on cycling, which has a very strong growth. Swedish Adrenaline are developing power meters for the bicycle market. Most runners and cyclists are using heart rate as an instrument to know their form. Among elite cyclists its common to use power meters, knowing the developed effect makes it possible to relate it to speed and pulse. This important training tool has been out of reach for most people due to the high cost. This is the driving force behind Swedish Adrenlines intiative.
The size of the target group for a power meter is approximately 6 million people in Europe and the U.S.. We believe that the number of users that will use a power meter increases from 1% to 20% within the next few years. Swedish Adrenaline intends to be a leading supplier of a power meter unique properties and at a price that ordinary exercisers finds attractive
To achieve our vision it's necessary to have a close connection to, and collaboration with research and researchers. Participation in CAISR is completely natural and gives us the necessary knowledge regarding signal processing that is required for the development of our present and future products.
http://www.swedishadrenaline.com/

Tappa Service AB
Tappa has since the founding of the company in 2005 had only one product, this product has since then been the market leader in Sweden. Around 2010 many of our customers began to ask for alternative products that could attract a large proportion of our customer's staff and also include the non-active part of the employees. The competence in our company at this moment where in creating web services, marketing and sales, and one alternative was to find an already existing product and fit it into our solution. Unfortunately this would have brought the price to unfavorable levels. We therefore needed help to take the initiative and develop a new technology and a new product, which would be a a natural progression from the step counter. We got this help from the University; with research by the researchers in CAISR and with product design through the HCH center.

During about one year we planned and tested for an own product. When we then found a producer and decided how the product would work, we got quick support at the university to develop our ideas into a product. As early as in the beginning of 2012, our first client could launch an Active Meter Contest and by today have several big companies in Norway and Sweden, either accomplished an Active Meter Contest or plan to do it during 2014. With this product we stand much stronger in the market, and have the possibility to help people to get in better shape, and thus a better quality of life, with positive effects not only for themselves but also for their companies and the society.
http://tappa.se

Toyota Material Handling Europe AB
Toyota Material Handling Europe is a global leader for providing Automated Guided Vehicles (AGVs) solutions for all kinds of material handling purposes. The business benefit calculation is simple for our customers; by replacing a manual fork lift with an automated vehicle they get a more effective, safer and reliable material handling for a lower life time cost.
The market direction is to replace more and more manual operated trucks with automated fork lifts. The demands we face now is to make more complex material handling possible with our AGV's. A key to make this possible is more advanced sensors and solutions based on vision technology.
The AIMS project within CAISR is focusing on these problems by using vision based systems. During the first 2 years we have done good progress in our research together, showing the potential of vision based systems.
http://www.toyota-forklifts.eu/

Volvo Group Advanced Technology & Research
The Volvo Group is one of the world's leading manufacturers of trucks, buses, construction equipment and marine and industrial engines. Inside the CAISR centre, Volvo collaborates with Halmstad University and other programme partners in the research field of fuel efficiency, traffic safety and vehicle automation. This common work makes an important contribution for more intelligent embedded automotive systems in the Volvo Group.
http://www.volvogroup.com

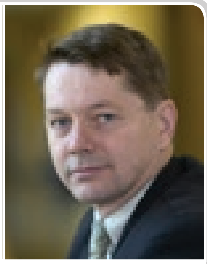

Christer Fernström

Christer Fernstrom is director and consultant at Fernstrom et Associates in Grenoble, France and the CTO of CommuniTeams in Copenhagen, Denmark. His current work involves technology transfer of research, and the development of community-based Web services. From 2005 to 2009 he was the Manager of Strategy and Planning at the Xerox European Research Centre reporting to the Centre Director. During the same period he was also in charge of co-ordinating company-wide research programmes on technologies and methods to support new service offerings. This work spanned across the research centres in Grenoble, Webster/Rochester and Palo Alto (PARC), and involved about 80 people.

Prior to his role as the Manager of Strategy and Planning Christer was a research area manager at Xerox, leading a team of some 20 researchers in the area of contextual and ubiquituous computing. Before joining Xerox he worked for the Cap Gemini research centre, where he headed research on workflow and also worked to develop European-wide service offerings in workflow. He has managed several EC-funded European projects, and was the Technical Director of a major European project in Software Engineering, the Eureka Software Factory.


Charlotta Falvin

Charlotta Falvin, has a Master of Science in Business and Economics from Lund University. She is known as an excellent business developer, company manager and creator of cooperation between academy and industry. She was awarded an honorary doctorate from the Faculty of Engineering at Lund University in 2011. She is currently Chairman of the board for MultiQ International AB, and board member at e.g. Doro AB, Chamber of Commerce and Industry of Southern Sweden and Axis Communications. She has previously been Chairman of the board for Teknopol AB, board member at Anoto and CEO for TAT (The Astonishing Tribe).


Lars Niklasson
Photo: University of Skövde

Lars Niklasson, is pro vice chancellor for University of Jönköping. He is professor in computer science and managed the establishment of a Knowledge Foundation funded research platform for "learning systems", which later developed into the Information Fusion KK-profile at University of Skövde. He has supervised several PhD students as well as organized and co-organized many scientific conferences. He has been on the executive board for Gothia Science Park in Skövde between 1999 and 2013, when he moved to the University of Jönköping.


Lisa Amini
Photo: IBM

Lisa Amini, is a Distinguished Engineer and the first Director of IBM Research Ireland, located on the IBM Technology Campus in Dublin, Ireland. The mission of the Dublin Research Lab is Smarter Cities, Exascale Computing, Hybrid Systems, and Risk Analytics. Previously, Lisa was Senior Manager of the Exploratory Stream Processing Research Group at the IBM TJ Watson Research Center, where she worked for 14 years. She was the founding Chief Architect for IBM's InfoSphere Streams product. She received her PhD degree in Computer Science from Columbia University.


Slawomir Nowaczyk, Christer Fernström and Anita Sant'Anna in discussion on a joint meeting with CAISR Reference Group, Industrial Advisory Board and staff

Misha Pavel is a Professor of Practice jointly appointed between College of Computer and Information Sciences and the Bouvé College of Health Sciences at Northeastern University. Dr. Pavel came from a position of a Program Director of Smart and Connected Health in Boston. Previously he served as chair of the Department of Biomedical Engineering and as Director of the Point of Care Laboratory. His earlier academic appointments included positions at New York University and Stanford University. His current fundamental research is at the intersection of multilevel computational modeling of complex behaviors of biological and cognitive systems, and augmented cognition. His most recent efforts are focused on fundamental science and technology that would enable the transformation of healthcare to be proactive, distributed and patient-centered. He has a Ph.D. in experimental psychology from New York University, an M.S. in electrical engineering from Stanford University, and a B.S. in electrical engineering from the Polytechnic Institute of Brooklyn. Misha Pavel is a Senior Member of IEEE.


Misha Pavel

Bertil Svensson, leads the Centre for Research on Embedded Systems (CERES) at Halmstad University, as well as the Foundation Research Centre (KK-miljö) "Research for Innovation" at the same university. He is professor of Computer Systems Engineering at Halmstad University since 1998 and at Chalmers University of Technology since 1991.

He earned his Master's and PhD degrees from Lund University. He was a member of the Scientific Council for natural and engineering sciences in the Swedish Research Council 2004 - 2009. He has authored or co-authored about 100 scientific papers in journals and full-paper reviewed international conferences and contributed to seven books. His research interests are mainly in embedded systems, parallel and reconfigurable computer architecture, as well as in intelligent systems.


Bertil Svensson

Progress during the year was very good and most of the goals have been reached. Although not fully up to the quantitative goals, the publications are of high quality, with several publications in highly ranked journals and conferences, and with good citation track records. International collaborations and exchanges are now well established, and several of the projects carried out in collaboration with the industry partners are beginning to generate interesting results, some of which are already being included in product development.

In terms of recruitment of doctoral students this has been satisfactory, but may need to be further boosted in terms of quantity. The target number of degrees in 2013 was not achieved, but will most certainly be compensated for by the higher number of degrees planned for in 2014. We have received very positive feedback from the doctoral students in place regarding the quality of tutoring and the way new doctoral students have been rapidly integrated into the CAISR research environment.

The industrial partners seem highly committed to the work in CAISR. For some of the smaller companies, CAISR projects are absolutely crucial to their strategic development, and for the larger partners CAISR has managed to build projects with a very good strategic fit. However, there are very few joint publications between researchers and industry and if CAISR has the ambition to be seen as a center of excellence in joint research between academia and industry, this aspect must be more seriously addressed. There are currently six industry partners in CAISR. A seventh partner dropped out early 2013, and although discussions are ongoing, the efforts to replace that partner have not yet been successful.

CAISR is structured around three research areas (machine learning, mechatronics and signal analysis) contributing to two application areas (intelligent vehicles and health care technologies) where projects in collaboration with the industrial partners are defined. This scheme seems to be working efficiently, although the signal analysis area, which has a very good research track record, will need to be better integrated with the application areas and become a more visible player in the industry collaboration.

International collaboration and networking are key factors to establishing CAISR as a recognized research centre. During the year, CAISR has increased its international reach through several means: participation in a new EU-funded project, hosting of visiting international professors in 2013 and planned for in 2014, organization of the Halmstad Colloquium where invited speakers (from Sweden and abroad) present their current research, as well as the hosting of foreign students. Future efforts should however also be made to strengthen the outgoing reach, with senior researchers and PhD students at CAISR paying visits and giving presentations to research organizations worldwide.

One aspect, which was particularly appreciated when CAISR was set up, was that the Health Technology Centre Halland, HCH, at the University provided an environment for working with a large number of stakeholders in the health sector. There are signs that HCH will be lacking funds for continued operation and we therefore emphasize the importance that HCH is maintained.

Application Area

Health technology

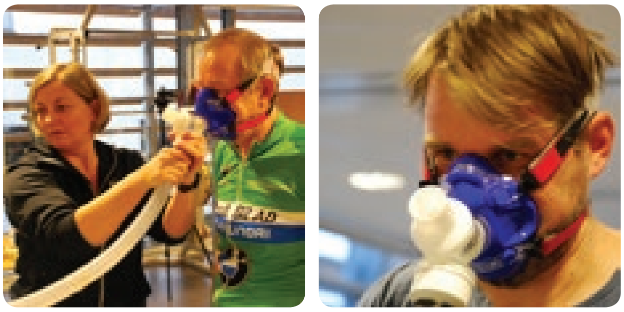
We envision a future where wearable sensors and smart environments are commonplace, where we can gather information about our activities, sleep patterns, social interactions, medical care, and many other sources of health-related data. The monitoring, analysis and use of such information require new aware intelligent systems that can - based on the available data - assess a given situation, learn and adapt overtime, and provide relevant and timely information.

Research

Our mission is to support healthy and active lifestyles, safe and independent aging, as well as effective care services by developing intelligent systems that are aware of a person's situation, health, and well-being using affordable, unobtrusive, and ubiquitous sensors. At CAISR, we develop technologies that support the acquisition and analysis of health-related data for monitoring and decision-support. We work with both mobile technologies and intelligent environments, and focus on movement analysis, behavior modeling and deviation detection techniques.

Activities

Two major projects ran during 2013 funded by the KK-foundation as part of CAISR: Situation Awareness for Ambient Assisted Living (SA3L), in collaboration with Neat Electronics; and Human Motion Classification and Characterization (HMC2), in collaboration with Tappa Service and Swedish Adrenaline.



Test leader Charlotte Olsson and test persons in the biomechanical lab at Halmstad university

On April 25, 2013, the first Human Motion Characterization Workshop took place at Halmstad University, where results concerning the analysis of movement data collected at the Göteborg Academy of Sports in November 2012 were presented and discussed. Further data collection activities have started in December 2013, in collaboration with the Biomechanics and Biomedicine research group at Halmstad University. This collaboration is marked by Dr. Charlotte Olsson joining the HMC2 project.
2013 has also been a busy year for the SA3L project. The data collection activities have been approved by the Ethical Review Board and the Home-Care Board, and are well underway. Three out of ten systems have already been deployed at home-care customers' homes in Halmstad. Other municipalities in Halland may be included in the near future. Thanks to a collaboration with the School of Social and Health Sciences, social aspects related to risk and safety in elderly people's everyday lives will also be considered in parallel with the technical aspects of the project.

Health Innovation Strategy

We often collaborate in health innovation projects headed by other research groups at Halmstad University. One example is the Successful, injury-free golf project, which uses different techniques and sensors to evaluate golf swing performance with respect to kinematics, muscle activity patterns, trajectory and variability. Another example is the GODIS project, which aims to scientifically study digital exercise intervention tools from an interdisciplinary perspective.
Interdisciplinary collaboration is a major strategic point in building a health innovation research environment at Halmstad University. This is exemplified by a number of initiatives such as the Research School in Entrepreneurship and Health and the Health Innovation Theme in undergraduate education, which bring together students from different areas in order to foster creative thinking and cross-disciplinary collaborations.
In order to innovate in health, however, we must also collaborate with society, e.g. local municipalities, and industry. The Centre for Health Technology Halland (HCH) is an arena at Halmstad University where academia, society and industry – commonly referred to as the triple helix – come together.
CAISR activities are always attuned to Halmstad University's health innovation strategy. We strive to collaborate with researchers from different fields, and our research directions are guided by the needs of society, and in an effort to co-produce with our industrial partners.

Future Activities

During 2014, we plan to start a new project within CAISR targeting mobile tools for health self-management. The core idea is to use smart phones and wearable sensors to gather diverse health-related information that can be used to increase patient self-awareness and to support decision making.
Furthermore, we are currently involved in one application for Horizon 2020 regarding the evaluation of a smart home platform to support older people with cognitive impairment; and one FORTE application regarding the development of an e-health platform for supporting person-centered care (PCC) for chronic heart failure patients.

CAISR company partners

Neat Electronics
Tappa Service AB
Swedish Adrenaline

Some of the technology used in the SA3L-project. In front a transceiver, wireless IR sensor and door alarm

Application Area

Intelligent Vehicles

We are witnessing major technological and societal developments in personal and commercial mobility. This includes ever smarter driver assistance systems, innovations based on the increasing amount and variety of data exchanged between vehicles and with the infrastructure, and rapid advances towards autonomous cars, both on the technological and legal front. Intelligent vehicles are at the cross-road of several disciplines, including artificial intelligence, robotics, signal analysis and perception, machine learning, big data analysis, human factors, and interaction design. Our in-house expertise combined with the capabilities and assets of our partners allows CAISR to push the boundary of the feasible and economically viable.

Our aim is to maintain and strengthen our contributions in the intelligent vehicles area in close collaboration with our partners, both inside the University and outside, academic as well as industrial, nationally as well as internationally. We have a track-record of successful industry cooperation in Sweden and have recently started a number of concrete collaborations with academic and commercial partners in Europe, Japan, and the USA.

Research

Our intelligent vehicles project portfolio builds on our strengths in machine learning on the one hand and autonomous systems on the other. This is reflected in our expertise in data-driven modeling, knowledge representation, localization, mapping, and motion generation.

Within machine learning, we develop methods and tools to analyse and leverage the wealth of data that can be collected on modern vehicles. The aim of this line of research is to model and detect behavior patterns in fleets of vehicles (self-awareness), and apply these models and methods to improve operational efficiency (situation awareness).

Concerning autonomous systems, our focus is on next-generation driver assistance and automation with an emphasis on keeping the human in the loop. This ranges from interactive semantic mapping as well as multi-vehicle motion planning and plan adaptation, especially in environments shared with humans and under shared control (situation and human awareness), to understanding and improving the modalities and interfaces that are most appropriate for bringing technological advances to the end user (human awareness).

Activities

We finalized three projects in 2013. ReDi2Service (Vinnova and AB Volvo) was about on-board data analysis to detect unusual behavior in on-board signals and link these patterns to causes before vehicle failures occur. FuelFEET (AB Volvo) extracted fuel consumption factors from extensive field operational data. The line of research behind these two projects is being continued in ongoing as well as upcoming projects. Our contributions to NG-Test (Vinnova) ended with a concrete case study on how verifiable simulations can be leveraged for developing and testing active safety systems. Results and contacts from this project are being carried into a proposal to Horizon 2020.

We continued work on three projects. InnoMerge (Vinnova) considers if and how innovation regarding uptime and safety can be transferred to and from emerging markets. AIMS (CAISR with Kollmorgen and Toyota Material Handling Europe) develops methods and tools for semantic mapping in intelligent warehouses. Within V-Charge (FP7) we focus on vision-based localization and multi-session mapping for autonomous navigation in parking structures.

In 2013, we began work on two new projects. Cargo-ANTs (FP7) investigates safe, automated, and efficient freight logistics in shared workspaces. Here, we focus on multi- and single-vehicle task and motion planning. LearningFleet (Vinnova) continues the investigation of fuel consumption factors that was begun in fuelFEET.

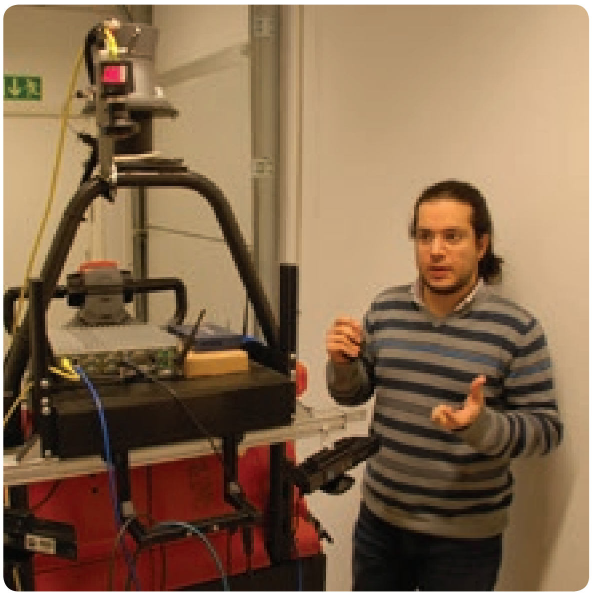
Outlook on 2014

In early 2014, we began work on two projects. Vasco (CAISR and AB Volvo) will become our flagship project with Volvo. It investigates shared human-robot construction of rich maps for worksite automation. In4Uptime (Vinnova) investigates how data that is plentiful but of highly varying quality can be leveraged, for instance in predictive maintenance applications. We are also closely involved with the VICTIg project at CERES (KKS and VTI) which investigates innovation methodologies for ICT in vehicles.

By June 2014, we will prepare two second-stage proposals for distributed research environments (SIDUS) funded by KKS. TINA-AIR proposes to investigate factors of trust in autonomous systems by focusing on activity and intention recognition. BIDAF proposes to investigate big data analytics for fleets. Both these proposals passed the first evaluation stage, and we are receiving funds to flesh them out with concrete research questions, work and collaboration plans, and infrastructure investments.

