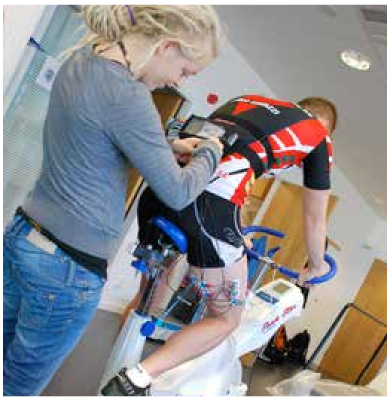
Center for Applied Intelligent Systems Research

CAISR Research Profile

ANNUAL REPORT 2012

Knowledge Foundation



HALMSTAD UNIVERSITY

Cover photos

Company representatives and CAISR staff at CAISR Kick-off December 2011			
PhD Anita Sant'Anna	Data collection for health technology purpose	Intelligent vehicles....	...telling their story
CAISR campus PhD students: Saeed Gholami Shahbandi, Jens Lundström, Siddhartha Khandelwal and Anna Mikaelyan			

Photos in the Annual Report: Roland Thörner and others

CAISR

Center for Applied Intelligent Systems Research

Research Profile
Annual Report 2012

HÖGSKOLAN HALMSTAD

Knowledge Foundation

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CAISR

Center for Applied Intelligent Systems Research

Annual Report 2012

Introduction

CAISR Research Focus

The scientific focus for the Center for Applied Intelligent Systems Research (CAISR) is "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. Also, aware intelligent systems will be ubiquitous in applications in 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 by sensing the human's physiological (face, length of body parts, iris, fingerprint, etc.) and behavioral properties (speech, lip-motion, articulation, gait, etc.) for various purposes, including but not restricted to identity, presence, and message recognition. An example of a human aware system is a transport vehicle that is aware of people around it, e.g. when making turns in the traffic or approaching zebra crossings. Where are the people? Where are they going? What are their intentions? This system could consist in sensors and software on-board the vehicle, possibly interacting with infrastructure hardware and sensors. Similar questions arise in material handling in industries with semi-autonomous or autonomous trucks.

Situation awareness is about having a "big-picture" and not just a few sensor readings. A situation aware system can react to an otherwise normal sensor reading or event if it happens concurrently with something else that is not supposed to happen. It could be an intelligent network of sensors installed in elderly living quarters, or in the clothes worn, that can help preventing an unwanted event in a friendly manner. The system can alarm when the movement or activity pattern for the elderly deviates from the person's normal activity pattern and/or when it deviates significantly from other people living under similar circumstances.

Thorsteinn Rögnvaldsson
Director of CAISR

A self-aware system can be a self-monitoring system; a system that is able to learn and describe what it does and tell when things go wrong. Systems that operate for a long time, work in remote areas or are mobile, that are expected to do "lifelong learning" and are likely to encounter new unforeseen need some self-awareness. 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". A self-explaining system can at least partially diagnose itself and assist the human operator, and explain to the human operator why it came to its conclusions.

The center builds around our research groups in three scientific areas: Signal Analysis, Mechatronics and Machine Learning. The industrial partners come from two application areas: intelligent vehicles and health care technology.

Scientific areas

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.

Machine learning is about designing algorithms that can be used to make machines (computers) develop knowledge (learn) from empirical observation from, e.g., sensors and data bases, 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

Aware systems will be important in many application fields in the future society, not least production industry. We have in CAISR chosen to focus on two application areas: intelligent vehicles and health care technology. Both these application areas have long term societal importance.

Health care technology. The coming EU Horizon 2020 framework program points to the health of the elderly, and a growing elderly population, as one of the major societal challenges for Europe in the years to come. Information and communication technologies (ICT) are considered as one of the key technologies to meet this challenge, e.g. through social (aware) robots and smarter environments that support them in their life. However, ICT and aware systems can also be used to motivate not so old people to live a healthier and more active life, so that their life quality later is improved. Technology development in this sector will undoubtedly create new business opportunities.

Intelligent vehicles. The prosperity of a society is closely linked to transportation. More efficient and safer transportation and logistics opens up new opportunities for trade and business. Easy and reliable transportation means opportunities for people to work and live a rewarding life. Smarter cars means new opportunities for older people and persons with disabilities to have a mobile life. It is no exaggeration that ICT is a key technology to achieve this.

CAISR Research Focus in the Halmstad University context

Halmstad University has identified Information Technology as one of three pillars on which to build its future research and advanced education. The Halmstad Embedded and Intelligent Systems (EIS) research environment, of which CAISR is part, constitutes about 40% of the total research (in terms of research funding) at Halmstad University. CAISR is one of two research profiles within EIS, making out about 1/3 of EIS, the other being CERES (Center for Research on Embedded Systems).