CAISR company partners

AB Volvo,
Optronic,
Toyota Material Handling Europe,
Kollmorgen,



Saeed Gholami Shahbandi describes different sensors used for navigating a fork lift in a warehouse

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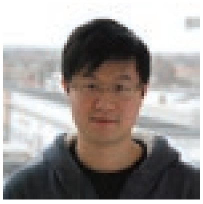

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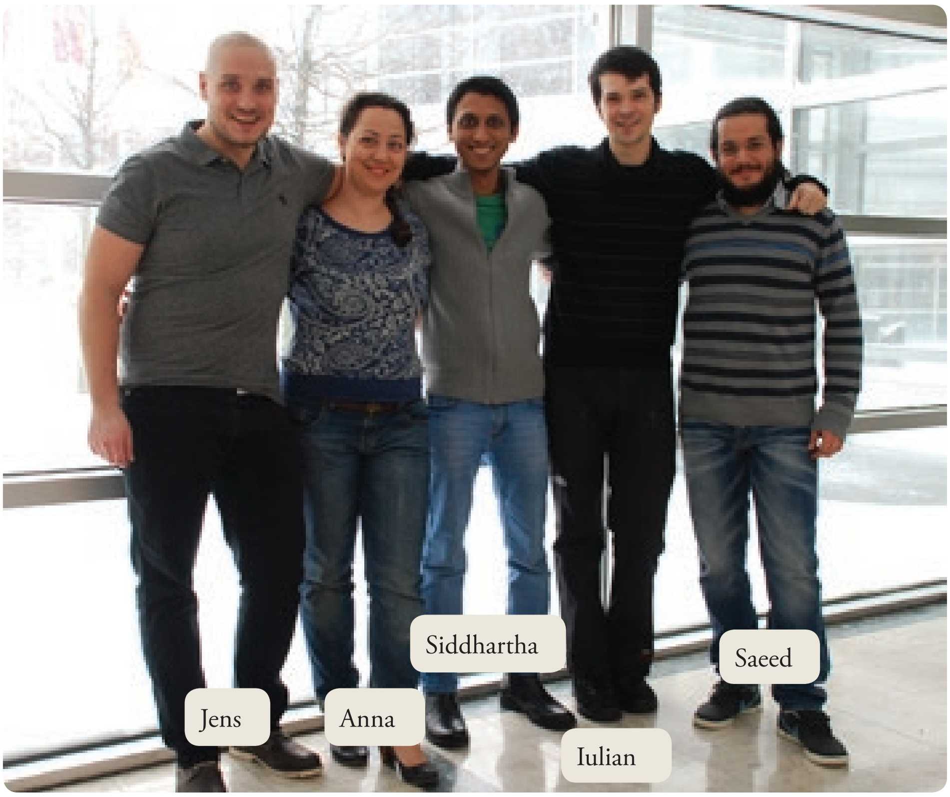
CAISR PhD students



Jens Lundström

I am working with applying machine learning (ML) methods in the area of Smart Homes. Currently, we are exploring how human behaviour models can be used to improve the elderly care and the quality of life for the elderly. A few examples of tasks carried out during 2013 in the SA3L project are: writing applications to the ethical review board, presenting the project to the municipality and installing sensors in the home of the participants. Meanwhile a sufficiently large data set is collected, we have developed an algorithm for detecting deviating behaviour patterns which is currently fed with data generated from a behaviour pattern simulator (a simulator which we also developed).

After graduating from the master program I continued to work at full time building my own business within the field of system development. The six years running the business gave experience in areas such as: project management, software development, image analysis, testing and system maintenance. It was a natural step to start pursuing the PhD degree in 2009. The studies started with the project, Predicting Print Quality, focused at assessing and exploring print quality using ML. My thesis defence is planned for 2014, where I will be discussing the work of two application areas into the context of situation awareness.

Anna Mikaelyan

I am Anna Mikaelyan and here, at Halmstad University, I am pursuing a PhD in image analysis.
I was funded by European Marie-Curie grant called BBfor2 (Bayesian Biometrics for forensics). Network within the project includes universities of different European countries working with forensic biometrics. My research is the analysis of bad quality forensic images, specially fingerprints.
Past year was conclusive year of the project and I went for final collaborative trips to University of Twente and NFI where worked with faces and fingerprints respectively. Thereafter, I traveled for a month to Finish forensic laboratory to work with forensic shoe print images.

Siddhartha Khandelwal

After finishing my Bachelor in Electronics, I worked for a year in a Robotics Start-up called ThinkLabs at IIT, Bombay (India) followed by a Masters in Robotics at WUT, Poland and ECN, France. In 2012, I joined IS-Lab at Halmstad University to pursue my PhD on Human Motion Analysis using Wearable Sensors. Currently, I'm associated with project HMC2 - Human Motion Characterization and Categorization with focus on Gait Analysis using accelerometers. My research revolves around healthcare applications that involve investigating characteristics of human gait in order to develop tools for clinical analysis of neuro-physiological diseases and health activity monitors for improving quality of living. Part of my research also focusses on analyzing technique of elite athletes, especially for running and bicycling, using wearable sensors.

PhD student Siddhartha Khandelwal
and supervisor Nicholas Wickström

Iulian Carpatorea

I have bachelor in "Computer science", graduating in Romania. After that I moved to Sweden and spent two and half years working in order to secure financial stability for full master studies. I have continued my studies at Halmstad University where I enrolled for Master in Embedded and Intelligent Systems program in 2010 and graduated in 2012. Following that I was directly co-opted in a pilot project in cooperation with Volvo Group Trucks Technology aimed at assessing driver influence and fuel consumption factors. After a long one and half year we had enough to make this work into a PhD which started in December 2013 under the supervision of Prof. Rögnvaldsson and assistant-prof Novaczyk.

Saeed Shahbandi Gholami

I studied Electrical Engineering at University of Mazandaran in Iran. Accomplished my BSc studies in "electronics" and "digital design" by "implementation of a convolutional decoder on FPGA". Following my education I attended a robotic master program (ASP) in Ecole Central de Nantes in France. Participating in Cart-O-Matic robotic group in University of Angers (ISTIA), for a French national competition (defi-carotte), I graduated by defending my thesis on "object recognition with neural network". I joined CAISR at Halmstad University in 2012, working in the AIMS project under supervision of Prof. Verikas and Åstrand. My contribution to the project is mainly focused on map analysis and semantic annotation (e.g. structural labels as corridors or local label such as pillars and pallet cells). The objective is to increase the support the awareness of lift-trucks (Auto Guided Vehicles; AGVs) via providing them with an understanding and knowledge on their surrounding environment. My main interests lie in "Robotic", "Computer Vision" and "Machine Learning".

Stefan Ericson - University of Skövde

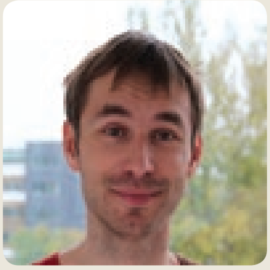
I received my M.Sc. in Electrical Engineering from University of Skovde in 1999. Then I worked as an electronics designer of space electronics at Omnisys Instruments AB for a couple of years. After that I returned to University of Skovde to work as a Lecturer. In recent years I have been studying part time towards a PhD degree. My studies are in collaboration with CAISR at Halmstad University, under the supervision of Dr. Åstrand and Prof. Rögnvaldsson. My research interest is visual navigation of mobile robots in agricultural environment. During 2013 I have mainly been on parental leave, but on my work time I focused on my PhD studies. I have among others participated in summer school on image processing (SSIP2013) where I received the price for the second best project.

Klas Hedenberg - University of Skövde

In 1995, I graduated from University of Skövde with a degree in Electrical Engineering and worked three years as a system engineer at Saab Military Aircraft in Linköping conducting tests for hardware and software. I went on to study for an M.Sc. in Electrical Engineering at the University of Skövde and graduated there in 1999. Following this, I continued to work as a lecturer in Electrical engineering at the University of Skövde. I have been the program director for engineering programs and have taught in many engineering courses. My research interest is mobile robots in industrial environments and how computer vision systems can be used for obstacle avoidance. I am currently working on how the safety standard for driverless trucks corresponds to 3D sensors. I am supervised by Prof. Rögnvaldsson and Dr. Åstrand.

Petras Ražanskas - University of Kaunas

I earned BSc and M.Sc. degrees in applied mathematics at Kaunas University of Technology (KTU). The studies heavily emphasized statistical methods of analysis, as well as techniques of digital data manipulation and data mining. In particular, I focused my attention on various methods of pattern recognition based on artificial intelligence approach, such as fuzzy logic systems or neural networks. For example, for my BSc thesis, I developed an algorithm that could train a robot to navigate a maze autonomously by using a predetermined set of corrective rules to influence the teaching process of a neural network. These interests, as well as the knowledge of statistical analysis, were perfectly matched when I was offered an opportunity to participate in a CAISR project about an intelligent system for fatigue detection and evaluation during cycling as a part of joint PhD studies in KTU and Halmstad University under the supervision of professor Antanas Verikas. My research at the moment is concentrated around analysis of spectral and temporal features of electromyographic signals, collected during a cycling exercise, with the goal of accurately predicting the fatigue levels of the test subjects.



Rune Prytz Andersson
Industrial PhD Student Volvo Group Advanced Technology & Research

I studied Electrical Engineering at Lund University in Sweden. My studies was concentrated towards automatic control and real time systems Following that I started working at Volvo Technology Cooperation in 2004. In 2009 I as an Industrial PhD student in cooperation with Volvo and Halmstad University. My interests are within fleet based predictive maintenance using both unsupervised and supervised approaches.

I have mainly been working in the research project ReDi2Service which was successfully ended in 2014.

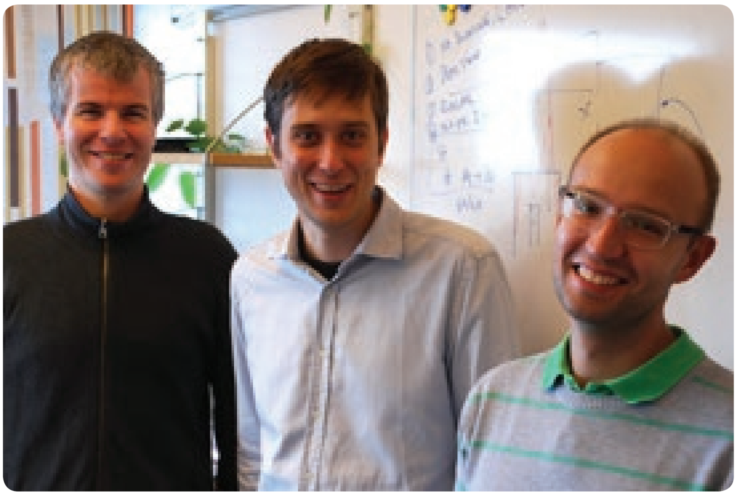
Magnus Svensson
Industrial PhD student Volvo Group Advanced Technology & Research

I have a MSc in Electrical Engineering from the Royal Institute of Technology in Sweden 2007. I am an industrial PhD student employed at Volvo, where I am also Uptime Specialist, Advanced Technology and Research. I have worked at Volvo for more than 10 years. My research topic is deviation detection of on-vehicle systems based on self-organized search for signal relationships. I presented my Licentiate thesis, "Vehicle Monitoring with Anomaly Detection by Embedded Agents", in 2010 and I plan to defend my PhD thesis during 2014. At Volvo I have previously developed embedded control software for various applications in the automotive field, not least on climate control where I developed the first fully automated climate controller in the heavy duty segment. I have also worked with developing and improving the innovation process at Volvo Technology.

Peter Mühlfellner
Industrial PhD Student Volkswagen Group

I obtained my Masters degree from Halmstad University, Sweden, and my Diploma Degree from the Salzburg University of Applied Sciences, Austria, in 2011/2012 respectively.

Currently, I'm an industrial PhD-Student with Halmstad University and Volkswagen Group Research. My research-interests include both Robotics and Computer Vision, with a focus on Visual SLAM in automated driving scenarios. To apply Visual SLAM in real-world scenarios, I'm developing a Multi-Session Visual SLAM system which incorporates information from multiple visits over several months, to the same location. My thesis-work is supervised by Prof. Rögnvaldsson and Dr. Philippsen.



Industrial PhD student Peter Mühlfellner together with his supervisor Dr. Roland Philippsen (left) and second supervisor Dr. Wojciech Derendarz from Volkswagen AG (right), on a meeting at Halmstad University

Halmstad Colloquium

The **Halmstad Colloquium** is a distinguished speaker series hosted by the School of Information Science and Computer & Electrical Engineering at Halmstad University. The speakers are invited from universities around the world to talk about topics in the areas of embedded and intelligent systems, cyber physical systems, and related areas. The colloquium is an activity of CERES (Centre for Research on Embedded Systems and CAISR.(Centre for Applied Intelligent Systems Research).

During 2013 Halmstad Colloquium had the pleasure to welcome the following persons, invited by CAISR:

Mechatronic Systems for the Repair and Training of Human Sensorimotor Control

Marcia O'Malley

Rice University

Event-based control and estimation

Karl H. Johansson

Royal Institute of Technology

Model-based Design of Cyber-Physical Systems

Janos Sztipanovits

Vanderbilt University

Autonomy is overrated: Towards shared human-machine control of vehicles and other mechanical systems

Karl Iagnemma

Massachusetts Institute of Technology

Interacting with Multi-Robot Networks

Magnus Egerstedt

Georgia Institute of Technology

And speakers invited by other labs/research groups at the School of IDE:

Warwick Tucker, University of Uppsala,
Validated Numerics

Robert Cartwright, Rice University,
To type or not to type ...

John Kenney, Toyota InfoTechnology Center,
A Linear Adaptive Control Approach to Congestion Management in Cooperative ITS

Radu Grosu, Vienna UT / Stony Brook,
The Human Heart An Ultimate Cyber-Physical System

Kishor S. Trivedi, Duke University,
Stochastic Petri Nets

Gul Agha, University of Illinois at Urbana-Champaign,
The Actor Model: Foundations, Languages and Open Problems

Doug Leith, National University of Ireland Maynooth,
Doug Leith on Decentralised Constraint Satisfaction

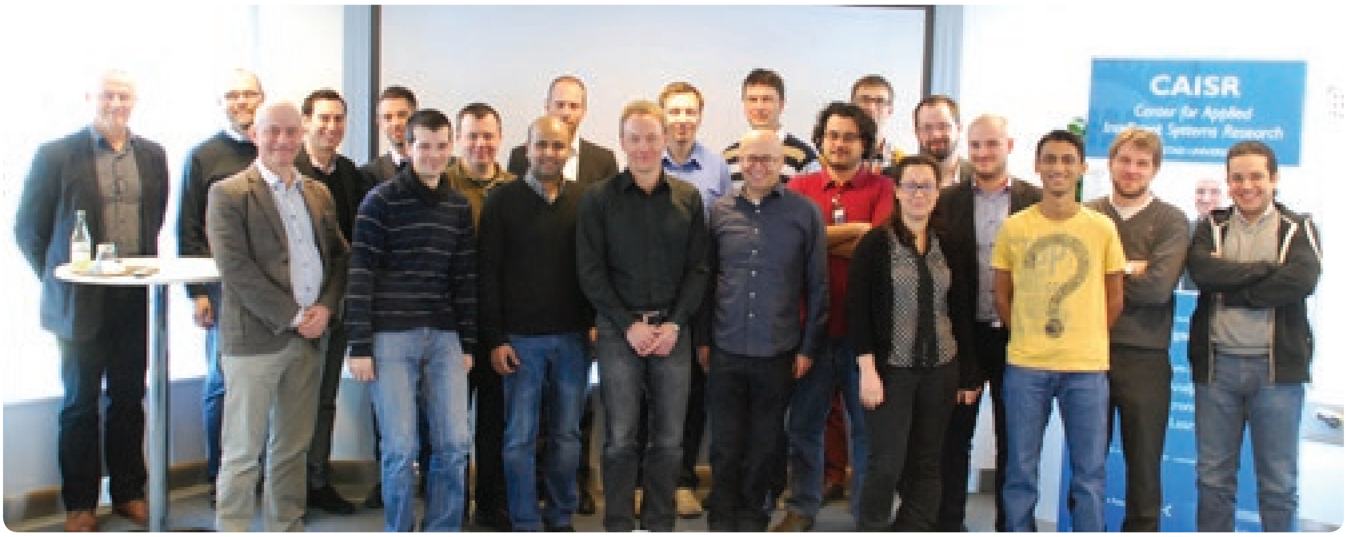
Mike Butt, Synopsys,
Kahn Process Networks in Silicon for Real-Time Embedded Systems

Dan Hammerstrom, DARPA,
The Future of Embedded Computing; a DARPA Perspective

Christoph Mecklenbräuker, Forschungszentrum Telekommunikation Wien,
Vehicular Channel Characterization for Dependable Intelligent Transport Systems

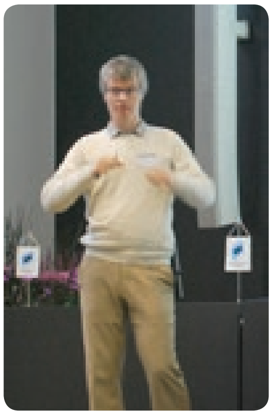
All Halmstad Colloquium talks are available on Youtube!

Highlights 2013

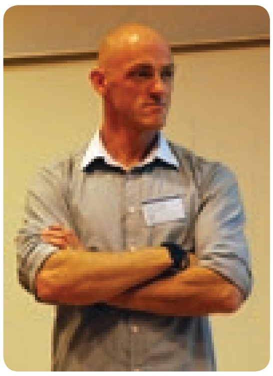


CAISR Industrial Advisory Board and staff at a joint meeting, February 2013

Right: Karl Iagnemma, guest professor from MIT and Roland Philippsen from CAISR, gave a appreciated talk about robotics at **Information Technology Open Day.** More than 200 visitors from industry, academi and others visited the day. One of the aims with the day was to draw attention to the many successful enterprises within the information technology area that have grown mutually with the research at Halmstad University. Lena Norder from The Swedish Electronics Trade Association talked about the need for further efforts within innovation and research.



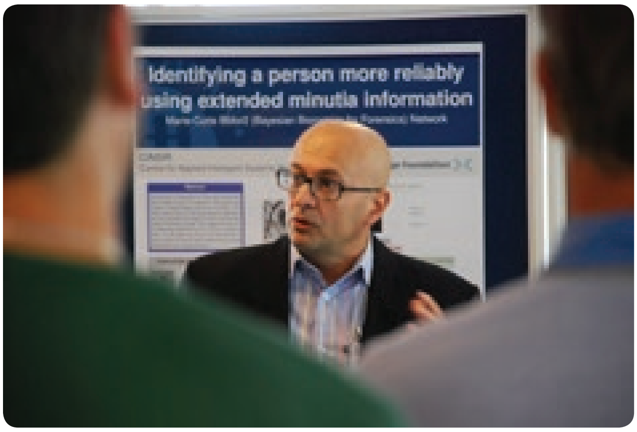
Sławomir Nowaczyk, Thorsteinn Rögnvaldsson and Stefan Byttner gave a seminar "Learning about maintenance needs from on-board streaming data and off-board data bases" were they presented how the streaming data on-board modern vehicles combined with off-board maintenance records, and other off-board databases, can be used to predict and detect maintenance needs for complex mechatronic products (city buses). Of course on a bus generously lent by one of CAISR industrial partners.



The Information Technology Open Day engaged speakers from industry as well as staff from the different labs at the School of IDE. Above Pontus Wärnestål and Maria Åkesson who gave the seminar "Doing digital service innovation" were they illustrated how they work with digital service innovation in practice. Pontus and Maria showed examples of design activities from different research projects, designing digital services such as peer-support for children with cancer, an iPad game for elderly, and digital newspaper services.

Hans-Erik Eldemark gave a talk about efficient use of electrical grids at a Smart Grid Workshop, that was held during three days in June. The Workshop aimed to:

- To start a dialog between researchers and companies about innovation opportunities in the area of smart grids;
- To find new research directions and start new collaborative research projects within the area of smart grids;
- To discuss the possibility of collaborative educational programs with a smart grid focus.



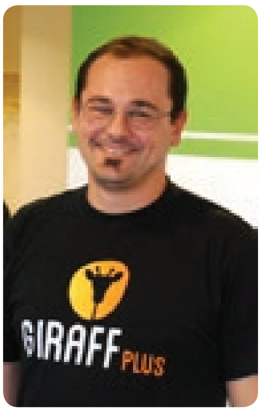
Poster session at IAB meeting in August 2013. Josef Bigun explaining minutia information

Ram Prasad visited us during September to November 2013. Ram is a PhD student in the Biometric Recognition Group - ATVS, Universidad Autonoma de Madrid. He is working under a Marie Curie Network which stipulates spending at least 6 month abroad during the PhD studies, in at least two different universities in order to increase mobility and network of young researchers. Josef Bigun was one of his supervisors in the project.

Siddhartha Khandelwal (left) received a Highly Commended paper award for his paper Estimation of the trunk attitude of a humanoid by data fusion of inertial sensors and joint encoders, at the16th International Conference on Climbing and Walking Robots and the Support Technologies for Mobile Machines in Sydney, Australia.

Wagner De Morais (right) - Winner of Doctoral Colloquium award at the 9th International Conference on Intelligent Environments 2013 with his paper A "Smart Bedroom" as an Active Database System. The conference was held in Athens, Greece.

Andrea Orlandini, Institute for Industrial Technology and Automation, National Research Council of Italy gave a seminar in which he described his experiences while submitting and working with projects within the EU FP7 programme. During the seminar, he also described the GiraffPlus project (FP7), developed in collaboration with Örebro, Lund, Spain, among other EU countries. The GiraffPlus project is about a home-based social robot that supports prevention and earlier detection of health problems as well as cognitive assistance.



Dr Thorsteinn Rögnvaldsson and Ahmed Mosallam, PhD student at Département Automatique et Systèmes Micro-Mécatroniques Group, University of Franché-Comte, visited us in October 2013. He presented his PhD thesis work on self-organized feature extraction for predicting useful remaining life for vehicle components, like bearings and batteries. He was inspired to take this research track when doing his Master thesis, which was supervised by CAISR members. Ahmed aims to defend his PhD thesis in 2014.

Matthias Mayr is a student in electrical engineering and information technology at Karlsruhe Institute of Technology, Germany, He visited CAISR on an internship and worked on the enhancement of the home assisted living architecture of Wagner De Morais with the services of a mobile robot. One goal is to enable the robot to find a person in an apartment and ask for the well-being if the assisted living system assumes that there's something wrong.

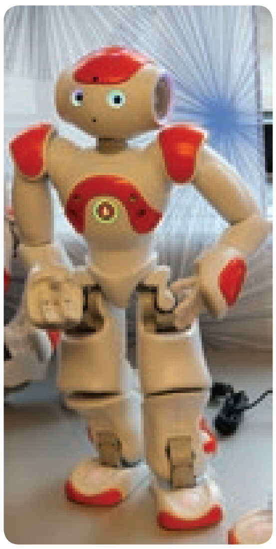
The robot "Max" ready for its mission.

The ReDi2Service video is published at Youtube in August 2013. ReDi2Service is a research project within the Vinnova FFI programme, Halmstad University and AB Volvo have developed a new predictive maintenance, fault detection and remote diagnostics algorithm. www.youtube.com

The HMC^2 project is collecting more data. A pilot test on bicycle was made in December. Charlotte Olsson and Nicholas Wickström keeps an eye on the test person

Cadence 101 RPM, heart rate 174., speed 42 km/h. Want to sign up as a test person?

Another robot, this time the humanoid Nao, who had a medially breakthrough on TV, first in a dance show and then as moderator in a Swedish scientific show for kids "Hjärnkontoret". Students from the school of IDE did the programming work.



Kan Nakada and Hiroto Shirahige spent two months at IS-lab/CAISR to finish their master thesis work. The visit was a part of a student exchange program between Halmstad University and Kagawa University in Japan. In 2012 and 2013 professor Keisuke Suzuki from the same university visited us and planned for student exchange between their Department of Intelligent Mechanical Systems Engineering and our Intelligent Systems Lab. Kan and Hiroto worked in a project on Intelligent Speed Adaptation (ISA) with the aim to optimize the Human-Machine-Interface of informative ISA based on the driver characteristics.

Stefan Byttner from CAISR and Keisuke Suzuki from Kagawa University, Japan

CAISR staff acted as test persons and received feedback from the Intelligent Speed Adaptation System

Fernando Alonso-Fernandez and Josef Bigun obtained the second position in the First ICB Competition on Iris Recognition (ICIR2013). The competition was organized in the framework of the 6th IAPR International Conference on Biometrics, held in Madrid, June 4 - 7. The system submitted by Halmstad University obtained the second place after an industrial contributor, being the first among academic contributors.

Kan Nakada and Hiroto Shirahige

Some test persons received continuously messages about driving too fast

IS-lab was visited by Ulf Johansson and Tuve Löfström from the University of Borås in March. Ulf and Tuve held a seminar about "Conformal Predictions" with the title "Conformal Prediction, a Tutorial". Conformal prediction is about how to assess the reliability in predictions done by machine learning algorithms.
From right: PhD student Tuve Löfström (BH), Senior lecturer Ulf Johansson (BH) and PhD student Jens Lundström (HH).

Extended Abstracts

Identity and Message recognition by biometric signals

J. Bigun, F. Alonso-Fernandez, S. M. Karlsson, A. Mikaelyan

Abstract

The project addresses visual information representation, and extraction. The problem is investigated within applications that are normally multidisciplinary, e.g. forensic science, human machine communication, and robotics. Multimodal person identification and messaging by biometric signals have been at the focus.

Keywords

Image processing, biometric identification, feature extraction, information encoding, information decoding.

Background and Motivation

Facial detection and recognition resilient to physical image deformations is a challenging problem that hinders not only face based identity recognition but also iris based identity recognition goes en-masse. We have been studying both in conjunction with periocular image analysis, Fig. 1.

Illumination, Scale, and orientation invariant information encoding and decoding is central to many pattern recognition problems. We have been studying this in the context of lip-motion analysis for identity and spoken message recognition.

Localization and identification by vision is a fundamental problem of robotics, [9]. Filtering techniques studied for illumination and scale invariant features are also useful for this application, which we have been proposing as a tool for robot steering, identification and localization to HH students, e.g. in the course Design of Intelligent Embedded Systems,
http://www.youtube.com/watch?v=4ryM3kl2-jU
http://www.youtube.com/watch?v=LKchAJvnjcA

Quality and orientation descriptors for forensic images is important to reliable and efficient use of Automatic Identification of Fingerprint Systems. In this project we have been studying image analysis techniques to help using the visual capabilities of human forensic experts more efficiently when they communicate with recognition engines.

Facial detection and recognition

Biometric identity recognition using periocular images based on retinotopic sampling grids and Gabor analysis of the local power spectrum has been studied. Periocular images include iris based recognition, a weak link of which is the segmentation of iris region containing useful identity cues. A new method, using the Generalized Structure Tensor, has been studied. Segmentation performance under different degrees of image defocus and motion blur has also been evaluated.

Figure 1: Automatic measurement of iris image quality. Second column shows the points where Iris Edge Sharpness measure (IES) is computed. Third column shows Orientation Certainty Level measure (OCL), brighter color indicating higher quality.

Image degradations can affect the different processing steps of iris recognition systems. With several quality factors proposed for iris images, its specific effect in the segmentation accuracy is often obviated, with most of the efforts focused on its impact in the recognition accuracy. We have evaluated the impact of 8 quality measures in the performance of iris segmentation, [19].

With the pronounced need for reliable personal identification, iris recognition has become an important enabling technology in our society. However, automatic iris recognition has to face unpredictable variations of iris images in real-world applications. Therefore the first ICB Competition on Iris Recognition (or ICIR2013 shortly) has been organized to track the state-of-the-art of iris recognition, wherein Halmstad University contributed with a system, [18], and obtained a second place after an industrial contributor, i.e. the rank of Halmstad University was the highest among university contributors.

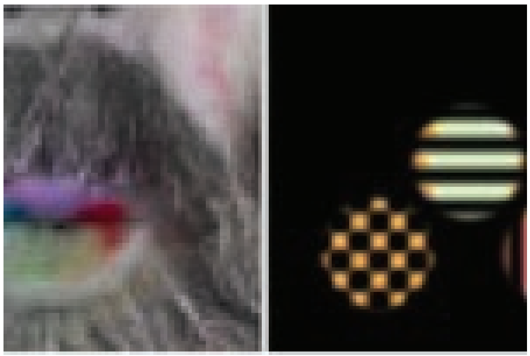


Figure 2: Real time optical flow, and video processing software, with support for camera input in Matlab, is able to track and classify lip motion

Speech & speaker recognition by lips

Methods for detecting high-level lip-motion events have been studied. The mouth events of opening and closing has been at the focus of attention, Fig. 2. The approach is based on a recently developed optical flow algorithm that handles the motion of linear structure in a stable and consistent way. Novel software relative to this research has been developed.

Measurements for Forensic identification

Forensic images are of extreme low-quality. We have been studying feature extraction for increased identification power of fingerprints by dense orientation maps with frequency adaptation. Annotated databases is important. However, such databases are scarce and those that exist contain few image samples. We have been investigating ways to obtain most from existing databases to facilitate method developments. Increasingly, reliable absolute frequency maps are needed, e.g. for image enhancement of forensic images. Less studied is however the mutual dependence of both, and how to estimate them when none is known initially. We have introduced logarithmic scale space generated by trace of structure tensor to study the relationship.

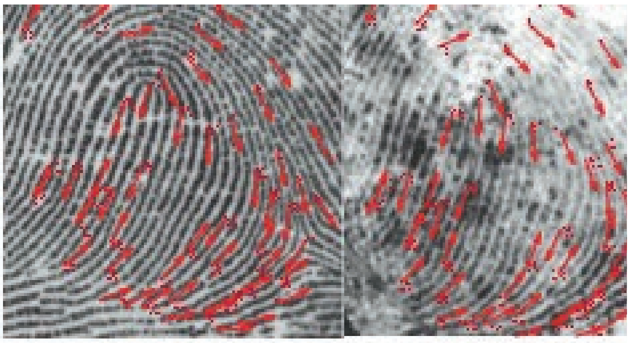


Figure 3: Forensic fingerprints minutia correspondence example, NIST-sd27

Results

We have shown that top verification rates can be obtained without rotation compensation, thus allowing to remove this step for computational efficiency. Also, the performance is not affected substantially if we use a grid of fixed dimensions, or it is even better in certain situations, avoiding the need of accurate detection of the iris region, [19], [17]. This is supported by that Halmstad University was among top-contenders in an international iris-recognition competion 2013,
http://www.zhuhaiyisheng.com/news/icir2013/

We have released publicly available software for motion estimation, with educative documentation, from research concerning lipmotion:
http://www.mathworks.com/matlabcentral/fileexchange/?term=authorid:174911

We have established ground truth of minutia level correspondences for the publicly available NIST SD27 data set, whose minutia have been verified by forensic fingerprint experts by using semi-automatic extraction methods, Fig. 3. We have been developing novel orientationbased features which are rotation invariant and use large neighborhoods, so that each minutia can be described with more than the minutiaridge orientation– the current practice.

Partners and Duration

The project has been implemented mainly with support of 3 sub-projects, the details of which are listed below. The CAISR project acting as a frame and catalyst is an appreciated supplement during 2012. Main partners of
collaboration have been University of Twente (NL), Autonomous university of Madrid (ES), Radboud University (NL), Dutch forensic institute (NL), Swedish Forensic Laboratorium (SE), University of York.

Swedish VR project(2010): Bio-distance,
Biometrics at a distance EU-Marie Curie project (2011-2012): BIOMETRICS AT A DISTANCE

Swedish VR project (2013-2014): Facial detection and recognition resilient to physical image deformations

Swedish VR project (2010-2011): Lipmotion, face and speech analysis in synergy, for human-machine interfaces

Swedish VR project (2012-2013): Scale, orientation and illumination invariant information encoding and decodingA study on invariant visual codes

EU-Marie Curie project (2011-2013: BBfor2Bayesian Biometrics For Forensics.

References

[1] Fernando Alonso-Fernandez, Julian Fierrez, Daniel Ramos, and Joaquin Gonzalez-Rodriguez. Qualitybased conditional processing in multibiometrics: Application to sensor interoperability. *IEEE Trans. On Systems, Man and Cybernetics, part A,* 40(6):1168–1179, 2010.

[2] Fernando Alonso-Fernandez, J. Fierrez-Aguilar, J. Galbally, and J. Ortega-Garcia. Exploiting character class information in forensic writer identification. In *IWCF, lncs 6540*, pages 31–42, 2010.

[3] S. M. Karlsson and J. Bigun. Directionality features and the structure tensor. In *Swedish Symposium on Image Analysis (SSBA2010)*, pages 109–112, No. 34 in CBA Report Series, ISSN 1100-6641, Uppsala, Sweden, March 2010.

[4] Stefan M. Karlsson, Sylvia C. Pont, Jan J. Koenderink, and Andrew Zisserman. Illuminance flow estimation by regression. *International Journal of Computer Vision,* 90(3):304–312, 2010.

[5] J. Ortega-Garcia, J. Fierrez, Fernando Alonso-Fernandez, J. Galbally, M. R. Freire, J. Gonzalez-Rodriguez, C. Garcia-Mateo, J. L Alba-Castro, E. Gonzalez-Agulla, E. Otero-Muras, S. Garcia-Salicetti, L. Allano, B. Ly-Van, B. Dorizzi, J. Kittler, T. Bourlai, N. Poh, F. Deravi, M. W. R. Ng, M. Fairhurst, J. Hennebert, A. Humm, M. Tistarelli, L. Brodo, J. Richiardi, A. Drygajlo, H. Ganster, F. M. Sukno, S. K Pavani, A. Frangi, L. Akarun, and A. Savran. The multi-scenario multi-environment biosecure multimodal database (bmdb). *IEEE Trans. on Pattern Analysis and Machine Intelligence*, 32(6):1097–1111, 2010.

[6] F. Alonso-Fernandez and J. Bigun. Iris pupil detec tion by structure tensor analysis. *In Swedish Symposium on Image Analysis (SSBA2011)*, Linkoping University, 50183, ISY Linkoping, Sweden, 6:15:P:37, March 17-18 2011.

[7] Josef Bigun and Stefan M. Karlsson. Histogram of directions by the structure tensor. In *Proceedings of the 4th International Symposium on Applied Sciences in Biomedical and Communication Technologies*, 2011.

[8] Javier Galbally, Julian Fierrez, Fernando Alonso-Fernandez, and Marcos Martinez-Diaz. Evaluation of direct attacks to fingerprint verification systems. *Springer Journal of Telecommunication Systems, Special Issue of Biometrics Systems and Applications*, 47(3):243–254, 2011.

[9] S. M. Karlsson and J. Bigun. Synthesis and detection of log-spiral codes. In *Swedish Symposium on Image Analysis (SSBA2011)*, Linkoping University, 50183, ISY, Linkoping, Sweden, :2:S:33, March 17-18 2011.

[10] F. Alonso-Fernandez and J. Bigun. Iris boundaries segmentation using the generalized structure tensor: A study on the effects of image degradation. In *The IEEE Fifth International Conference on Biometrics: Theory, Applications and Systems (BTAS 2012), Washington DC*, pages 6–. IEEE XPLORE, Sep. 23-26 2012.

[11] F. Alonso-Fernandez and J. Bigun. Iris segmentation using the generalized structure tensor. In *Swedish Symposium on Image Analysis (SSBA2012)*, March 8–9 2012.

[12] Fernando Alonso-Fernandez and Josef Bigun. Periocular recognition using retinotopic sampling and gabor decomposition. In *Computer Vision – ECCV 2012. Workshops and Demonstrations*, number 7584 in Lecture Notes in Computer Science, 2012.

[13] Fernando Alonso-Fernandez, Julian Fierrez, and Javier Ortega-Garcia. Quality measures in biometric systems. *IEEE Security and Privacy*, 10:52–62, 2012.

[14] Javier Galbally, Fernando Alonso-Fernandez, Julian Fierrez, and Javier Ortega-Garcia. A high perfor mance fingerprint liveness detection method based on quality related features. *Elsevier Future Generation Computer Systems Journal*, 28(1):311–321, 2012.

[15] Stefan Karlsson. Lip-motion events analysis and lip segmentation using optical flow. In *Computer Vision and Pattern Recognition Workshops (CVPRW), Biometrics*, pages 138–145, 2012.

[16] Anna Mikaelyan and Josef Bigun. Ground truth and evaluation for latent fingerprint matching. In *2012 IEEE Computer Society Conference on Computer Vision and Pattern Recognition Workshops, CVPRW 2012*, IEEEComputer Society Conference on Computer Vision and Pattern Recognition workshops, pages 83–88, 2012.

[17] Fernando Alonso-Fernandez and Josef Bigun. Biometric recognition using periocular images. In Swedish *Symposium on Image Analysis 2013 (SSBA), Gothenburg*, 14-15 March, 2013.

[18] Fernando Alonso-Fernandez and Josef Bigun. Halmstad university submission to the first icb com petition on iris recognition (icir2013), 2013. Contribution to Competition.

[19] Fernando Alonso-Fernandez and Josef Bigun. Quality factors affecting iris segmentation and matching. In *Proceedings 2013 International Conference on Biometrics:*, pages 1–6, 2013. IEEE Catalog Number: CFP1392R-ART.

ReDi2Service (Remote Diagnostics Tools and Services)

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1. CAISR, Halmstad University, Sweden
2. Volvo Group Trucks Technology, Gothenburg, Sweden

There is a high demand for better tools for wear and maintenance prediction on vehicles and services connected with these. The ReDi2Service project builds on using distributed embedded agents for self-monitoring, i.e. self-organized discovery for fault detection, fault isolation, diagnostics and wear prediction.

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1. Background and Motivation

The last decades have seen a very strong development in vehicle electronics. A modern car, truck or bus is effectively a cyber-physical system with mechanics and a large number of embedded processors and computers on-board. Vehicles have data networks (e.g. CAN) where sensor readings, control commands, fault codes and other signals are communicated in a continuous stream of data. The idea behind ReDi2Service project is to develop algorithms for self-monitoring vehicles, capable of discovering and describing their own operation, and detecting when deviations from the norm occur. By using data mining across the many data streams available on-board, and by comparing discovered relations across the fleet, our system can self-discover faults and component wear early and continuously monitor the vehicle status.

Traditional approaches to condition monitoring of vehicles (and other equipment) have all very much the same approach; a reference model is built off-line, based on expert knowledge and data from test runs, verified, and finally implemented on-board. Building such models is expensive in terms of man hours and experiments and compromises regarding the scope have to be made since it is too costly to adapt them to all usage profiles and all climate conditions. Finally, traditional approaches require that faults are thought of beforehand.

In ReDi2Service we take advantage of the fleet aspect and allow models of expected behavior to be created in self-organizing fashion. By focusing on differences in operation between similar individuals, our system is capable of discovering previously unknown deviations.

2. Methodology

The project has both a hardware and software aspect. The former is the development of an on-board hardware (VACT) that listens to the data streams on the vehicles and the telematics gateway for transmitting the information to a back-office application. The software aspect is the software running on the "clients" (i.e. in each VACT module), the embedded agents, and the data mining algorithm in the back-office application.

The algorithmic methodology we use is a mixture of machine learning and statistical methods. The fault detection problem can be split into three separate (or semi-separate) parts. First is finding the interesting signals and relationships to monitor. Second is comparing these relationships across the fleet, and finally determining when everything is normal and when individual systems deviate in a significant way (see Figures 1 and 2).