Halmstad University has, since 2010, the right to award doctoral degrees within Information Technology. This doctoral education is conducted within EIS and the researchers in CAISR are supervising the doctoral education in Signals and Systems Engineering, which is one of the two subjects currently offered within Information Technology. A substantial fraction of the doctoral students in CAISR are industrial doctoral students (see presentations later in this report).

CAISR Management during and industry 2012

CAISR is managed by a project manager who is appointed by the university. An *Academic management team* is supporting the project manager. The partners in the CAISR project have agreed on creating a *Reference Group* with representatives from national and international research and industry organizations. The partners have further decided to create an *Industrial advisory board (IAB)*, consisting of representatives from each industrial partner. Beside this organization, shall each individual research project appoint a steering group. The different roles for staff and groups are described in the agreements signed by the university as well as the industrial partners.

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, Project manager Health Technology Centre Halland

Thorsteinn Rögnvaldsson

Antanas Verikas

Josef Bigun

Magnus Hållander

Industrial advisory board	
Industrial partners	**Representatives***
Free2move AB	Per-Arne Wiberg
Kollmorgen Särö	Jonas Rahm (chairman)
NEAT Electronics AB	Lars Nyström
Optronic AB	Emil Hällstig
Redsense Medical AB	Patrik Byhmer
Tappa Service AB	David Johansson
Toyota Material Handling Europe AB	Henrik Eriksson
Volvo Group Advanced Technology & Research	Joakim Svensson

* The representatives above are the ordinary members in the Industrial advisory board

Jonas Rahm
chairman of IAB

Industrial partners

The CAISR research environment consists of Halmstad University and eight companies, which together have signed an agreement on cooperating in several research projects and in different settings. The companies are presented below and how they express their own aims for being a partner in the project.

Free2move AB, Halmstad
Free2move is a company with its roots in Halmstad University. It is natural and important to have proximity to the University, not only in corporate marketing when many talented persons are educated and gathered in the higher education community, and these are of interest to industry. Future potential employees from the university, also bring innovation to the industry. To create interfaces with other companies is a positive factor for a small organization like ours. Participating in several projects together with others, always provides perspective on our own.
http://www.free2move.se

Kollmorgen Särö AB
Kollmorgens's AGV control solution shall be known as the defacto standard with AGV. It shall be cost efficient, high performing, easy to use and integrate in standard lift trucks. This project shall aim to reduce the amount of time it takes to install an AGV system with a factor at two.
http://www.danahermotion.com

Optronic AB
Optronic is a leading service provider in the field of optoelectronics, with a focus on integrated development and manufacturing. We want to provide the project with a sensor system for automatic inventory and mapping of stock, thereby developing a custom sensor to obtain this purpose and to obtain knowledge about this type of applications.
http://www.optronic.se

Neat Electronic
The next generation of home care systems will have more sensors and more mobile sensors (sensors that the person wears) and the possibilities for fusing the information from several sources into a more comprehensive picture of the person's health status will be improved. Competence development of own staff, but also access to a wider competence base within the project. National and international networking.
http://www.neatelectronics.se

Redsense Medical AB
Redsense Medical is interested in how our products can meet the continuously increasing demands on robustness and fault detection/handling mechanisms for medical devices. In particularly signal analysis and statistical methods for evaluation and risk analysis are important. Competence development of our own staff. The close collaboration with different scientific competencies gives additional values to our company.
http://www.redsensemedical.com

Tappa Service AB
The goal of the project is to make use of medical evidence for health promotion with the opportunities presented by technical research in the motion analysis field. This allows Tappa to offer new services that build business advantages over the competitors in the field. One additional important aspect of the collaboration is to increase the competence of our own staff.
http://tappa.se

Toyota Material Handling Europe AB
Toyota Material Handling Europe is active in the AGV market and supplying a wide range of machines that manages inventory shipments without drivers, reducing customer costs significantly. The need is to develop new technologies in sensors and installation area to create safer solutions and reduce project times. Furthermore, we want to develop systems for goods identification and inventory in order to offer customers increased productivity and efficiency at a reduced cost.
http://www.toyota-forklifts.eu/

Volvo Group Advanced Technology & Research
Embedded and intelligent systems are and will be very important for automotive development. VTEC aims at being at the forefront in these fields and it is strategically important to cooperate with focused academic research groups in these fields.
http://www.volvogroup.com

CAISR Reference Group

Christer Fernström, has a PhD in computer engineering / computer design from Lund University. He is director at Fernstrom et Associates but worked previously at Xerox Labs, as manager for strategy and planning and research area manager. He has also worked for Capgemini. He was chairman for the reference group for CERES, Halmstad University's first Knowledge Foundation funded profile.