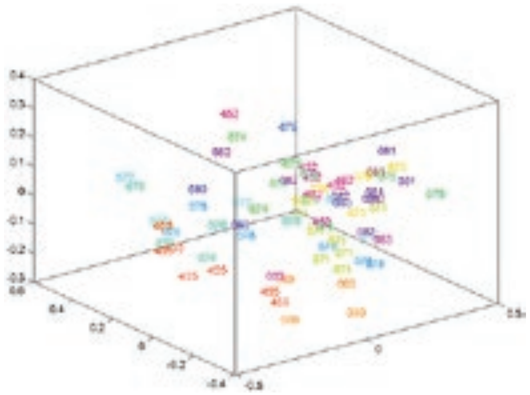

Figure 1: Distribution of the engine oil temperature characteristics in a fleet during a week when everything is normal. Each point corresponds to one vehicle and one day.

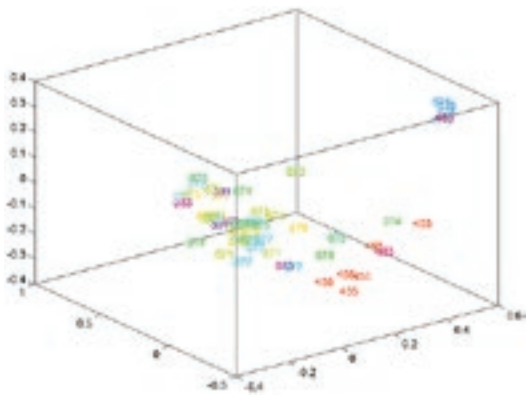

Figure 2: Distribution of the engine oil temperature characteristics in a fleet during a week when one vehicle has a fault – its characteristics form a separate cluster away from the fleet. Commercial diagnostic systems on-board the vehicle did not capture the fault (a broken ECU).

There are several research questions embedded in this process, e.g. how to autonomously detect “interesting” relationships to monitor without knowing what a fault looks like, how to robustly determine which systems deviate, an analysis of whether such an approach could replace traditional monitoring methods or if it should complement them, how to go beyond fault detection and do diagnostics with a distributed artificial intelligence approach (i.e. how a fleet of vehicles can be used to build diagnostic models and to aid in the search for a fault).

3. Results

A new hardware system (VACT) for listening to signals on-board vehicles has been designed, built, and used for a more than 2-year long longitudinal study on city buses in Kungsbacka. Over this time we have shown that the system can detect multiple problems and reduce the number of unplanned stops. The adaptive nature of our approach allows it to evolve with the fleet, always focusing on the relevant faults. Especially for issues that are rare or non-critical it offers a highly cost effective complement to engineered diagnostics, and can also be used to increase knowledge about a vehicle’s usage.

Figures 3 and 4 show an example; a problem that led to a jammed cylider, requiring new cylinder linings and three unplanned weeks in the workshop. It was visible in the data for months before the actual break-down.

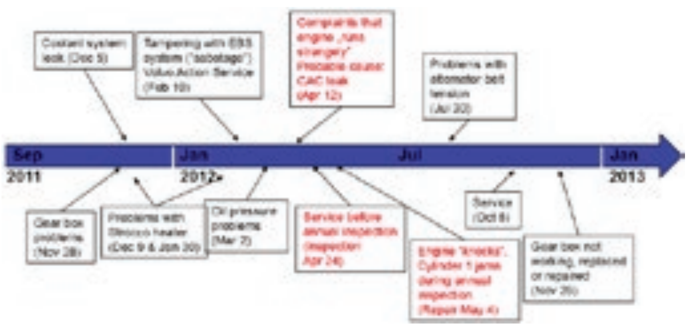

Figure 3: Excerpts from the service history for a bus that experienced an engine break-down. This is a good example of a rare problem that is complex and too expensive/difficult to make a dedicated diagnosis algorithm for.

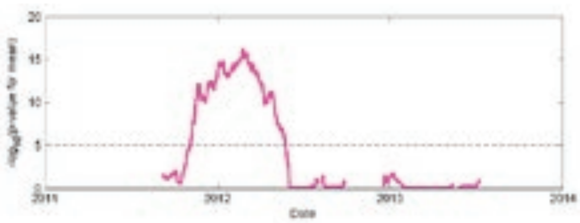

Figure 4: Warning level for a temperature signal for the vehicle. It grows above a critical threshold six months before the engine break-down. The warning disappears after the engine renovation (mid May 2012).

PARTNERS AND SPONSORS

The project is done in cooperation with Volvo Group Trucks Technology and the project manager is Niclas Karlsson. The project external sponsors have been Volvo GIB-T, Vinnova and the Knowledge Foundation.

PUBLICATIONS

[1] S. Byttner, S. Nowaczyk, R. Prytz, T. Rögnvaldsson (2013). ”A field test with self-organized modeling for knowledge discovery in a fleet of city buses”. *IEEE Int’l Conf. Mechatronics and Automation (ICMA 2013), Kagawa, Japan, August 4-7, 2013.*

[2] R. Prytz, S. Nowaczyk, T. Rögnvaldsson, S. Byttner (2013). ”Analysis of Truck Compressor Failures Based on Logged Vehicle Data”. *9th Int’l Conf. Data Mining (DMIN’13). Las Vegas, AZ, July 22-25,2013.*

[3] S. Nowaczyk, R. Prytz, T. Rögnvaldsson, S. Byttner (2013). ”Towards a Machine Learning Algorithm for Predicting Truck Compressor Failures Using Logged Vehicle Data”. *12th Scandinavian AI conf. (SCAI). Aalborg, Denmark, Nov. 20-22. 2013.*

[4] S. Nowaczyk, S. Byttner, R. Prytz (2012). ”Ideas for Fault Detection Using Relation Discovery”. *27th annual workshop of the Swedish Artificial Intelligence Society (SAIS), Örebro, Sweden, May 14-15, 2012.*

[5] G. Vachkov, S. Byttner, M. Svensson (2012). ”Battery aging detection based on sequential clustering and similarity analysis”. *6th IEEE Int’l Conference on Intelligent Systems. Sofia, Bulgaria, September 6-8, 2012.*

[6] N. Karginova, S. Byttner, M. Svensson (2012). ”Data-driven methods for classification of driving styles in buses”. *SAE World Congress 2012, Technical paper 2012-01-0744. Detroit, MI, April 24-26 2012.*

[7] M. Svensson, T. Rögnvaldsson, S. Byttner, M. West, B. Andersson (2011). ”Unsupervised deviation detection by GMM - A simulation study”. *8th IEEE Int’l Symposium on Diagnostics for Electrical Machines, Power Electronics and Drives (SDEMPED). Bologna, Italy, September 5-8, 2011.*

[8] R. Prytz, S. Nowaczyk, S. Byttner (2011). “Towards relation discovery for diagnostics”. *First International Workshop on Data Mining for Service and Maintenance, San Diego, CA, August 21-24, 2011.*

[9] S. Byttner, G. Vachkov, M. Svensson (2011). ”Incremental classification of process data for anomaly detection based on similarity analysis”. *IEEE Symposium on Computational Intelligence. Paris, France, April 11-15, 2011.*

[10] A. Mosallam, S. Byttner, M. Svensson, T. Rögnvaldsson (2011). ”Nonlinear relation mining for maintenance prediction”. *IEEE Aerospace conference. Big Sky, MO, March 5-12, 2011.*

[11] S. Byttner, T. Rögnvaldsson, M. Svensson (2011). ”Consensus Self-organized MOdels for Fault Detection (COSMO)”, *Engineering Applications of Artificial Intelligence, 24(5), pp. 833-839.*

[12] S. Byttner, M. Svensson, T. Rögnvaldsson (2010). ”Finding the Odd-One-Out in Fleets of Mechatronic Systems using Embedded Intelligent Agents”. *AAAI Spring symposium 2010, Palo Alto (Stanford), CA, March 22-24, 2010.*

Patent: J. Hansson, M. Svensson, T. Rögnvaldsson, S. Byttner, ”Remote diagnosis modelling”, US Patent 8,543,282 B2. Granted Sept. 24, 2013. (International filing date: May 14, 2007. Publication date for application: Nov. 20, 2008).

Fuel FOT Energy Efficient Transport

Learning Fleet
Marcus Elmer1, Iulian Carpatorea2 and Sławomir Nowaczyk1,2

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2. CAISR, Halmstad University, Sweden

Understanding factors influencing fuel consumption is a very important task both for automotive manufacturers, as well as for their clients. There is a lot of knowledge already available concerning this topic, but it is poorly organized and often more anecdotal than rigorously verified. Nowadays, however, enough rich datasets from actual vehicle usage are available and a data-mining based approach can be used to not only validate earlier hypotheses, but also to potentially discover unexpected influencing factors.

1. Background and Motivation

The number of embedded computers on-board modern vehicles is growing continuously, and the data exchanged among them contains a lot of information about the state of the system. It is now becoming possible to get access to numerous signals over data networks (such as CAN), coming from sensors, control units and fault codes. This kind of data is being collected within multiple projects, but it is important to recognise that the data itself is an additional asset and it can often be used for more than one purpose.

The continuous recording of driver behaviour data on the road have allowed researchers to conduct in-depth investigations on humans, machines, and their interaction in a way not possible just a few years ago. Statistical modelling and tools such as pattern recognition and data mining has the potential to become a key building block in this kind of investigations, but its full impact has yet to be explored.

2. Methodology

ATR at Volvo has collected large amounts of real-world data during the projects euroFOT and Customer Fuel Follow-up. The goal of this project is to use these rich datasets in order to better understand the factors that influence fuel consumption, with the special focus on impact of driver behaviour.

Fuel consumption depends on many different aspects of a vehicle, such as configuration, technical condition or cargo, as well as external conditions, including weather and terrain. This makes it difficult to isolate influence of those factors over which driver or fleet owner has control from the inescapable ones. This pilot study on using data mining methods over available data will assess which are the major driver-related factors affecting fuel consumption and quantify their impact, finding a way to abstract away or compensate over external conditions.

The first step is to model the fuel consumption process and develop an understanding of the main influencing factors behind it in terms of environment, vehicle and driver. This will provide a framework for analysing driver behaviour impact on fuel consumption in a way that takes relevant external factors into account. Our goal is to incorporate unknown factors into a single number, specific for each trip, in such a way that it will lead to a much more fair comparison between drivers, and to a list of driver behaviours that affect fuel consumption, and a quantitative estimation of their respective importance.

A wide range of systems and services could directly benefit from the results of the proposed project, for example Volvo could introduce efficient on-line and off-line driver coaching, which would targets specific behaviours of individual drivers that mostly improve fuel consumption and safety on the road. Those results can also be used to dynamical adapt vehicle settings, targeting lower fuel consumption, as well as for better fuel consumption approximations in vehicle simulators.

3. Results

A literature review of past works in the field has been performed, resulting in fuel consumptions models that are based on expert knowledge but tuned using on-board data. This resulted in high-accuracy fuel consumption predictions on large percentage of typical road situations. One of the challenges still left to overcome is the incomplete or nonexistent data regarding factors such as cargo, weather and tire characteristics, to name just a few that prevent more global model generalization. Good predictions regarding fuel consumption we are able to obtain are only available under a number of constraints, some of which we would like to be able to lift.

We have defined the concept of "Base Value" (BV) as "fuel used at constant speed, in top gear, on a flat road, given current vehicle and environmental characteristics". BV is the ideal fuel consumption but in practice we will never be able to calculate so our number is an approximation of the above definition.

In the last months we have investigated a number of ways of calculating BV, as well as conditions under which it is possible to do so, arriving at more and more consistent and useful results, but also discovering new factors that need to be taken into account.

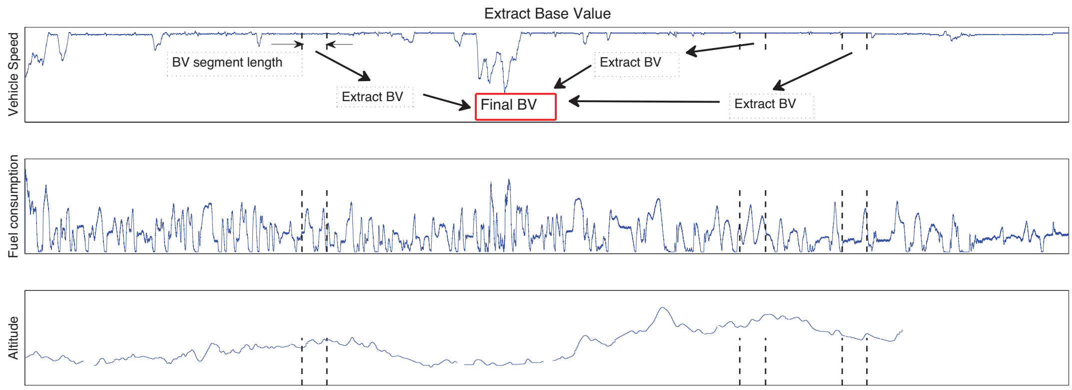


Figure 1: Fuel consumption comparison. (TOP) Fuel consumption relative to BV (MIDDLE) Measured Fuel Consumption, (BOTTOM) Vehicle Speed

NG-Test – Next Generation Test Methods for Active Safety Functions

Jawad Masood, Roland Philippsen

March 16, 2014

Introduction

Active safety systems are increasingly found in series production automobiles, with the aim of eliminating road accidents with serious or fatal outcome. One of the major bottlenecks for widespread deployment of active safety systems is the challenge of validating and verifying them.

For example, figure 1 showsa a baloon car that is used by Autoliv to evaluate active safety systems for scenarios of merging onto highways. Such physical testing is onerous and comes rather late in the engineering process. Shortcomings identified at this stage have a significantly higher impact on deployment and costs than issues identified earlier.

NG-Test is a three-year project to address this challenge. It is funded by Vinnova under the Strategic Vehicle Research Partnership FFI and involves AB Volvo, SP Technical Research Institute, Volvo Car Corporation, Autoliv, VTI, Chalmers, and Halmstad. CAISR has contributed to this project until late 2013 in the domain of requirement modeling as well as validation and verification of the entire testing framework.

Figure 1: Balloon car being used to assess active safety systems in highway-merging scenarios.

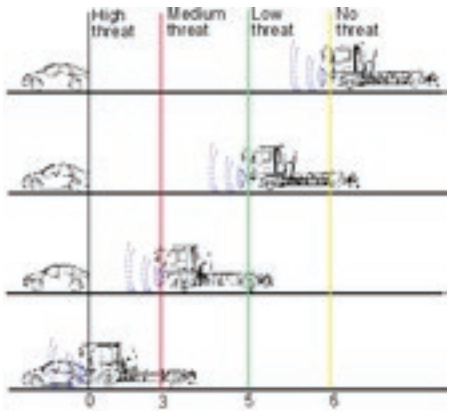


Figure 2: The scenario investigated by our case study involves an Automatic Emergency Braking system.

Contributions

NG-Test, we applied the concept of rigorous simulation to a case study in active safety system performance. A particularly clear link arose between the needs for standardisation and the tools required to streamline the engineering process. The resulting work will be presented at FISITA 2014 World Automotive Congress.

Title Domain Analysis for Standardised Functional Safety: a Case Study on Design-Time Verification of Automatic Emergency Braking

Authors Jawad Masood, Roland Philippsen, Jan Duracz, Walid Taha, Henrik Eriksson (SP Technical Research Institute), Christian Grante (AB Volvo).

Objectives The viability of future Advanced Driver Assistance Systems (ADAS) will depend heavily on the virtualization of tests and formal verification of system performance. Simulation traditionally computes individual trajectories, which severely limits the assessment of overall behaviour. To address this fundamental shortcoming, we rely on computing enclosures to compute bounds on system behaviour instead of individual traces. Major benefits are expected from the link created between early stage engineering and empirically validated standards compliance.

Methodology The formal computation of general bounds on hybrid system behaviour (termed enclosures) is a formidable challenge studied intensively by a large research community. To develop a methodology for virtualized testing based on en-

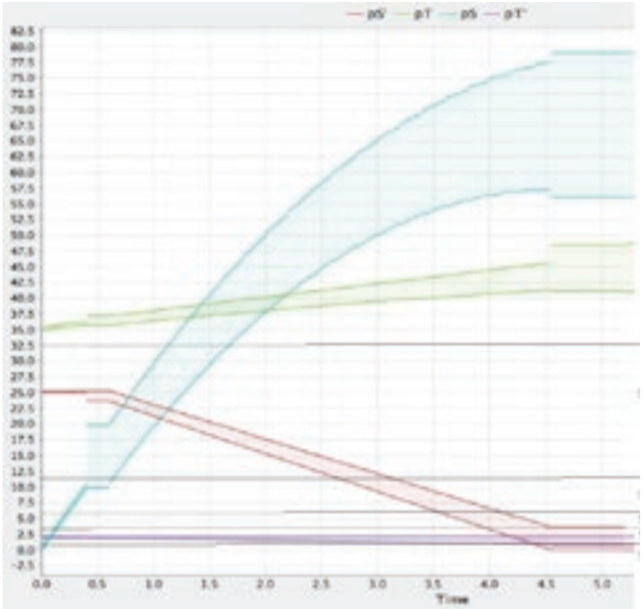


Figure 3: Using the enclosure semantics of Acumen, we can rigorously simulate the bounds on system behavior and thus directly evaluate the range of possible severities.

closures, we formulated a generic ADAS component model and identified a set of characteristics to guide the engineering process from initial sketches to more complex and complete models. In the present case study, we investigate the enclosures of a generic Automatic Emergency Braking (AEB) system and demonstrate how this creates a direct link between requirement specification and standardized safety criteria, such as exposure, severity, and controllability, as put forward by ISO 26262. The case study shows how to systematically craft and refine a hybrid system model, and illustrates the significance of the work with the example of determining rear-end collision severity levels.

Results We discuss our generic ADAS component model and a set of complexity measures that can easily be extracted from hybrid system models thereof. We describe how the hybrid systems modelling approach fits the engineering process using the AEB system as concrete example (see Figure 2). We show its implementation in Acumen, a domain-specific modelling language for cyber-physical systems with direct support for enclosure semantics (see Figure 3). A set of concrete enclosure simulations round off the study by showing the use of Acumen simulations for severity level analysis according to ISO 26262.

Limitations Tractability of hybrid systems enclosures is an unresolved challenge in general. While we propose a methodology based on enclosures for functional safety and clearly demonstrate its relevance, the studied AEB system is fairly simple. Note, however, that appropriately chosen enclosures will produce over-approximations of system behaviour – a simple model is thus still a very effective tool for early stage decision making.

Conclusion Our case study indicates that a methodology based on enclosures can provide a missing link across the engineering process, from design to compliance testing. This result is highly relevant for ongoing efforts to virtualize testing and create a unified tool-chain for next generation ADAS development.

NG-Test Partners

Volvo AB, SP Technical Research Institute, Volvo Car Corporation, Autoliv, VTI, the Swedish National Road and Transport Research Institute, Chalmers, Halmsyad

Innomerge

S. Byttner[1], S. Nowaczyk[1], T. Rögnvaldsson[1], A. Yadav[2], and D. Zackrisson[2]

[1] CAISR, Halmstad University
[2] Volvo Group Trucks Technology

Background and motivation

This project addresses the challenges related to the major growth opportunities expected to be found in emerging markets of South America, Africa, India and East Asia for Swedish truck OEMs. The local transport industry in these markets is typically entrepreneurial and innovative, but also fragmented and with very high expectation on short return on investment time. Many of the premium brand solutions successfully developed for the mature markets will need a "re-design" both in terms of technology content but also, and perhaps more important, of the way these solutions are offered to market by new and innovative business models based on a profound understanding of the business conditions in emerging markets.