Christer Fernström

Misha Pavel, is Program Director for the (US) National Science Foundation program Smart Health and Wellbeing. He is also professor in the Department of Medical Informatics and Clinical Epidemiology, at Oregon Health and Science University (OHSU). Previously, he was a chair of the Department of Biomedical Engineering and the Director of the Point of Care Laboratory at OHSU. His current research is focused on technology that enables transformation of healthcare to be proactive, evidence-based, distributed and patient-centered. He has a Masters degree from Stanford University and a PhD from New York University.

Misha Pavel

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).

Charlotta Falvin
Photo: Axis

Lars Niklasson, is pro vice chancellor for University of Skövde. 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 Skövde University. 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.

Lars Niklasson
Photo: University of Skövde

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.

Lisa Amini
Photo: IBM

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 90 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

Statement from CAISR Reference Group

The CAISR Reference Group is of the opinion that the overall goals of CAISR are well expressed in the activity plan and appreciates that both qualitative and quantitative goals have been formulated. Given the global aim of CAISR to establish a research focus based on the existing research in signal analysis, machine learning and mechatronics, the overall research environment appears to be appropriately staffed with a sufficient mix of competences, at various academic levels, to establish a clear and common research direction and to achieve a scientific impact. However, given the focus towards situation awareness, additional competences in higher level reasoning and planning could be of interest, to enhance statistical efficiency for prediction and impact assessment. The self-aware aspect, could be extended with competences in sensor management, to cope with situations when the data are sparse or data quality is low.

One of the strengths and opportunities of CAISR is the access to competences outside CAISR, within the larger context of research at Halmstad University. CAISR operates within EIS – "Embedded and Intelligent Systems", which is a research collaboration across different labs at the University - and has collaborations with CERES (the Centre for Research on Embedded Systems) and with HCH (the Health Technology Centre). We advise the CAISR team to take advantage of such interdisciplinary collaboration whenever suitable.

The research environment appears to have strong and long-lasting collaboration with industry, both with large companies and with SMEs, to support the long-term vision of conducting industrially relevant research within the chosen research direction. Never the less, the expected industrial value should be better articulated (with the help of the industry partners). Knowledge transfer to the industry partners is a key success factor for CAISR and one suggestion to further support such knowledge transfer between the research environment and the participating companies could be to use industrial PhDs to a higher degree than suggested in the activity plan. This would also increase the potential for future collaboration.

The Reference Group has had the opportunity to meet with representatives from the industrial partners to obtain their views and motivations for CAISR. This includes aspects from long-term research on topics the industry partners do not have the capacity to address (for example data fusion) to the opportunity provided by CAISR to work with application domain specialists and potential users (for example through the Health Technology Centre), or to be a door opener for working with top-level research partners on an international level.

Funding and goals for 2012

We had set a number of goals for 2012, of which we achieved some and fell short of some.

We had planned to reach a gross research turnover of about 16 million Swedish kronor (SEK) at the university (i.e. not counting the company in-kind contributions). We reached 15.6 million. The economy is summarized in the figure below. The company contribution ended up to be larger than we had planned for 2012. We planned to have a significant contribution of research grants from the Swedish Research Council (Vetenskapsrådet, VR) and the EU seventh framework program (FP7). About one third of our external research grants came from VR and the EU FP7.

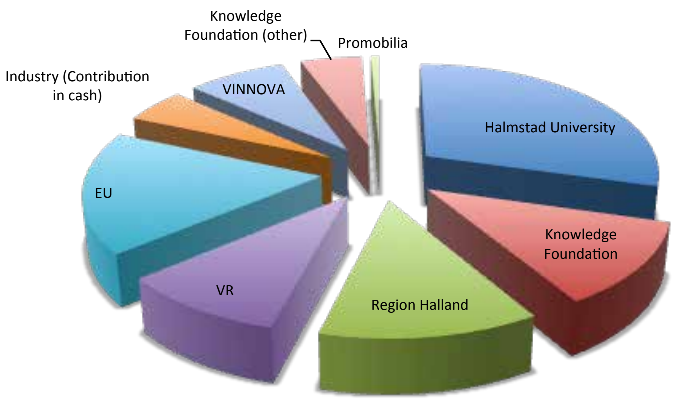
We had planned to publish 12 scientific Journal papers and 12 conference papers. We published 8 Journal papers and 13 conference papers. We planned to have 8-9 active PhD students within CAISR by the end of 2012. We reached 10. We planned to have two PhD dissertations during 2012. We had one. We planned that our PhD students should have the possibility to have a longer stay at an international research institution during their education. One of our PhD students visited University of Twente for three months. We planned to initiate an international visitor program where we invite researchers from international research institutes and where our staff can visit international research organizations. During 2012 we, together with CERES, started the Halmstad Colloquium series, presented later in this report. We invited guests and arranged for a visiting professorship during 2013. One of our younger robotics researchers started a three month research visit at Willow Garage in California.