Objectives

The InnoMerge project is about business models and reverse innovation for emerging markets. The main objectives of the project are:

- Building knowledge on how advanced technologies and business models can be transferred to an emerging market context in order to speed up the adoption of more sustainable truck solutions (environment and traffic safety)
- In more detail, the project will use uptime and traffic safety as the main application areas and will include the development and testing of business models and technology for on-board diagnostics
- Develop a process for reverse innovation, i.e. how innovations can be transferred back to more mature markets
- Develop cooperation with Swedish, Indian and Chinese academia

Current status

Different markets and truck operators have been investigated in an India, and the primary needs of these markets have been mapped. Data collection/measurement in a prototype truck (developed specifically for the Indian market) has been performed in 2012 and 2013. Data analysis (especially usage profiling) will be performed during 2014.

Partners in the project

Volvo Group Trucks Technology, Chalmers University of Technology and Halmstad University.

Vasco – Shared Human-Robot Construction of Rich Maps for Worksite Automation

Gaurav Gunjan, Roland Philippsen

March 21, 2014

Objectives

This project aims to develop software tools and algorithmic methodologies for robot-aided building and annotation of rich maps in worksite environments. These maps will be used for planning and execution of tasks where the degree of automation can range from assisted manual control to autonomous operation in shared work-yards, such as harbors, quarries, or construction sites. We focus on integrating state-of-the art techniques for perception, mapping and planning while developing new approaches to allow human users to interactively annotate and modify maps, define work-site constraints and task goals.

Motivation

This project will create knowledge to enable the technology and tools needed for progressive introduction of automation in work sites. A central challenge here remains as the mapping and navigation of unstructured, dynamic and changing environments like construction sites. Addressing the related research questions is essential to further the practical implementation of robotics as a tool in real-world scenarios. A particular emphasis if placed on the questions regarding how best to bring the human into the loop, a prerequisite for enabling an effective exchange of information and control between robots and human workers. Identifying and taking into account the varying needs, depending on the role of the involved human workers (such as workers, drivers, site planner and managers, and providers of automation solutions), is expected to become a key factor in smoothly transitioning toward automated worksites.

Vasco is geared to become a flagship project in Autonomous Systems for the collaboration with AB Volvo in CAISR. This will complement our existing strong collaborations, particularly in the domain of Machine Learning, with this important industrial partner. The theme of semantic mapping in mixed workyards with varying degrees of autonomy is strongly aligned with the long-term automation strategy at AB Volvo. It is also closely aligned with work on semantic mapping in the AIMS project (focusing on indoor environments with our partners at Kollmorgen, Toyota Material Handling Europe, and Optronic). The associated theme of motion planning and adaptation, in interaction with humans with a wide variety of roles is the focus of our contribution to Cargo-ANTs, another project where we closely collaborate with AB Volvo.

Work Plan

In the beginning of 2014 we kicked off a one-year pilot study to mark the beginning of Vasco. The pilot combines exploratory work with very concrete goals elaborated in close cooperation with AB Volvo in order to ensure the significance of the work. A prototype software with appropriate interfaces for automated construction and labeling of a rich map for a real-world harbor terminal (e.g. the port of Gothenburg) is the main target for the first year. The focus here will be on perception and mapping.

During the second year, we expect to investigate interactive techniques for concurrently aligning automatically generated maps with human knowledge and other outside information, such as aerial images and architectural plans. An extension to other work yard scenarios will also be considered, such as quarries or road construction sites. To aid with broadening the scope and ensuring a proper foundation in the state of the art, an extended exchange with the Robotic Mobility Group at MIT, USA, will take place at the beginning of that phase.

The focus during the remaining two years will depend on experiences from the first part as well as possibly changing constraints and opportunities. One promising direction could be to leverage safe corridor concepts to support vehicles with non-trivial motion characteristics. Another promising idea is to extend the semantics for workyards that change significantly due to the activities, such as on construction sites with diggers and haulers.

Project Partners

AB Volvo, Halmstad University.

Cargo-ANTs – Cargo Handling by Automated Next Generation Transportation Systems for Ports and Terminals

Roland Philippsen

March 16, 2014

Introduction

The Cargo-ANTs project aims to create smart Automated Guided Vehicles and Highly Automated Trucks that can co-operate in shared workspaces for efficient and safe freight transportation in main ports and freight terminals. It is a 3-year project that began in September 2013. It is funded by the European Union under Framework Programme FP7. The total budget of 4.7M EUR gets 3M EUR from the European Commission, of which 314k EUR go to CAISR. This allows us to fund one PhD student, who will join us in early 2014, as well as some equipment and advisory costs.

Objectives

The emphasis of the project is on

- increased performance and throughput;
- high levels of safety;
- development of automated shared workyards;
- planning, decision, control, and safety for AGVs;
- environment perception and grid-independent positioning.

Research Questions

The main research questions center on the following:

- Which combination of positioning techniques and sensors allow for reliable and accurate positioning for the proposed applications?
- How can reliable environmental perception be achieved, in particular moving and stationary object detection, drivable path detection, docking point detection, absolute and relative object positioning?
- How to set up and integrate a vehicle control system, including high-level site planning, path planning, interaction planning, and feedback control? How can functional safety of automated vehicles be achieved?

Contributions

Halmstad will focus on multi- and single-vehicle path planning for automated trucks as well as autonomous cargo transportation vehicles, as well as planning the interaction between moving entities and adaptation the planned path to changing conditions.

Partners

TNO, Netherlands; AB Volvo, Sweden; ICT Automatisering Nederland; CSIC, Spain; Halmstad University.

V-Charge - Auitomated Valet Parking and Charging for e-Mobility

Collaborative Project no. FP7-269916
Roland Philippsen

Concept and objectives

Under the umbrella of V-Charge, e-mobility is combined with autonomous valet parking to spark customer's interest in electric vehicles (EV) via improved parking and charging comfort and enhanced safety during regular operation. This involves the development and implementation of a concept to manoeuvre and charge electric vehicles autonomously in designated areas (e.g. University Campus), to compensate for longer charging cycles of today's battery packages and to advance car safety in dense traffic. This implies three major fields of research:

1. Vehicle functionality
This includes:

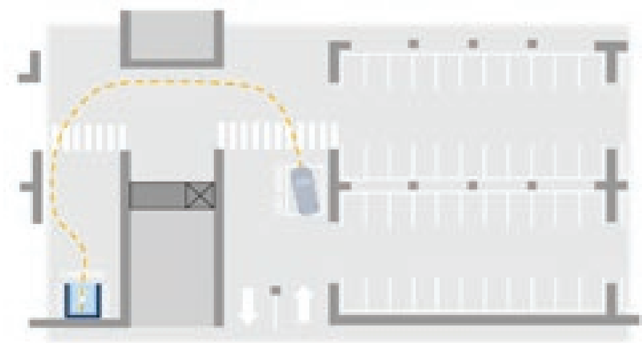
- Perception: Detection of objects and dynamic obstacles of any kind.
- On-board localization: Pose estimation using low-cost sensors.
- Path planning: global path planning (mission planning) and local path planning (obstacle avoidance).
- Digital Map: Representation of environment containing infrastructure and mission information downloaded from server that are fused with the locally established map to leverage localization and global path planning
- Power Management: Includes optimizing and monitoring power consumption of system hardware (PCs, ECUs, sensors) as well as the development of a standby concept
-

2. Logistics concept
This includes the development and the implementation of a concept to efficiently schedule charging and to assign available parking spots.

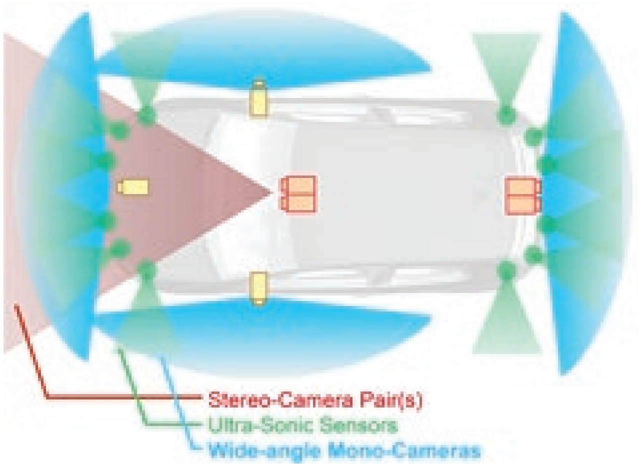
3. Infrastructure functionality and modification.
This includes

- Server: Installation of data base to store and share information about the infrastructure such as marker position, docking position at charging station and position of available parking spots.
- Communication framework: Installation of signal repeaters that provide area-wide coverage to communicate with server, allowing the vehicle to receive and share information about their environment
- Charging: Install an automatic charging plug connection device using an industrial robot.

Halmstad University is involved in V-Charge indirectly by supervising PhD student.



The goal of Peter Mühlfellner's PhD thesis, which is part of the The goal of Peter Mühlfellner's PhD thesis, which is part of the V-Charge project, is to endow an intelligent vehicle with the capability of localizing itself in parking lots and garages using close-to-market sensors.



The sensors used in V-Charge cover practically all angles around the vehicle. Localization relies on the four wide-angle cameras shown in blue.

Automatic Inventory and Mapping of Stock (AIMS)

Björn Åstrand, Saeed Gholami Shahbandi

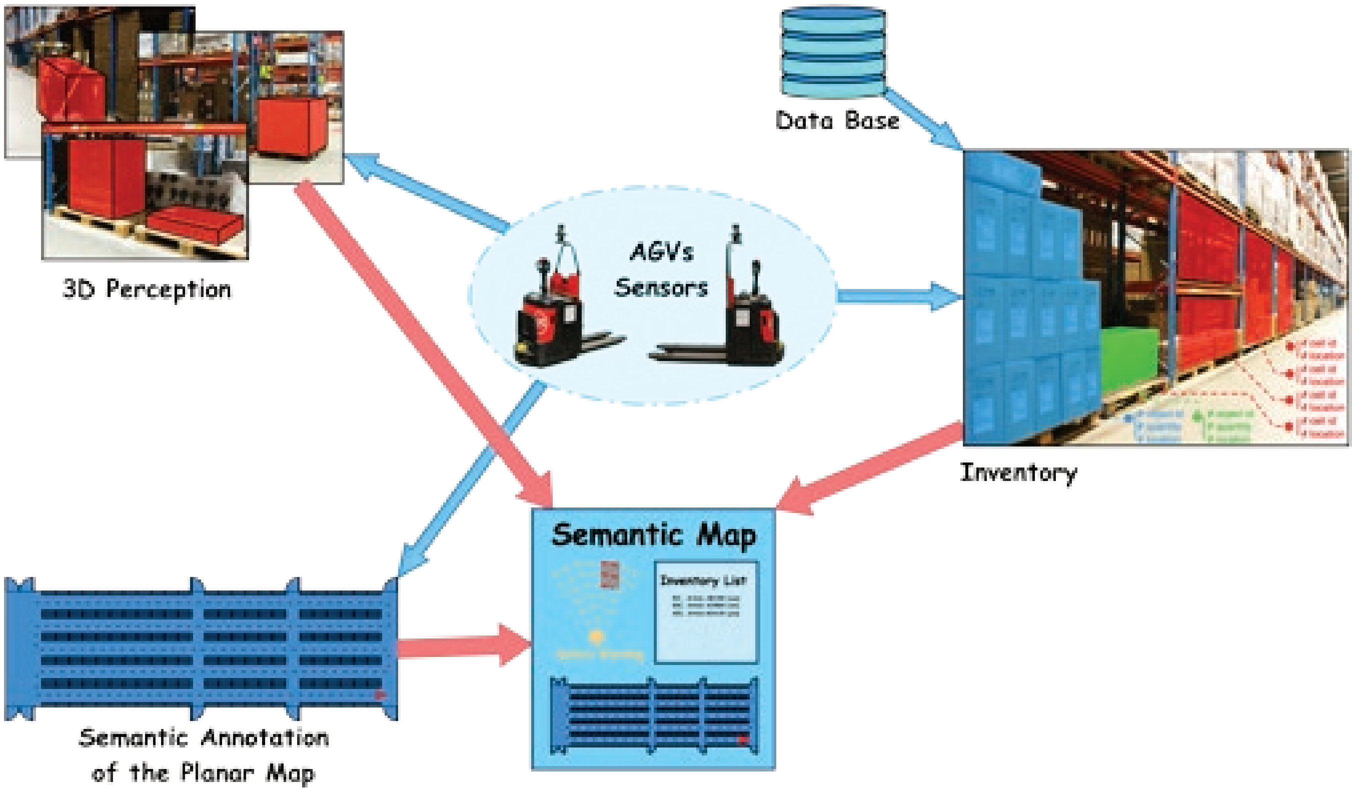


Fig. 1: AIMS overall view

Introduction

The state of the art in autonomous robotics has advanced sufficiently that open implementations of many core technologies are now readily available. Consequently, there is growing research on the design and development of innovative solutions that leverage insights from several specialist domains.

The AIMS project lies in this category. Its goal is to develop a system that seamlessly combines inventory management with autonomous forklift trucks in intelligent warehouses. Information compatible with human operators, management systems, as well as mobile robots is of particular importance here. A rich and "life" map combining metric and semantic information is a crucial ingredient for effective management of logistics and inventory, especially for autonomous fleets working in the same space as humans and human-operated devices.

Motivations and Objectives

Motivations: an important skill for future robots and automated guided vehicles (AGV:s) is the ability to recognize and describe objects that the robot shall handle and the environment in which the robot operates. The ability to structure and sort information provided by sensors increases the system's flexibility and ability to adapt to new settings. The purpose of AIMS is to make autonomous systems and AGV:s operating in a warehouse setting more intelligent, by extending their functionality with a system for automatic inventory and mapping of goods. Achievement of this purpose requires:

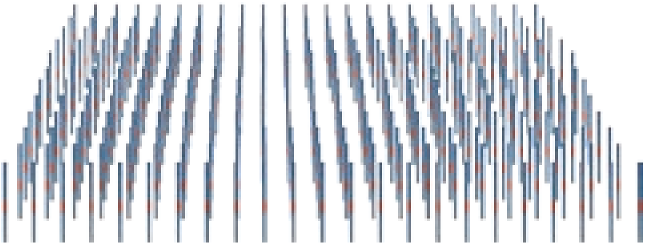
- *situation awareness* through different types of sensors, data fusion and employment of nobel methods for interpretations of the information.
- maintaining practicability by means of *flexibility* and *adaptability* for handling variety of environments and sensor's data.

Objectives: acquiring the skills of *situation awareness*, *flexibility* and *adaptability*, demands accomplishment in different disciplinary areas:

- *Mapping and semantic anonnation*, both as a foundation of the semantic map for addressing articles and trucks in the environment, and to provide an automatic surveying and layout design for initial installation.
- *Inventory list maintainance*; a dynamic map maintanance approach in order to keep track of the inventory, linked with the warehouse management system.
- *3D Perception*; sevring the objectives of obstacle avoidance and articles' quantity estimation for inventory list

Results

To speed up the process of AGV installation in the warehouse, and as a foundation for addressing the articles in the warehouse, an abstract and semantic interpretation of Occupancy Grid Map (Fig. 2b) is overlaid with the map of pillars (Fig 2a). Abstraction and semantic annotation of Occupancy Grid Map helps the construction of the layout from a global aspect (detailed in Fig 3). On the other hand semantic annotation of the pillar map (Fig.4) provides details for the layout from a loca aspect.

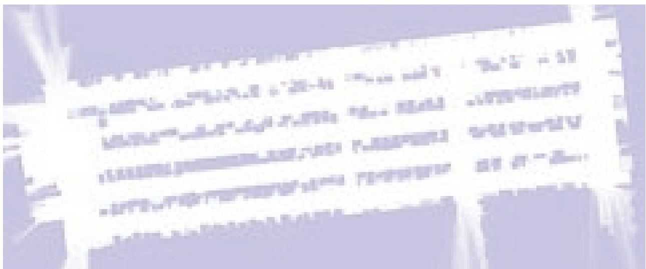


(a) map from fisheye camera

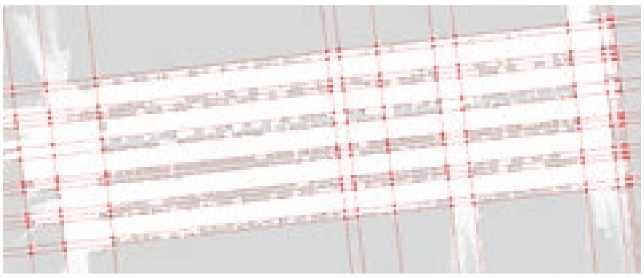
(b) map from range data

Fig. 2: Semantic annotation of 2 different kinds of maps

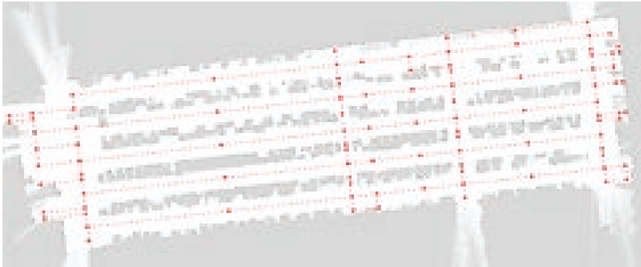
Occupancy Grid Map (Fig.3a) is a metric map derived from laser scanner which makes it a reliable source for metric surveying. OGM does not have any semantic notation except occupancy. The semantic labels revised for AIMS project are relying on the straight line model of the environment (Fig.3b) and respective connectivity map (Fig.3c). Figure 3d illustrates the results of straight line model of the environemnt along with semantic labels.



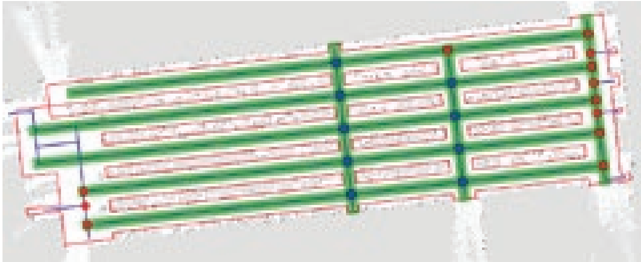
(a) occupancy grid map



(b) environment model



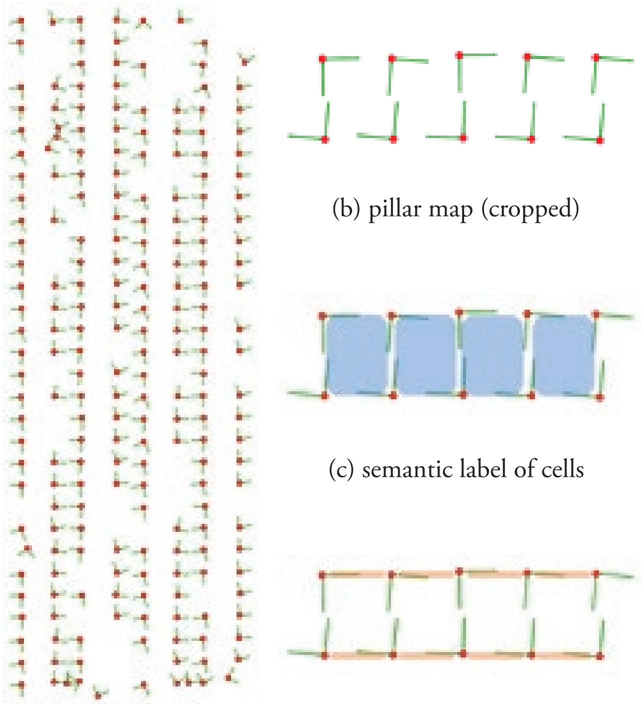
(c) connectivity map



(d) semantic annotation

Fig. 3: Abstract and semantic interpretation of *Occupancy Grid Map*

Detection of pillars from fisheye images is followed by bearings from truck's pose. Intersection of bearings results in the position of the pillars. Resulting pillar map is shown in Fig. 4a. Aforementioned local semantic labels are inferred from this map. Figures 4c and 4d demonstrate how such labels fit the environemnt.