We planned to start four larger projects within CAISR during 2012. We started five but one of them was cancelled during the second part of 2012 because one of the industrial partners, Redsense Medical, could not continue with their commitment from January 1, 2013. Another partner, Division By Zero, will therefore take their place in CAISR from January 1, 2013. We planned to hold the first thematic workshop during 2012. We did not achieve this goal but plan for this during 2013.

All in all, we met almost all of our goals for the first year.

Funder	**Budget 2012 (SEK)**	**Result 2012 (SEK)**
Knowledge foundation	3 903 818	1 802 386
CAISR Industrial partners*	4 608 280	9 058 657
Other external funding**	9 000 000	8 873 000
Halmstad University	3 482 167	4 459 421
Sum	**20 994 265**	**24 193 464**

* Both cash and 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).
**VR, EU, Vinnova, companies et cetera



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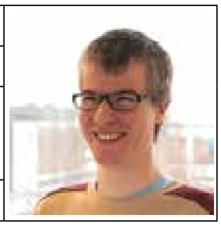

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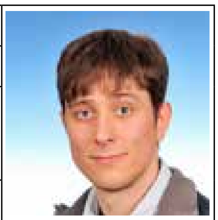

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CAISR PhD students

At Campus Halmstad

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 (deficarotte), I graduated by defending my thesis on "object recognition with neural network". I joined CAISR at Halmstad University in 2012, currently working in the AIMS project under supervision of Prof. Verikas and Åstrand. My main interests lie in "Robotic", "Computer Vision" and "Machine Learning".

Jens Lundström
After graduating from the master program in Computer System Engineering at Halmstad University I continued working 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, customer care, software development, image analysis, database systems, testing and system maintenance. It was a natural step to start pursuing the PhD degree in the field of Information Technology (2009). The studies started with a project, Predicting Print Quality (PPQ), focused at assessing and exploring print quality using data mining methods. I am now working with applying machine learning methods in the area of Health Technology, a field with many interesting challenges. Currently, we are exploring how human behaviour models can be used to improve the elderly care and the quality of life for the elderly.

Anna Mikaelyan
I have completed my undergraduate and master studies at the Department of Algebra and Discrete Mathematics, Southern Federal University, Russia.
Then I followed my education by taking one year MA course in Financial Mathematics at Halmstad University studying explicit solution of differential equations in financial mathematics.
During that period I worked at the University as a professor assistant.
Currently, I am pursuing PhD within Marie-Curie European project BBfor2 (Bayesian Biometrics for Forensics). My main part of research is performed at Halmstad University under the supervision of prof. Bigun. Here we explore forensic fingerprints and investigate descriptors for improved fingerprint matching. Minor research is hold at Twente university (Holland) supervised by prof. Veldhuis. There we investigate influence of facial features on performance of recognition of state-of-the-art facial matchers.

Siddhartha Khandelwal
I did my B. Tech in Electronics and Instrumentation at VIT University, India and graduated in 2009 by defending my Bachelor thesis named "Developing a path planning algorithm and tracing system for an autonomous mobile robot participating in Eurobot 2009" at TU Dresden, Germany. For the next 9 months I worked in business development at a robotics start-up called ThinkLabs (IIT Bombay, India) after which I went on to do my Masters in Advanced Robotics (EMARO) with the Erasmus Mundus Category-A scholarship. As per the course, I did my 1st year at WUT, Poland and 2nd year at ECN, France and graduated in 2012 by defending my Master thesis named "Estimation of the trunk attitude of a humanoid by data fusion of inertial sensors and joint encoders". Then I joined CAISR at Halmstad University, Sweden as a PhD and am currently working on "Human motion analysis for health-care applications".

Stefan Ericson - University of Skövde

I received my M.Sc. in Electrical Engineering from University of Skövde in 1999. Then I worked as an electronics designer of space electronics at Omnisys Instruments AB for three years. After that I returned to University of Skövde to work as a Lecturer. Recent years I have been working both as the head of the engineering department and as a PhD student. 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 particular visual odometry.

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 MSc 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 PhD Åstrand.

Petras Razanskas - University of Kaunas

I earned my Bachelor of Mathematics degree at Kaunas University of Technology in 2009. My studies were concentrated around discrete mathematics and signal analysis, with secondary emphasis on applied statistics and differential equations. My BMath thesis was on machine learning without direct supervision based on decision correction. I immediately enrolled into the Master of Mathematics studies at the same university and successfully finished them in 2011. The studies emphasised multivariate statistical analysis and time series, as well as combinatorial and functional optimisation. My MMath thesis was on defect detection in textured surfaces using statistical analysis of image features in time-frequency domain. Currently I am a PhD student enrolled at Kaunas University of Technology under supervision of prof. Antanas Verikas, and the topic of my research is fatigue detection and evaluation using analysis of electromyographic signals. This project is done within CAISR.