(b) pillar map (cropped)

(c) semantic label of cells

(a) pillar map

(d) semantic label of cells' entrance

Fig. 4: Pillar map and its semantic annotation [in progress]

Partners

Automatic Inventory and Mapping of Stock (AIMS) is a collaborative project between KOLLMORGEN, OPTRONIC, TOYOTA MATERIAL HANDLING EUROPE and UNIVERSITY OF HALMSTAD. AIMS project is a part of *Center for Applied Intelligent System Research* (CAISR) funded by *Knowledge Foundation*.

Investigation of Swedish driver's characteristics for optimizing the HMI of ADAS

K. Nakada[1], K. Suzuki[1], S. Byttner[2]

1. Kagawa University, Japan
2. CAISR, Halmstad University, Sweden

Intelligent Speed Adaptation (ISA) is an effective way for preventing traffic accidents in residential areas, but the effectiveness of the informative type ISA (non-control type) is affected by driver's characteristics. This project is aimed to optimize the Human-Machine-Interface of informative ISA based on the driver characteristics.

1. Background and Motivation

The rate of fatal traffic accidents regarding vehicle-pedestrians is high in Japan. To prevent and mitigate the damage of accidents, slowing down the vehicle velocity is very effective. Intelligent Speed Adaptation (ISA) system is one type of Driver Assistance System (DAS) which focus on vehicle velocity. ISA is aimed to keep the vehicle velocity within the speed-limit by controlling the gas-pedal or alarm to the driver.

This project focused on the driver characteristics to optimize the Human-Machine-Interface (HMI) for improving the effectiveness of the ISA system. The driver characteristics are investigated through a real vehicle experiment and questionnaires. Based on the result of the investigation, the drivers were categorized into driver groups and the HMI of ISA was optimized for each driver group.

A previous project was only focused on Japanese drivers. However, to make the system more universal, additional investigation which includes aspects of a different country was needed. This project conducted a real vehicle experiment (along with questionnaires) to investigate the characteristics regarding drivers in Sweden. The result of the investigation was compared with result of the experiment in Japan. The rate of traffic fatal accidents is 2.9 person / population in 2010. In Japan it is 4.5 person / population. Therefore Sweden is thought that the one of top country regarding traffic safety. The feature of Swedish traffic accidents are a small rate of fatalities regarding pedestrians. It is about two times lower than Japan. Therefore the investigation of driver characteristics regarding Swedish drivers is very important to improve the effectiveness of ISA system and feedback to Japan.

2. Investigation of driver characteristic

This project conducted the real vehicle experiment and questionnaires to investigate the driver characteristics. Table 1 shows the condition of real vehicle experiments in Sweden and Japan. The participants drove the two conditions, one is a normal driving and the other is driving with ISA system. The ISA system has two functions, Speed-alarm and Intersection reminder.

- **Speed alarm**
  System warns to the driver by a visual image and 3.7 [kHz] beep sound when the vehicle exceeds 30 [km/h].
- **Intersection reminder**
  System inform the driver by a visual image and 1.0[kHz] beep sound when a vehicle approaches to an intersection within 50 [m].

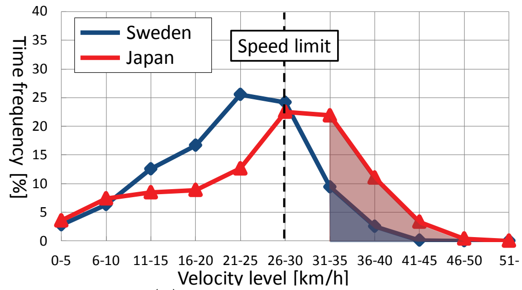
Table 1. Experimental condition

	Japan	Sweden
Number of participants	17	12
Course Environment	Residential area Speed-limit : 30km/h	
Distance [km]	4.2	4.0
Test Vehicle	Participant's vehicle	University's vehicle (Volvo S60 D3)
Presenting information	Beep-sound Visual information (by LED indicator)	Beep-sound Visual information (by LCD monitor)

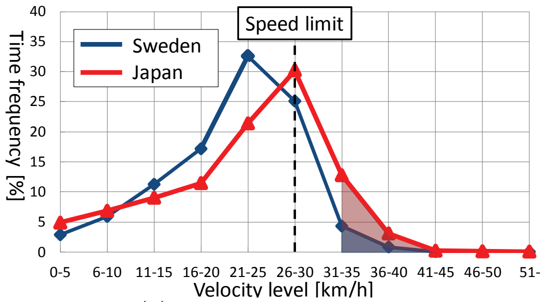
3. Experimental result

3.1 Compare Sweden and Japan

Fig.1 shows the average histogram regarding running velocity in both the condition of using the system and without using it. Average speeding rate in without system condition is 36.6[%] in Japan, and it is 12.0[%] in Sweden. When using ISA system it become 16.2[%] in Japan and it is 5.2[%] in Sweden. This result suggests that Swedish drivers were driving with lower velocity than Japanese drivers regardless of using or not using the system. A feature of Swedish drivers is the peak of running velocity at 21-25[km/h] in both conditions.



(a) Normal driving



(b) Using ISA system

Fig.1 Histogram regarding velocity

Questionnaires were given to the drivers called driving style questionnaire (DSQ). The DSQ are four-level questionnaire. The DSQ has eighteen questions and they clarify the eight items regarding the driving style of each driver. Fig.2 shows the average result of DSQ in Japan and Sweden. As a tendency Swedish driver have a confidence in own driving skill and exactitude than Japanese, this could be explained by a higher average age of the Swedish drivers.

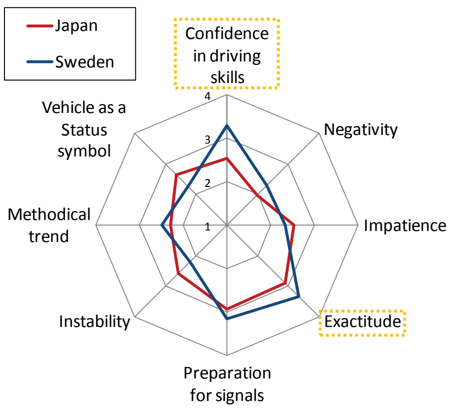


Fig.2 Result of DSQ

There are factors that could influence the Swedish drivers to drive at low velocity. In terms of traffic environment, Swedish roads have many parked vehicles and there are some speed-bumps. Especially speed-bumps have large effect to reduce velocity. In the experiment, most of the participants drove around 20[km/h]. In Japan, there are no speed-bumps, and there are few parked vehicles on the road. Therefore Swedish roads make the velocity lower than in Japan. Regarding pedestrians, Swedish residence road have walkways for pedestrians which makes safety high. In contrast, Japanese residential areas sometimes do not have walkways.

3.2 Categorizing Swedish drivers

Cluster analysis was conducted to categorize twelve drivers into driver groups based on the result of the real-vehicle experiment and questionnaires. The word method was used for calculating the distance of each cluster.

Fig.3 shows the result of cluster analysis, three groups were detected; #A, Careful, and Composed based on the feature of each group. #A has only one driver; therefore a specific name for this group was not given.

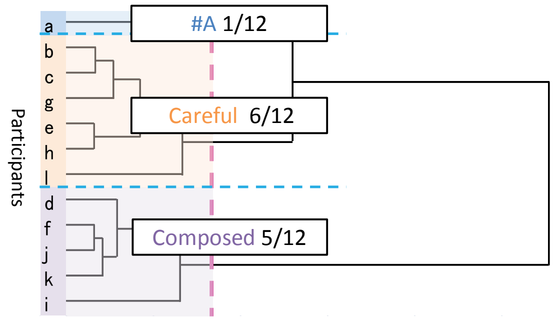


Fig.3 Result of the cluster analysis

Table 3 shows the system effect for each driver group. The ISA system have larger effect for #A and Careful group than for Composed group. Regarding Careful group, their running velocity became very low in the condition of using ISA system.

Table 3 System effect of each driver group

	Speeding-rate [%]		Average velocity at intersection [km/h]		Maximum velocity at intersection [km/h]	
	without ISA	with ISA	without ISA	with ISA	without ISA	with ISA
#A	22.8	6.7	27.67	23.37	43.34	32.60
Careful	8.2	1.6	22.69	19.79	33.06	27.82
Composed	14.4	9.1	24.54	23.01	34.63	31.26

As a result of questionnaires, #A and Careful group have a versatile and worrier tendency. And they feel burdened regarding in-vehicle environment. In-vehicle environment is effected by loud sound etc, and the ISA system makes a loud sound as an alarm. In contrast, Composed group doesn't feel burdened regarding the in-vehicle environment. These result show that the #A and Careful group slow down because they don't like the sound of the system. Composed group slowed down because they understand the system objective. In terms of HMI, this ISA system HMI is suitable for Composed group. However, more soft HMI is needed for #A and Careful group.

4. Conclusion

- Swedish drivers drove slower than Japanese.
- Swedish road environment make the vehicle velocity low.
- #A, Careful and Composed group are detected by the cluster analysis. #A and Careful group feel burdened regarding sounds of the system.
- Composed group don't feel burdened regarding the ISA system, therefore the effect of ISA system is smaller than other groups.

SA^{3}L - Situation Awareness for Ambient Assisted Living

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NEAT Electronics AB, Varuvägen 2, 246 42, Löddeköpinge, Sweden

March 2014

1 Background and Motivation

A demographic change is occurring in many areas of the world. The population share in which people in age over 60 years has been increasing for the last decades and estimations predict that this group of elderly population will near quadruple in the year 2050 [1]. This change will bring exponentially increasing costs of health care [3], which will be supported by the decreasing share of younger people. One solution to this challenge is through technological developments aiming at reducing the costs of health care. Smart environments, [2], targeted for ambient assisted living, enable people to remain independent at their own home and to live in a decent way longer. Key functions of such environments are:

- Answering queries (where is the person, for example).
- Activity recognition (what the person is doing).
- Detection of specific behaviour and potentially dangerous situations.
- Fall monitoring.

Camera sensors have been used for the detection of human activities of daily living (ADL). However, the privacy issues of such camera-based solutions motivates the usage of other sensors such as wearable inertial sensors and accelerometers. A wearable sensor is dependent on several aspects of human behaviour such as remembering to put on the sensors and doing so properly. Other, often used, sensors in ubiquitous computing are switches, motion detectors and electromechanical sensors, which do not, at the same extent, breach the privacy of individuals. Because of the large variety of sensor types and settings, information processing approaches, and individuals living in the environments, finding an accurate, robust and economically efficient solution to the problem is a hard task.

This project focuses on data mining methods and sensors to model human behaviour in home environments and techniques to infer knowledge from such models.

2 Goals

The main objectives of the SA^{3}L project is to develop robust recognition of dangerous situations, detecting deviations of behaviour, generalizing easily over different homes and individuals, and exploiting online data streams to adapt processing algorithms in an incremental fashion.

3 Approach

The project is divided into seven work packages:

- **WP1. Customer needs, features and specification of foreseen product.**
  This step involves investigating the need for future products and specifications of such products.
- **WP2. System for getting information from and interfacing with end users.**
  To develop a web-based system for collecting information from the end users in order to receive ground-truth of human behaviour and alarm situations.
- **WP3. Upgrade the data collection environment.**
  To upgrade the existing data collection environment. To develop a data simulator based collected data.
- **WP4. Data collection.**
  This work package involves collecting data from different persons in their homes and also in a simulated home environment.
- **WP5. Data analysis.**
  To develop methods and algorithms for achieving the project goals.
- **WP6. PhD education.**
  During the project one to two persons will be educated with at least one Licentiate and one PhD level dissertation.
- **WP7. Evaluation of end results.**
  To evaluate the quality of the end products, prototypes and services.

During 2013 fil.dr. Helena Eriksson and fil.dr. Anna Isaksson from the *School of Social and Health Science* (Halmstad University) were included in the project. Helena and Anna will study the perception of risk and security in the participants everyday life from a social scithe project partner Neat Electronics is positive to the perspective and expertise Helena och Anna brings to the project. Ph.D. in Statistics Eric Järpe also joined SA^{3}L and collaborates with the other researchers on the signal processing parts of the project.

4 Results from 2013

Currently the project focus on how to model behaviour and how to detect and explain deviations from such *normal behaviour*. Five months of data will be acquired from each of ten individuals, the collected data will be used as reference for normal behaviour. The measurement was preceded by writing an ethical application to the board of ethical vetting, test and purchase sensors, establish contact and presenting the project for different levels in the organization of Halmstad municipality, informing and getting consent from the participants, and installing sensors. In December 2013 already three participants had the measurement system installed and more participants are planned to be included in the measurements during 2014.

While waiting for data to be collected a behaviour pattern simulator was developed. The simulator is built upon probabilistic models that describe specific behaviour during a certain time. For two examples of such behaviour models see Figure 1. The models consider a certain type of home layout and mobility of the person. The data generated by the simulator was

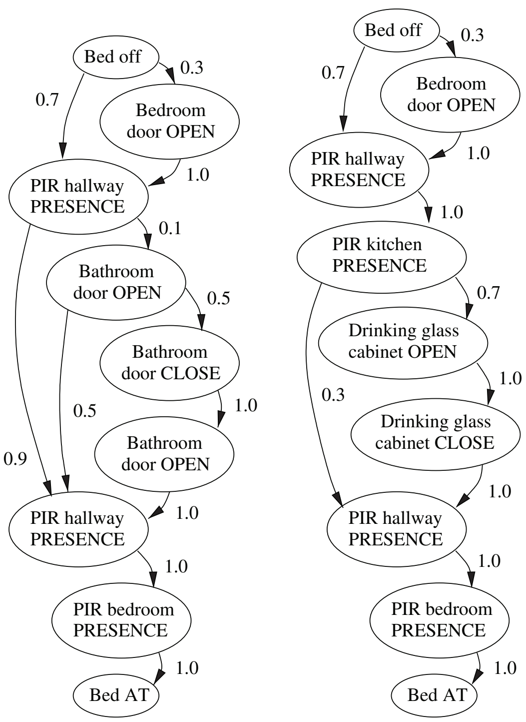

Figure 1: Two simulator models depicted as flowcharts: "Going to the bathroom at night" (left) and "Going to the kitchen at night" (right). For each pair of states the direction of transition is indicated by an arrow and the corresponding transition probability written next to it.

then used to study different approaches for modelling behaviour patterns and to detecting deviations. A preliminary algorithm for modelling and deviation detection was developed. A journal paper is planned to be sent to *Knowledge-Based Systems* in the beginning of 2014.

Moreover, data from the previous project *Safe at Night* were analyzed and included in a joint published paper with Wagner De Morais [5] (presented at the Ambient Assisted Living and Active Aging conference in Costa Rica December 2013). The *Safe at Night* project was also discussed in an innovation perspective focusing on the synergy between technical and social sciences, the result was published in [4]. Also, contacts have been initiated with smart home researchers from Ulster and Middlesex University. A short visit during next year at each research environment is planned.

5 Partners and Status

Funding: The Knowledge Foundation.
Companies: Neat Electronics AB.
Other partners: Centre for Health Technology Halland and the municipality home care service provider in Halmstad (Hemtjänsten).
Status: The project is active and the next step is to use data collected from the current home environments in order to test algorithms for behaviour modelling and deviation detection. Concurrently measurements systems will also be installed in the home of new participants during 2014.

References

[1] D. E. Bloom and D. Canning, *Global demographic change: Dimensions and economic significance*, http://www.globalhealth.harvard.edu/ WorkingPapers.asp, 2005.

[2] D. J. Cook and M. Schmitter-Edgecombe, *Assessing the quality of activities in a smart environment*, Methods of Information in Medicine **48** (2009), no. 5, 480–485.

[3] E. Dini and S. Goldring, *Estimating the changing population of the "oldest old"*, Population Trends **132** (2008), 8–16.

[4] H. Eriksson, A. Isaksson, Anna, and J. Lundström, *Technology and trust : Social and technical innovation in elderly care*, Equality, growth and innovation - in theory and practice, 9-10 October 2013, Luleå, 2013.

[5] W. De Morais, J. Lundström, and N. Wickström, *A database-centric architecture for home-based health monitoring*, Ambient Assisted Living and Active Aging - 5th International Work-Conference (Carrillo, Costa Rica), 2013, pp. 26–34.

HMC²- Human motion categorization and characterization

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The objective is to design wearable instruments/devices that can characterize and classify human motion. The devices shall be small and "non-intrusive", similar to a step counter. We are looking at two sensor modalities: inertial sensors (e.g. accelerometers and gyros) and electrical sensors for detecting, e.g., electromyography (EMG) signals.

1. Background and Motivation

Moderate physical activity can improve health substantially over an individual's lifetime. Even physically active people can improve their health status by increasing their activity. Physical activity helps to control diseases; adopting healthy behaviors, including physical activity, decrease and control the effects of diseases like, e.g., diabetes, heart disease, depressions and dementia.

There are two important aspects in the problem of increasing the level of physical activity for an individual. One is the matter of having a portable method/device for measuring an individual's level of physical activity. The other is the ability to motivate the individual by providing suitable feedback on his/her level of activity.

It is important to develop simple and wearable devices that can measure the daily physical activity of an individual. Such devices can be used both to monitor physical activity, e.g. in a treatment scenario or to gauge the levels of physical activity in a cohort, and to motivate physical activity. A simple example of such a device is the step counter. However, the step counter gives a very coarse measurement and it only measures the activity during walking or running.

If a portable device (preferably wearable) would be available that could "ubiquitously" measure different sorts of physical activity and estimate the intensity level, then it would open up new frontiers promoting treatments and pro-active approaches to better health.

Muscle fatigue may occur during cycling. It occurs locally and is characterized by the declining ability to perform muscle contractions and force exertions. A person experiencing muscle fatigue will generally feel pain in those muscles. High levels of muscle fatigue can cause serious injuries. Objective assessment of muscle fatigue would help athletes, trainers, and hobby cyclists to assess fitness and prevent muscle injuries.

Analysis of electromyographic (EMG) signals can be applied to evaluate local muscle fatigue. Stationary equipment is usually used to record EMG signals.

2. Approach

Inertial sensors

The approach is to use wearable sensors, typically accelerometers (inertial sensors), to estimate motion intensities and qualities and estimate energy consumption. The person wearing the sensors can get immediate (or almost immediate) feedback as well as a time log of energy consumptions.

EMG

The approach is to use EMG sensors weaved into a wearable textile belt, which can be comfortably put on a leg. Other modalities than EMG sensors can also be weaved. Some processing can be done in the sensors and (e.g.) a smart phone can be used for more advanced analysis. The person wearing the belt can therefore get immediate information on muscle status as well as results of a comprehensive analysis of the data after the training session.