Peter Mühlfellener - Industrial PhD Student Volkswagen Group

I obtained my Master's degree from Halmstad University, Sweden, and my Diploma Degree from the Salzburg University of Applied Sciences, Austria, in 2011/2012 respectively. In my Master's thesis, I worked on a framework for hardware-based image-feature extraction and classification - prototyped on an FPGA - in conjunction with Volkswagen AG, Germany. The thesis-work was supported by Prof. Rögnvaldsson and Assoc.-Prof. Åstrand at Halmstad University. Currently, I'm an industrial PhD-Student with Volkswagen Group Research and Halmstad University, where Prof. Rögnvaldsson, alongside Assoc.-Prof. Philippsen, continues to be my supervisor. My research-interests include both Robotics and Computer Vision, with a focus on Multi-Session Visual SLAM in realistic automated driving scenarios.

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

I studied Electrical Engineering atLunds University in Sweden. My studies was concentrated towards automatic control and real time systems. I graduated with a MSc degree accomplishing " Memory Protection in a Real-Time Operating System ". The thesis was awarded with the Bengt-Asker award for best real-time master thesis. Following that I started working at Volvo Technology Cooperation in 2004. While working I accomplished courses in project management at Chalmers Technical University. In 2009 I as an Industrial PhD student in cooperation with Volvo and Halmstad University. My interests are within fleet based predictive maintenance and remote diagnostics.

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 2013. 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.

Highlights 2012

2012 was very much the starting up year, meaning that the highlights were very much oriented towards organizational aspects and getting everything in place and started. We started up the reference group, a truly great group of people with very well complementing qualities, and had a meeting with them in June. We had internal kick-offs and kick-offs with our industrial partners. We discovered, as is often the case, that we had been a bit overly optimistic on how quickly we would get PhD students in place. However, we finally managed to collect some really great PhD candidates (see presentations earlier).

Chair of Reference Group - Christer Fernström

Meeting with the Reference Group, June 20, 2012

The CAISR Kick-Off December 7, 2011

Jonas Rahm, appointed chairman of IAB

Internal Kick-Off, May 8, 2012...

... with external speaker Marika Kajo

Measuring muscle status and fatigue

As a part of the project Measuring muscle status and fatigue in active people, have eight subjects participated in data collection. One setting at Halmstad University with six persons, and one setting in Gothenburg at the Sports Academy at University of Gothenburg. The pictures show one of the test persons during data collection in the laboratory.

During this session EMG signals were recorded from four muscles of both legs, in addition readings from accelerometers, as well as measurements of heart rate, oxygen consumption, lactose concentration in blood, cadence, and also subjective evaluations of fatigue. Further information about the project and results so far, is found in the extended abstract.

Data collection on a workshop at School of Sports and Science, Gothenburg, November 2012

In cooperation with Tappa Service did researchers in CAISR develop the "actimeter", a wearable device for measuring physical activity. This actimeter turned out to be very successful and is now used, e.g., for encouraging a more active lifestyle for workers on oil drill platforms in the North Sea. The King and Queen of Sweden were also given one actimeter each when they visited Halmstad university in 2012. The picture shows when Carl Gustav XVI was given an actimeter by Karin Starrin, chairman for the Halmstad university board of governors.

The Tappa Actimeter, a wearable device for measuring physical activity

Safe at night

Jens Lundström talking about the project Safe at Night, May 25. More than 100 visitors on the seminar together with The Health Technology Center and Neat Electronics

The project Safe at Night, which started as a project within the Health Technology Center (HCH) has investigated how the use of social alarm, can be developed to play an important role in the night supervision, that is conducted in the homes of elderly with that needs.

Fifteen elderly in Falkenberg and Halmstad have during some weeks 2011 and 2012 acted as test persons in the project and agreed on that researchers from the university collected data from sensors in their homes. Five of them have taken part in interviews about their experience and feeling regarding the technology.

To the left is a picture from a seminar from the initial project where more than 100 visitors from municipalities and companies attended.

The initial project within HCH is now fulfilled; during the last year the project has developed and is now a part of the research at CAISR. The objectives of the new project is to develop methods and tools for: answering queries, performing 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.

Visit and visitors

Anna Mikaelyan is currently working within FP7 Marie Curie network BBfor2 (Bayesian Biometrics for Forensics) that consists of various European research institutes and associated partners.

Anna Mikaelyan, here ready to evaluate faces with marks

Within the project she received a cooperation internship at Twente University, Netherlands in spring 2012. In Twente she was evaluating performance of face identification software and algorithms for faces with marks (scars, blunches, pimples, etc.). In the work she was collecting images of people with and without marks and then testing if algorithms will still identify a person. That could be useful in forensic context to identify people having temporary marks (beaten or injured) or in security to verify that none can fool the machine by using a temporary mark.

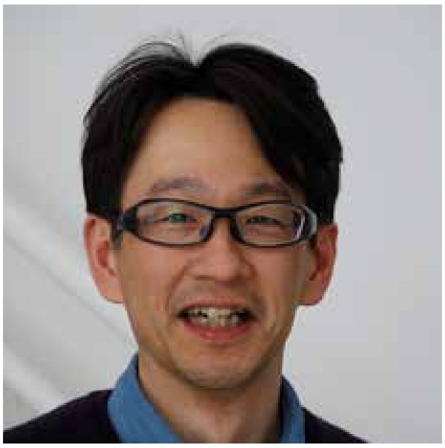
Laurent El Shafey

Laurent El Shafey, PhD student at Idiap Research Institute in Switzerland visited CAISR during April to June 2012. His work is funded by the EU FP7 Marie Curie Initial Training Network Bayesian Biometrics For Forensics (BBfor2).

Karl Iagnemma, director of the Robotic Mobility Group at MIT, visited us in August. He will be joining CAISR part-time as visiting professor during 2013 and work with us and our industrial partners at Volvo and Kollmorgen.

Karl Iagnemma

Professor **Keisuke Suzuki,** Department of Intelligent Mechanical Systems Engineering at Kagawa University, Japan, visited us with one of his students and a colleague from Tokyo University, Dr. Motoki Shino. One of professor Suzuki's students will do a research visit with CAISR during 2013. The long term ambition is to establish a small scale student exchange between CAISR and the Department of Intelligent Mechanical Systems Engineering at Kagawa University.



Keisuke Suzuki

The humanoid NAO came to Halmstad, in December, Roland Philippsen introduced it to snow

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 CAISR and CERES. The talks are available at www.youtube.com

During 2012 Halmstad Colloquium had the pleasure to welcome:


Edward A. Lee, Berkeley


Steven Shladover, ITS Berkeley


Charles Consel, INRIA


Aaron Ames, Texas A&M


Karl-Erik Årzén, LTH


Claus Führer, LTH


The Colloquium talks are video recorded and found at www.youtube.com

Best papers

In the 6th IEEE International conference on Intelligent systems (Sofia, Bulgaria, Sept 2012), the paper "**Battery Aging Detection Based on Sequential Clustering and Similarity Analysis**" authored by **Gancho Vachkov, Stefan Byttner and Magnus Svensson won the best paper award.** The paper presents an algorithm for aging detection of batteries in electric and hybrid vehicles based on sequential clustering and a fuzzy inference procedure. The algorithm was tested on batteries that were used in a real vehicle driving cycle and was shown to be able to detect when a battery was aged.

A. Sant'Anna et al. received the pest paper award at the International Conference on Bio-Inpired Systems and Signal Processing (BIOSIGNALS/BIOSTEC) for the paper entitled **"A wearable gait analysis system using inertial sensors Part II: evaluation in a clinical setting."** The paper was written in collaboration with researchers from the Center for Patient Centered Care at Gothenburg University and the Orthopedic department at the Sahlgrenska Institute. The paper reports the results of a study conducted at the orthopedic ward at Mölndal's hospital, where accelerometers and gyroscopes were used to evaluate quality of gait of hip-replacement patients after the surgery, and three months later. This is a follow-up to the paper "A wearable gait analysis system using inertial sensors Part I: evaluation of measures of gait symmetry and normality against kinematic data," where the gait quality measures were validated against state-of-the-art in-lab gait analysis tools.

PhD Education

During 2012 the research at CAISR resulted in one PhD thesis and one licentiate thesis.

Jens Lundström defended his licentiate thesis on *Understanding Offset Print Quality: A Computational Intelligence-based Approach* on June 11, 2012. The presentation took place at Halmstad University and the discussion leader was Ulf Johansson, School of Business and IT, University of Borås.

Anita Pinheiro Sant'Anna defended her PhD thesis *A Symbolic Approach to Human Motion Analysis Using Inertial Sensors: Framework and Gait Analysis Study* on April 13, 2012. The defence took place at Halmstad University and the opponent was Kamiar Aminian, École Polytechnique Fédéral de Lausanne.