3. Results so far

Inertial sensors

A large data collection, involving around 20 subjects, is ongoing. The target is to validate our previously developed algorithm for estimation of energy expenditure for common activities in the low to medium intense activity range. To make best possible validation, the gold standard for measurement of energy expenditure is used as a reference. Furthermore, several different placement options are selected to measure sensitivity to placement.

An example of a pilot measurement is shown in Figure1, where one subject performed a protocol of different activities. The red curve is measured by the VO2 apparatus (50K+ EUR) whereas the blue curve is estimated by the ActiveMeter (which is developed by members of the project team).

To develop applications for long term analysis of gait in uncontrolled environments, some of the proposed methods in the literature for estimation of the characteristic events (heel strike and toe-off) in gait is not good enough. A new method based on continuous wavelet transform, see Figure 2, in combination with prior expert knowledge was proposed [2]. The method can robustly find the events, even when the data is very noisy due to ground conditions and other movement artifacts.

The estimated information could not only prove useful for sports applications, optimization of cadence and similar, but also for healthcare applications such as estimating gait variability over time to assess the risk of falling, especially for the elderly.

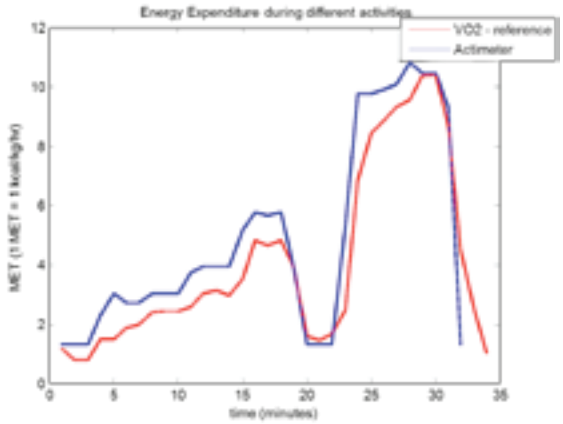

Figure 1: Estimation of MET (metabolic energy transfer) from accelerometers. The red curve is from the VO2 measurements, each data point is an average of six measurements to give 1 data point per minute. The blue curve is an estimate by the ActiveMeter.

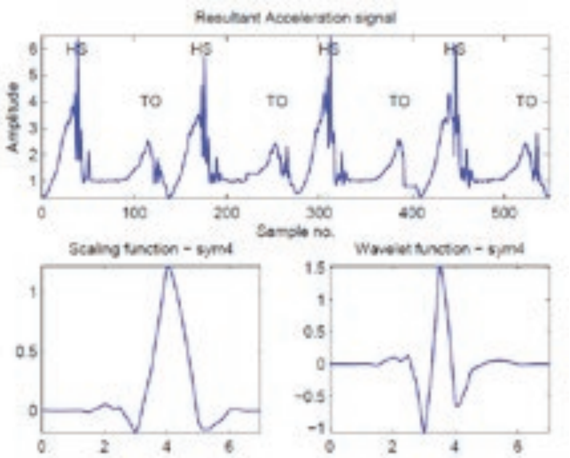

Figure 2. Identifying the characteristic event, heel strike (HS) and toe-off (TO) in outdoor walking. The top part is the resultant acceleration for well-behaved steps. The bottom part show the sym4 wavelet which matches the HS quite well.

EMG

Two subjects participated in the data collection experiment conducted at the facilities of the Sports Academy of University of Gothenburg. Progressively increasing and constant loads were used and EMG signals were recorded from four muscles of both legs, eight channels in total. In addition to EMG signals, readings from accelerometers attached to the legs and chest, as well as measurements of heart rate, oxygen consumption, lactate concentration in blood, cadence, and subjective evaluations of fatigue were also taken. Data collection activities have been continued in December 2013 at Halmstad University using the same protocol with the exception that the load was kept constant.

A random forest-based lactate level prediction model was build using data of the first experiment. Each 512 samples long EMG signal segment was characterized by 50 features reflecting signal variability and distribution of signal energy. Table 1 summarizes performance of the model, where the coefficient of determination of the model estimated on unseen data is shown for data collected from different muscles. In Table 1, M stands for muscle, L for leg, COM means combination (data from both legs of two participants are used), RF, VL, SR, and BF denote four different leg muscles, LR, LL, MR and ML stand for left and right leg of subject L and subject M.

Table 1. The coefficient of determination of the model.

M\L	LR	LL	MR	ML	COM
RF	0.83	0.83	0.90	0.88	0.82
VL	0.90	0.87	0.91	0.91	0.89
ST	0.76	0.77	0.92	0.86	0.82
BF	0.75	0.72	0.83	0.85	0.76

The study has shown that **a)** during dynamic exercise, fatigue does *not* manifest itself consistently in change of the mean/median frequency of the EMG signals (see Fig. 3); **b)** however, information is present in signal variability and distribution of signal energy (relatively high prediction accuracy shown in Table 1)

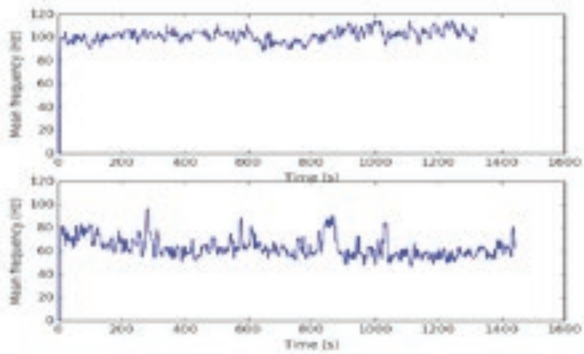

Figure 3. Mean frequency from the RS muscle as a function of time for two participants.

4. Partners and Status

Industrial Partners: TAPPA, Swedish Adrenaline.
Project funding: CAISR profile funding from the KK, TAPPA, Swedish Adrenaline, and Halmstad University.
Duration of the project: January 2012 – December 2015.
Project leader is Antanas Verikas.

Publications

[1] M. Schafflinger, Quality assessment of bicycle training, *Master Thesis, IDE1223,* Halmstad University, 2012.

[2] Khandelwal, S., & Wickström, N. (2014). Identification of Gait Events using Expert Knowledge and Continuous Wavelet Transform Analysis. In *7th International Conference on Bio-inspired Systems and Signal Processing, Angers, France, March 3-6, 2014*.

A lightweight method for detecting sleep-related activities based on load sensing

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Over the last years, there has been an increased interest in using sensor-based monitoring systems to complement or enhance healthcare delivery, both at clinical and home settings. These systems represent an alternative to current practices, such as for sleep assessment. For example, the polysomnogram is the current gold standard for sleep study. However, polysomnographic sleep recording is an expensive procedure, typically performed at clinical settings by specialized personal. It requires at least a full night sleep in a laboratory as well as the use of electrodes and sensors attached to the body to measure brain, heart, and muscle activity, eye movements, and respiration, among other indicators.

There have been many advances in developing less intrusive alternatives to polysomnography. The Actigraph for instance, is a wristwatch-like accelerometer-based device that measures and records movements, and has been used in research to study sleep. Non-intrusive solutions include beds equipped with sensors, such as load cells (weight sensors) [1].

Our approach employs beds equipped load cells and proposes a lightweight method to detect sleep-related activities, such as bed entrances and exits, bed time, awakenings, wakefulness, and atonia (low or no muscle activity).

When the bed is occupied by a person, voluntary and involuntary body movements generate disturbances in the load cell signal that are not present when the bed is unoccupied or loaded with static weight. The proposed approach employs a finite-state machine that analyses such disturbances in order to detect or estimate sleep-related activities and parameters. The proposed state machine is illustrated in Figure 1 and for more details about its operation, please refers to [2].

The proposed approach was evaluated with a dataset collected from 15 different homes of 15 care beneficiaries participating in the "Trygg om natten" project [3]. The dataset contains load cell data from a load cell installed at the top left support of the bed. Events captured by motion sensors and a bed sensor are also available in the dataset.

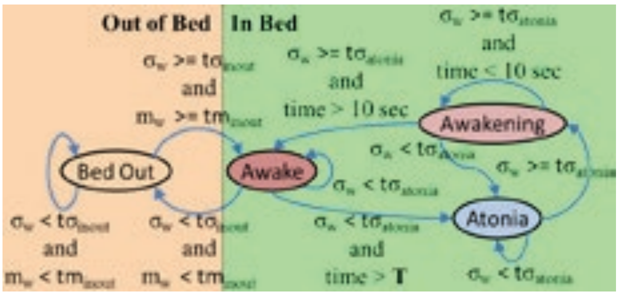


Figure 1. The proposed finite-state machine to detect sleep-related activities. Bed entrances and exits are captured by the method. Awakenings, wakefulness, and atonia states are estimated.

Table 1 presents the activities detected by the method and events measured by other sensors for a selected participant, who had the measurement system installed at home during 24 nights. Figure 2 depicts sleep-related activities detected by the method and sensor events for the 18th night.

Although the method still needs to be validated against the polysomnography and results are preliminary, some of them worth to be discussed.

One is the inconsistency between the number of bed exits detected by the proposed approach (BEx in Table 1) and the number of bed exits detected by the bed sensor (BedSensor in Table 1). For the selected individual, the bed sensor missed 17 bed exits (approximately 20%) and generated 6 inexistent bed exits. Besides, the bed sensor does not capture bed entrances and when they occur.

The estimated sleep parameters (bed time, sleep latency, and sleep efficiency) can enable healthcare professionals to distinguish and identify individuals with sleep disturbances. For the select individual, some of these parameters are in accordance with age-related trends (consistency in Bed Time and Sleep Efficiency ranging from 75% to 85%).

In hospitals, the proposed approach might enhance interventions targeting falls and pressure sores prevention, by detecting when individuals are about to leave the led, agitated in bed or at the same rest position for a long-period of time. At home settings, it can enable remote monitoring of individuals that require night-time supervision. Remote monitoring can avoid unnecessary visits, which in turn might reduce sleep disturbance complaints and conserve healthcare resources.

Table 1. A summary of detected and estimated events and activities for one of the participants. BEx (Number of Bed Exits), BIn (Bed entrances), BT (Bed Time), SL (Sleep Latency), TiB (Time in Bed), TiA (Time in Atonia), SE (Sleep efficiency, which is the ratio of the estimated TiA to the estimated TiB).

Night	BEx	BIn	Awake	Atonia	Awanening	BedSensor	Visits	BT	SL	TiB	TiA	SE
1st	4	5	13	16	16	0	0	22:24:48	00:29:49	07:13:54	04:13:21	58%
2nd	5	6	12	12	12	0	0	22:17:54	00:04:48	08:15:50	08:02:23	97%
3rd	3	4	7	15	14	0	0	22:23:30	00:05:23	07:21:59	07:18:02	99%
4th	3	4	7	8	7	2	1	22:32:05	00:06:29	07:14:36	06:58:11	96%
5th	3	4	9	7	6	4	3	22:07:26	00:02:21	07:37:28	07:30:28	98%
6th	5	6	9	5	4	5	4	22:08:07	00:07:19	07:34:50	07:17:54	96%
7th	3	5	12	14	13	4	4	< 10PM	NA	07:38:02	07:18:27	96%
8th	4	5	8	7	6	5	3	22:22:23	00:02:42	07:16:01	07:07:38	98%
9th	6	7	12	9	9	4	3	22:20:04	00:35:46	07:22:14	06:36:59	90%
10th	4	5	7	5	5	4	5	22:22:25	01:21:07	07:23:03	05:55:37	80%
11th	4	5	8	4	3	4	3	22:23:45	00:11:42	07:13:24	07:07:20	99%
12th	4	5	7	5	4	4	3	22:28:16	00:25:02	07:17:07	06:36:13	91%
13th	4	5	12	13	12	4	3	22:34:37	00:05:33	07:08:42	06:35:18	92%
14th	2	3	9	11	10	2	1	22:26:27	00:02:28	07:20:06	07:06:22	97%
15th	4	5	10	10	9	5	2	22:36:43	00:36:20	07:02:45	06:20:20	90%
16th	4	6	13	16	16	4	2	< 10PM	NA	07:41:12	07:10:55	93%
17th	5	6	18	20	19	5	1	22:20:58	00:05:40	07:17:06	06:14:32	86%
18th	**6**	**6**	**12**	**13**	**13**	**5**	**3**	**22:29:19**	**00:30:54**	**07:07:20**	**06:11:41**	**87%**
19th	2	4	10	11	11	3	2	< 10PM	NA	07:48:42	06:59:11	89%
20th	5	6	12	9	9	5	1	22:37:22	00:28:16	07:06:35	05:45:40	81%
21st	2	4	11	14	13	3	1	< 10PM	NA	07:46:08	06:26:54	83%
22nd	4	5	15	14	14	3	2	22:20:43	00:40:05	07:26:55	05:48:14	78%
23rd	3	4	12	12	11	3	1	22:14:52	00:18:38	07:36:14	05:33:51	73%
24th	5	6	18	19	19	5	1	22:18:49	00:05:04	07:19:32	04:56:24	67%

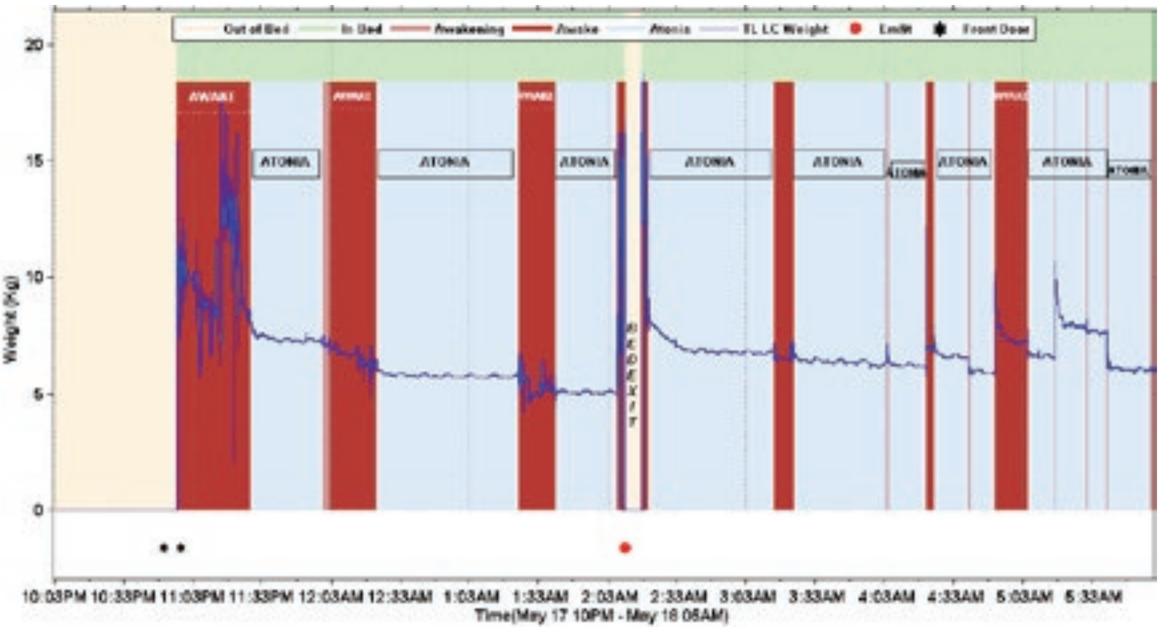


Figure 2. Detected sleep activities, during one night for the selected user, are highlighted according to the legend. In the lower area in the graph, black stars represent night-time home care visits, while entering and leaving the home. Red circles indicate bed exits detected by the Emfit Bed Sensor.

REFERENCES

[1] A. Adami, A. Adami, G. Schwarz, Z. Beattie, and T. Hayes, "A subject state detection approach to determine rest-activity patterns using load cells," in Engineering in Medicine and Biology Society (EMBC), 2010 Annual International Conference of the IEEE, 2010, pp. 204–207.

[2] W. O. de Morais and N. Wickstrom, "A lightweight method for detecting sleep-related activities based on load sensing", IEEE 3rd International Conference on Serious Games and Applications for Health, SeGAH 2014, Rio de Janeiro, Brazil, May 2014.

[3] R. Thörner, M. Persson, H. Eriksson, A. Isaksson, and J. Lundström, "Trygg om natten", Centre for Health Technology in Halland, Halmstad University, Halmstad, Sweden, Tech. Rep., 2011.

CAISR Publications 2011-2013

Journals

2013

Lundström J, Verikas A, Tullander E, Larsson B. Assessing, exploring, and monitoring quality of offset colour prints. Amsterdam: Elsevier; Measurement. 2013;46(4):1427-1441.

Lundström J, Verikas A. Assessing print quality by machine in offset colour printing. Amsterdam: Elsevier; Knowledge-Based Systems. 2013;37:70-79.

Kalsyte Z, Verikas A, Bacauskiene M, Gelzinis A. A novel approach to designing an adaptive committee applied to predicting company's future performance. Oxford: Pergamon Press; Expert systems with applications. 2013;40(6):2051-2057.

Kalsyte Z, Verikas A. A novel approach to exploring company's financial soundness: Investor's perspective. Oxford: Pergamon Press; Expert systems with applications. 2013;40(13):5085-5092.

Sentis L, Petersen J, Philippsen R. Implementation and stability analysis of prioritized whole-body compliant controllers on a wheeled humanoid robot in uneven terrains. New York: Springer; Autonomous Robots. 2013;35(4):301-319.

Vachkov G, Byttner S, Svensson M. Detection of Deviation in Performance of Battery Cells by Data Compression and Similarity Analysis. Wiley Periodicals; International Journal of Intelligent Systems. 2013;

Sant'Anna A, Wickström N, Eklund H, Zügner R, Tranberg R. Assessment of Gait Symmetry and Gait Normality Using Inertial Sensors : In-Lab and In-Situ Evaluation. Heidelberg: Springer Berlin/Heidelberg; 2013. p. 239-254. Communications in Computer and Information Science, 357.

2012

Alonso-Fernandez F, Fierrez J, Ortega-Garcia J. Quality Measures in Biometric Systems. New York, NY: IEEE Computer Society; IEEE Security and Privacy. 2012.

Englund C, Verikas A. A novel approach to estimate proximity in a random forest: An exploratory study. Amsterdam: Elsevier; Expert systems with applications. 2012;39(17):13046-13050.

Holmberg U, Sjöberg K. A modular CACC system integration and design. IEEE transactions on intelligent transportation systems (Print). 2012;13(3):1050-1061.

Stasiunas A, Verikas A, Bacauskiene M, Miliauskas R. An adaptive panoramic filter bank as a qualitative model of the filtering system of the cochlea: The peculiarities in linear and nonlinear mode. Oxford: Elsevier; Medical Engineering and Physics. 2012;34(2):187-194.

Vaiciukynas E, Verikas A, Gelzinis A, Bacauskiene M, Uloza V. Exploring similarity-based classification of larynx disorders from human voice. Elsevier; Speech Communication. 2012;54(5):601-610.

Verikas A, Bacauskiene M, Gelzinis A, Vaiciukynas E, Uloza V. Questionnaire- versus voice-based screening for laryngeal disorders. Amsterdam: Elsevier; Expert systems with applications. 2012;39(6):6254-6262.

Verikas A, Gelzinis A, Bacauskiene M, Olenina I, Olenin S, Vaiciukynas E. Automated image analysis- and soft computing-based detection of the invasive dinoflagellate Prorocentrum minimum (Pavillard) Schiller. Amsterdam: Elsevier; Expert systems with applications. 2012; 39(5): 6069-6077.

Verikas A, Gelzinis A, Bacauskiene M, Olenina I, Olenin S, Vaiciukynas E. Phase congruency-based detection of circular objects applied to analysis of phytoplankton images. Amsterdam: Elsevier; Pattern Recognition. 2012; 45(4): 1659-1670.