JENS LUNDSTRÖM
Licentiate Thesis Örebro University
Main supervisor: Antanas Verikas, professor, Halmstad university
Co-supervisor: Ivan Kalaykov, professor, Örebro university
Opponent: Ulf Johansson, associate professor, School of Business and IT, University of Borås
Examiner: Silvia Coradeschi, professor Örebro university

This thesis proposes a novel approach to automated print quality assessment in offset lithographic printing. Producing newspapers with acceptable and constant print quality is a non-trivial task. Each printing house must be as efficient as possible in the use of the available resources: paper, ink and printing press. Fewer service stops taken for maintenance makes it difficult to maintain a constant and hight quality.
The offset lithographic printing industry therefore needs methods capable of assessing print quality online and providing quality evaluations that correlate well with the human judgements of print quality. In this work, to provide online print quality evaluations, quality attributes are computed from images, acquired online, of small standard measurement patches that are printed worldwide in newspapers. It is shown that print quality attributes can be aggregated to provide quality evaluations correlating well with print quality assessments made by a group of people. It is also shown that the developed, random forest based, decision support system is able to explain quality variations in terms of paper and printing press parameters.

Jens Lundström

Jens Lundström and Antanas Verikas his main supervisor

ÖREBRO UNIVERSITY

Licentiate Thesis

Understanding Offset Print Quality:
A Computational Intelligence-based Approach

JENS LUNDSTRÖM

A Symbolic Approach to Human Motion Analysis Using Inertial Sensors: Framework and Gait Analysis Study

ANITA PINHEIRO SANT'ANNA
PhD thesis Halmstad University
Main supervisor: Professor Thorsteinn Rögnvaldsson (Halmstad university)
Co-supervisor: Senior lecturer Nicholas Wickström (Halmstad university)
Opponent: Professor Kamiar Aminian, EPFL, Lausanne, Schweiz
Grading committee:
Docent Lanie Gutierrez-Farewik, KTH
Professor Lars Niklasson, Skövde university
Professor Leif Sörnmo, Lund university

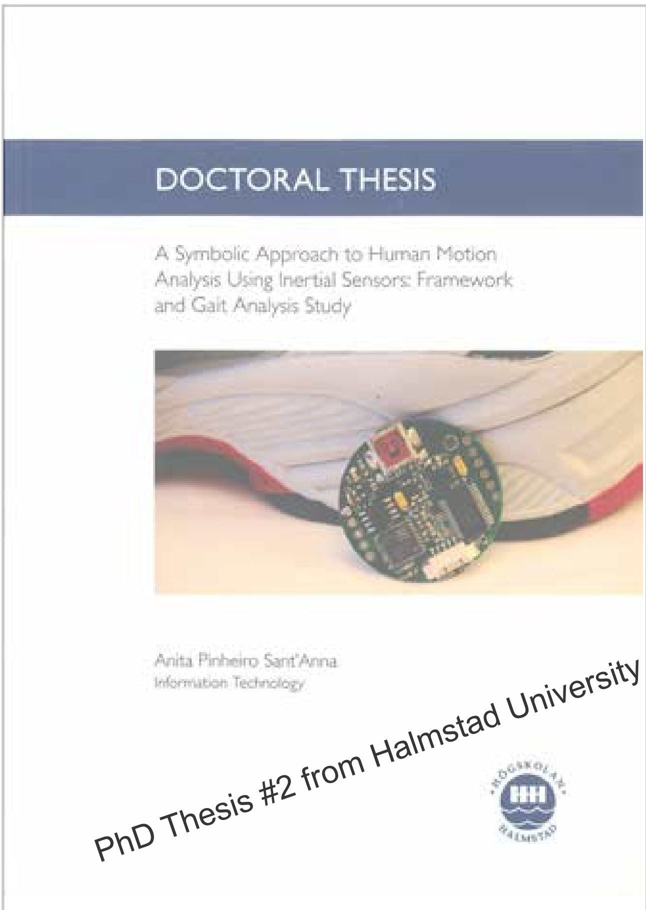
Human motion analysis deals with the automatic detection and description of human movements and activities. Which is particularly important for determining the health status and wellbeing of a subject in health-related monitoring applications. One of the most important everyday activities to monitor is walking, for it can reflect not only the physical but also the cognitive condition of patients. Motion analysis deals with determining what and how activities are being performed by a subject, through the use of sensors. The process of answering the "what" question is commonly known as classification, and answering the "how" question is referred to as characterization. Frequently, combinations of inertial sensor such as accelerometers and gyroscopes are used for motion analysis. These sensors are cheap, small, and can easily be incorporated into wearable systems. The overall goal of this thesis was to improve the processing of inertial sensor data for the characterization of movements. This thesis presents a framework for the development of motion analysis systems that targets movement characterization, and describes an implementation of the framework for gait analysis.