2011

Assabie Y, Bigun J. Offline handwritten Amharic word recognition. Amsterdam: Elsevier; Pattern Recognition Letters. 2011;32(8):1089-1099.

Byttner S, Rögnvaldsson T, Svensson M. Consensus self-organized models for fault detection (COSMO). Oxford: Pergamon Press; Engineering applications of artificial intelligence. 2011;24(5):833-839.

Kontrimas V, Verikas A. The mass appraisal of the real estate by computational intelligence. Amsterdam: Elsevier; Applied Soft Computing. 2011;11(1):443-448.

Lütkebohle I, Philippsen R, Pradeep V, Marder-Eppstein E, Wachsmuth S. Generic middleware support for coordinating robot software components : The Task-State-Pattern. Bergamo, Italy: The University of Bergamo; Journal of Software Engineering for Robotics. 2011;2(1):20-39.

Sant'Anna A, Salarian A, Wickström N. A new measure of movement symmetry in early Parkinson's disease patients using symbolic processing of inertial sensor data. Piscataway, N.J.: IEEE; IEEE Transactions on Biomedical Engineering. 2011;58(7):2127-2135.

Stasiunas A, Verikas A, Bacauskiene M, Miliauskas R. A Serial-Parallel Panoramic Filter Bank as a Model of Frequency Decomposition of Complex Sounds in the Human Inner Ear. Amsterdam: IOS Press; Informatica (Vilnius). 2011;22(2):259-278.

Verikas A, Gelzinis A, Bacauskiene M. Mining data with random forests : a survey and results of new tests. Oxford: Pergamon Press; Pattern Recognition. 2011;44(2):330-349.

Verikas A, Gelzinis A, Hållander M, Bacauskiene M, Alzghoul A. Screening web breaks in a pressroom by soft computing. Amsterdam: Elsevier; Applied Soft Computing. 2011;11(3):3114-3124.

Verikas A, Guzaitis J, Gelzinis A, Bacauskiene M. A general framework for designing a fuzzy rule-based classifier. London: Springer London; Knowledge and Information Systems. 2011;29(1):203-221.

Verikas A, Lundström J, Bacauskiene M, Gelzinis A. Advances in computational intelligence-based print quality assessment and control in offset colour printing. Amsterdam: Elsevier; Expert systems with applications. 2011;38(10):13441-13447.

Conferences with full-paper review

2013

Khandelwal S, CHEVALLEREAU C. Estimation of the Trunk Attitude of a Humanoid by DataFusion of Inertial Sensors and Joint Encoders. In: Nature-Inspired Mobile Robotics: . The 16th International Conference on Climbing and Walking Robots and the Support Technologies for Mobile Machines (CLAWAR 2013),Sydney, Australia,14 - 17 July, 2013. Singapore: World Scientific; 2013. p. 822-830.

Vaiciukynas E, Verikas A, Gelzinis A, Bacauskiene M, Sulcius S, Paskauskas R, et al. Prototype-Based Contour Detection Applied to Segmentation of Phytoplankton Images. In: AWERProcedia Information Technology and Computer Science: 3rd World Conference on Information Technology (WCIT-2012). 3rd World Conference on Information Technology (WCIT-2012), 14-16 November 2012, University of Barcelon, Barcelona, Spain. 2013. p. 1285-1292. AWERProcedia, 3.

Byttner S, Nowaczyk S, Prytz R, Rögnvaldsson T. A field test with self-organized modeling for knowledge discovery in a fleet of city buses. In: : . IEEE International conference on Mechatronics and Automation. 2013.

Alonso-Fernandez F, Bigun J. Quality Factors Affecting Iris Segmentation and Matching. In: Proceedings 2013 International Conference on Biometrics: . ICB-2013, The 6th IAPR International Conference on Biometrics June 4 - 7, 2013, Madrid, Spain. Piscataway: IEEE conference proceedings; 2013. p. 1-6.

Muehlfellner P, Furgale P T, Derendarz W, Philippsen R. Evaluation of Fisheye-Camera Based Visual Multi-Session Localization in a Real-World Scenario. In: Intelligent Vehicles Symposium (IV), 2013 IEEEWorkshop on Environment Perception and Navigation for Intelligent Vehicles: . IEEE Intelligent Vehicles Symposium, June 23-26, 2013, Gold Cost, Australia. Piscataway, NJ: IEEE Operations Center; 2013. p. 57-62. IEEE Intelligent Vehicles Symposium.

Zeng Y, Rose C, Brauner P, Taha W, Masood J, Philippsen R, et al. Modeling Basic Aspects of Cyber-Physical Systems, Part II. In: : . 4rd International Workshop on Domain-Specific Languages and models for ROBotic systems (DSLRob-13). 2013.

Gelzinis A, Verikas A, Bacauskiene M, Vaiciukynas E. Learning Accurate Active Contours. In: Engineering Applications of Neural Networks: 14th International Conference, EANN 2013, Halkidiki, Greece, September 13-16, 2013 Proceedings, Part I. 14th International Conference, EANN 2013, Halkidiki, Greece, September 13-16. Berlin Heidelberg: Springer Berlin/Heidelberg; 2013. p. 396-405. Communications in Computer and Information Science, 383.

Nowaczyk S, Prytz R, Rögnvaldsson T, Byttner S. Towards a Machine Learning Algorithm for Predicting Truck Compressor Failures Using Logged Vehicle Data. In: Twelfth Scandinavian Conference on Artificial Intelligence: . 12th Scandinavian Conference on Artificial Intelligence, Aalborg, Denmark, November 20–22, 2013. Amsterdam: IOS Press; 2013. p. 205-214. Frontiers in Artificial Intelligence and Applications, 257.

Prytz R, Nowaczyk S, Rögnvaldsson T, Byttner S. Analysis of Truck Compressor Failures Based on Logged Vehicle Data. In: : . 9th International Conference on Data Mining, July 22–25, Las Vegas, Nevada, USA. CSREA Press; 2013.

De Morais W, Lundström J, Wickström N. A Database-Centric Architecture for Home-Based Health Monitoring. Ambient Assisted Living and Active Aging - 5th International Work-Conference, IWAAL 2013, Carrillo, Costa Rica, December 2-6, 2013, Proceedings, pp 26-34.

2012

Alonso-Fernandez F, Bigun J. Iris Boundaries Segmentation Using the Generalized Structure Tensor : A Study on the Effects of Image Degradation. The IEEE Fifth International Conference on Biometrics: Theory, Applications and Systems (BTAS 2012), Washington DC, September 23-26, 2012. 2012. p. 6-.

Alonso-Fernandez F, Bigun J. Periocular Recognition Using Retinotopic Sampling and Gabor Decomposition. In: Computer Vision -- ECCV 2012. Workshops and Demonstrations. Intl Workshop "What's in a Face?" WIAF, in conjunction with the European Conference on Computer Vision, ECCV, Springer LNCS 7584, Firenze, Italy, October 7-13, 2012. Berlin: Springer; 2012. Lecture Notes in Computer Science, 7584.

Kalsyte Z, Verikas A, Vasiliauskaite A. Predicting trends of financial attributes by an adaptive committee of models. In: Proceedings of the 7th International Conference on Electrical and Control Technologies ECT 2012. Electrical and Control Technologies, ECT-2012. Kaunas, Lithuania: Kaunas University of Technology; 2012. p. 48-53. Electrical and Control Technologies.

Andreasson H, Bouguerra A, Lilienthal A, Björn Å, Rögnvaldsson T. Gold-fish SLAM: An application of SLAM to localize AGVs. In: Proceedings of the 8th International Conference on Field and Service Robotics. The 8th International Conference on Field and Service Robotics, July 16-19, 2012, Matsushima, Miyagi, Japan. 2012.

Karginova N, Byttner S, Svensson M. Data-driven methods for classification of driving styles in buses. SAE 2012 World Congress & Exhibition, Cobo Center, Detroit, Michigan, USA, April 24-26, 2012. Warrendale, PA: SAE International; 2012. SAE Technical Papers, 2012-01-0744.

Karlsson S M, Bigun J. Lip-motion events analysis and lip segmentation using optical flow. In: . 2012 IEEE Computer Society Conference on Computer Vision and Pattern Recognition Workshops, CVPRW 2012, 16-21 June, 2012, Rhode Island, USA. Piscataway, N.J.: IEEE Press; 2012. p. 138-145.

Mikaelyan A, Bigun J. Ground truth and evaluation for latent fingerprint matching. In: 2012 IEEE Computer Society Conference on Computer Vision and Pattern Recognition Workshops, CVPRW 2012. 2012 IEEE Computer Society Conference on Computer Vision and Pattern Recognition (CVPR), Providence, Rhode Island, June 16-21, 2012. Piscataway, NJ: IEEE Computer Society; 2012. p. 83-88. IEEE Computer Society Conference on Computer Vision and Pattern Recognition workshops.

Nowaczyk S, Byttner S, Prytz R. Ideas for Fault Detection Using Relation Discovery. The 27th annual workshop of the Swedish Artificial Intelligence Society (SAIS), 14–15 May 2012, Örebro, Sweden. Linköping: Linköping University Electronic Press; 2012. p. 1-6. Linköping Electronic Conference Proceedings, 071.

Sentis L, Petersen J G, Philippsen R. Experiments with Balancing on Irregular Terrains using the Dreamer Mobile Humanoid Robot. Robotics: Science and Systems VIII, July 09-July 13, 2012, University of Sydney, Sydney, NSW, Australia. 2012.

Vachkov G, Byttner S, Svensson M. Battery aging detection based on sequential clustering and similarity analysis. In: IS'2012: 2012 6th IEEE International Conference Intelligent Systems, Proceedings. 6th IEEE International Conference Intelligent Systems, IS 2012, Sofia, Bulgaria, 6-8 September 2012, Category number: CFP12802-PRT, Code: 94030. Piscataway, N.J.: IEEE Press; 2012.

Gelzinis A, Vaiciukynas E, Bacauskiene M, Verikas A, Sulcius S, Paskauskas R, et al. Boosting performance of the edge-based active contour model applied to phytoplankton images. In: Proceedings of the 13th IEEE International Symposium on Computational Intelligence and Informatics. 13th IEEE International Symposium on Computational Intelligence and Informatics,Budapest, Hungary. Budapest, Hungary; 2012. p. 273-277.

Sant'Anna A, Wickström N, Zügner R, Tranberg R. A wearable gait analysis system using inertial sensors Part I: evaluation of measures of gait symmetry and normality against 3D kinematic data. In: Proceedings of the International Conference on Bio-inspired systems and signal processing. BIOSIGNALS 2012. 2012. p. 180-188.

Sant'Anna A, Wickström N, Eklund H, Tranberg R. A wearable gait analysis system using inertial sensors Part II: Evaluation in a clinical setting. In: Proceedings of the International Conference on Bio-inspired systems and signal processing. BIOSIGNALS 2012. 2012. p. 5-14.

2011

Byttner S, Svensson M, Vachkov G. Incremental classification of process data for anomaly detection based on similarity analysis. In: EAIS 2011: 2011 IEEE Workshop on Evolving and Adaptive Intelligent Systems : April 11-15, 2011, Paris, France. Symposium Series on Computational Intelligence, IEEE SSCI 2011 - 2011 IEEE 5th Workshop on Evolving and Adaptive Intelligent Systems, EAIS 2011, Paris, France, 11 - 15 April 2011. p. 108-115.

Gelzinis A, Verikas A, Bacauskiene M, Olenina I, Olenin S. Categorizing cells in phytoplankton images. In: Recent Advances in Signal Processing, Computational Geometry and Systems Theory. The 11th WSEAS International Conference on Signal Processing, Computational Geometry and Artificial Vision (ISCGAV'11), Florence, Italy, August 23-25, 2011. Athens: World Scientific and Engineering Academy and Society; 2011. p. 82-87.

Gelzinis A, Verikas A, Bacauskiene M, Olenina I, Olenin S. Detecting P. minimum cells in phytoplankton images. In: Electrical and Control Technologies : proceedings of the 6th international conference on Electrical and Control Technologies ECT 2011 / Kaunas University of Technology, IFAC Committee of National Lithuanian Organisation. The 6th international conference on Electrical and Control Technologies ECT 2011, May 5-6, 2011, Kaunas, Lithuania. Kaunas, Lithuania: Kaunas University of Technology, Lithuania; 2011. p. 61-66. Electrical and Control Technologies, 2011.

Hedenberg K, Åstrand B. Safety standard for mobile robots : a proposal for 3D sensors. In: Proceedings of the 5th European Conference on Mobile Robots, ECMR'2011. The 5th European Conference on Mobile Robots, ECMR 2011, Örebro, Sweden, September 7-9, 2011. Örebro: Centre for Applied Autonomous Sensor Systems (AASS); 2011. p. 245-251.

Lundström J, Verikas A. System for Assessing, Exploring and Monitoring Offset Print Quality. In: Recent Researches in Circuits, Systems, Communications & Computers: Proc. of 2nd European Conference of Communications (ECCOM'11). The 2nd European Conference of Systems (ECS '11), Puerto De La Cruz Tenerife, Spain, December 10-12, 2011. Athens: World Scientific and Engineering Academy and Society; 2011. p. 28-33. Recent Researches in Circuits, Systems, Communications & Computers, 2.

Mosallam A, Byttner S, Svensson M, Rögnvaldsson T. Nonlinear relation mining for maintenance prediction. IEEE Aerospace conference 2011, 5-12 march. New York: IEEE Press; 2011. p. 1-9.

Nemati H M, Åstrand B. Tracking of People Using Laser Range Sensor in Occlusion Situations. In: Proceedings of 2011 International Conference on Information and Computer Technology (ICICT). International Conference on Information and Computer Technology (ICICT), 27 to 28 August 2011 Yantai, China. 2011.

Ourique De Morais W, Wickström N. A Serious Computer Game to Assist Tai Chi Training for the Elderly. In: 2011 IEEE 1st International Conference on Serious Games and Applications for Health, SeGAH 2011. 2011 IEEE 1st International Conference on Serious Games and Applications for Health (SeGAH 2011), Braga, Portugal16-18 November 2011. Piscataway: IEEE Press; 2011.

Philippsen R, Sentis L. Open Source Whole-Body Control Framework for Human-Friendly Robots. 4th Workshop on Human-Friendly Robotics (HFR 2011), University of Twente, The Netherlands, November 8-9, 2011. 2011.

Prytz R, Nowaczyk S, Byttner S. Towards relation discovery for diagnostics. In: Proceedings of the First International Workshop on Data Mining for Service and Maintenance. 17th ACM SIGKDD Conference on Knowledge Discovery and Data Mining. New York, NY: Association for Computing Machinery (ACM); 2011. p. 23-27.

Sant'Anna A, Wickström N. Symbolization of time series : an evaluation of SAX, persist, and ACA. In: CISP 2011: Proceedings, the 4th International Congress on Image and Signal Processing, 15-17 October 2011, Shanghai, China. 4th International conference on Image and Signal Processing (CISP). Piscataway, N.J.: IEEE Press; 2011. p. 2223-2228.

Stasiunas A, Verikas A, Bacauskiene M, Miliauskas A. An adaptive functional model of the filtering system of the cochlea of the inner ear. In: Proceedings of the 4th Imternational Symposium on Applied Sciences in Biomedical and Communication Technologies, ISABEL 2011. ISABEL 2011. ACM Press; 2011.

Svensson M, Rögnvaldsson T, Byttner S, West M, Andersson B. Unsupervised deviation detection by GMM - A simulation study. 8th IEEE Symposium on Diagnostics for Electrical Machines, Power Electronics and Drives, SDEMPED 2011, Bologna, Italy, 5-8 September, 2011. Piscataway, N.J.: IEEE Press; 2011.

Verikas A, Bacauskiene M, Gelzinis A, Uloza V. Monitoring Human Larynx by Random Forests Using Questionnaire Data. In: Proceedings of the 11th International Conference on Intelligent Systems Design and Applications, ISDA, Cordoba, 22-24 november, 2011. The 11th International Conference on Intelligent Systems Design and Applications. IEEE Computer Society; 2011. p. 914-919.

Other conference papers
2013-2011

Alonso-Fernandez F, Bigun J. Biometric Recognition Using Periocular Images. In: : . Swedish Symposium on Image Analysis 2013 (SSBA 2013), Gothenburg, 14-15 March. 2013.

Eriksson H, Isaksson A, Lundström J. Technology and trust : Social and technical innovation in elderly care. In: : . Equality, growth and innovation - in theory and practice, 9-10 October 2013, Luleå. 2013.

Alonso-Fernandez F, Bigun J. Iris Segmentation Using the Generalized Structure Tensor. SSBA Symposium 2012 (SSBA2012), Stockholm, 8-9 mars, 2012. 2012.

Alonso-Fernandez F, Bigun J. Iris Pupil Detection by Structure Tensor Analysis. In: . SSBA Symposium 2011 (SSBA2011), Linköping, 17-18 mars, 2011. 2011.

Karlsson S, Bigun J. Synthesis and detection of log-spiral codes. SSBA Symposium i bildanalys, 17-18 mars 2011, Linköping. 2011. p. 4-.

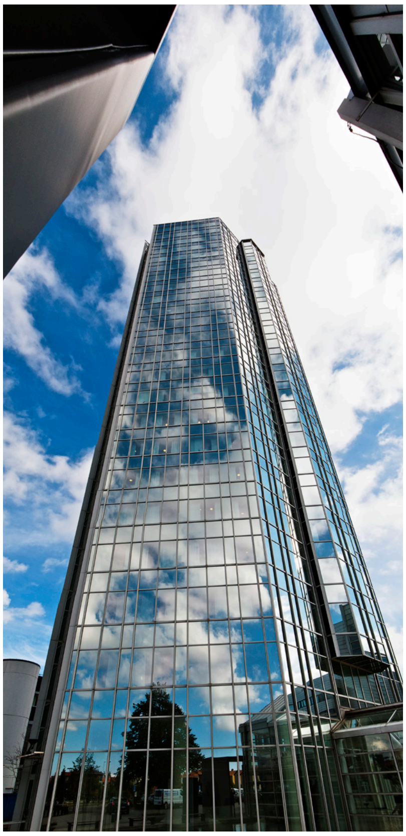
Books/Book chapters
2013-2011

Alonso-Fernandez F, Fierrez J, Bigun J. Quality Measures in Biometric Systems. In: Encyclopedia of Biometrics, 2nd edition: . 2 Springer; 2013.

Alonso-Fernandez F, Fierrez J. Fingerprint Databases and Evaluation. In: Encyclopedia of Biometrics, 2nd edition: . 2 Springer; 2013.

Sant'Anna A, Wickström N. Symbolic Approach to Motion Analysis: Framework and Gait Analysis Case Studies. In: Telehealthcare Computing and Engineering: Principles and Design: . 1 CRC Press; 2013. p. 557-602.

Kamińska H, Rögnvaldsson T. Evaluation of a new probabilistic approach to scoring algorithms in protein identification by Peptide Mass Fingerprinting (PMF). In: Nutraceutics, biomedical remedies and physiotherapeutic methods for prevention of civilization-related diseases. Wroclaw, Poland: Indygo Zahir Media; 2011. p. 171-180. Biomedical Engineering Acta, 4/2011.



CAISR, the Center for Applied Intelligent Systems Research, is a long-term research program on intelligent systems established by Halmstad University. The key application areas that the center does research in are intelligent vehicles and health care technology. The industrial partners include multinational companies as well as research-based growing companies.

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