The proposed framework is organized in terms of information abstraction levels, from sensor data, through information and knowledge, to wisdom. It decomposes motion analysis systems into tasks that transform the data from one abstraction level to the next. One substantial aspect of the framework is symbolization, which transforms the sensor data into strings of symbols. This enables the use of many data mining methods which are only available for symbolic data such as Markov models and text mining. Another aspect of the framework is the inclusion of human expert knowledge. This facilitates the connection between data and human concepts, clarifies the analysis process to a human expert, and allows the inclusion of available information without the need for acquiring additional experimental data. The proposed system was compared to state of practice gait analysis systems, and evaluated in a clinical environment.

Results showed that symbolization and the inclusion of expert knowledge can contribute to the development of gait analysis systems. Expert knowledge was successfully used to parse symbolic data and identify the different phases of gait. In addition, the symbolic representation enabled the creation of new gait symmetry and gait normality indices. The proposed symmetry index was superior to many others in detecting movement asymmetry in early-to-mid-stage Parkinson's Disease patients. Furthermore, the normality index showed potential in the assessment of patient recovery after hip-replacement surgery.

In conclusion, this implementation of the gait analysis system illustrated that the framework can be used as a road map for the development of movement analysis systems. The symbolization of sensor data, albeit delicate and under-explored, is a powerful and versatile process. It facilitated not only the inclusion of expert knowledge but also the characterization of movements. In addition, the inclusion of expert knowledge addressed an important aspect of health-related applications, the link between sensor data and human concepts.

Professor Kamiar Aminian, EPFL, Lausanne, Schweiz



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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 embedded into multidisciplinary applications, e.g. robotics, forensic science,, human machine communication. Multimodal biometric identification and communication has 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 invari- ant 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.

Quality and orientation descriptors for forensic images is important to reliable and effficient 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.

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.

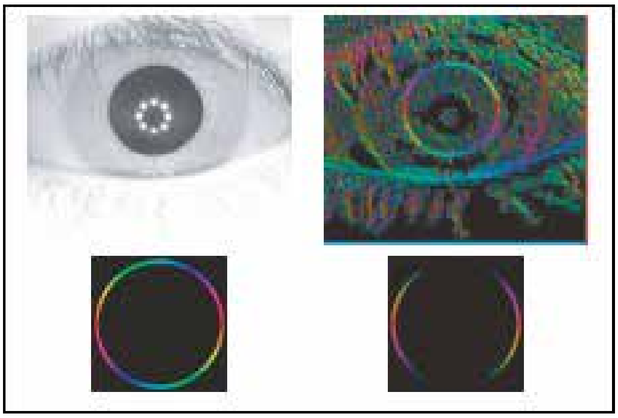

Figure 1: Iris segmentation depicting orientation map representing directions with hue, the models of pupil and scelera in orientation space. mouth-opening (area)

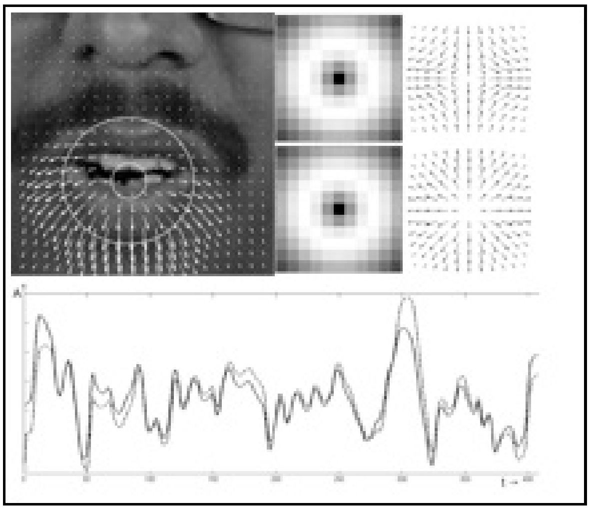

Figure 2: Lip-movements estimation, and the estimated mouth-opening (area)

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.

Results

We also show that top verification rates can be obtained without rotation compensation, thus allowing to remove this step for computationalefficiency. Also, the performance is not detected 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.

Reported results shows the effectiveness of the proposed algorithm, with similar performance than the others in pupil detection, and clearly better performance for sclera detection for all levels of degradation.

We have developed a novel method for mouth opening and closing events. We have shown that it is translation and rotation invariant, works at very fast speeds, and does not require segmented lips. A semi-automatic tool for generating groundtruth segmentation of video data, based on the optical flow algorithm used for tracking keypoints at faster than 200 frames/second has been developed. This resulted in groundtruth for 50 sessions of vi- sual speech of the XM2VTS database consisting of hours of lip-movements.

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 orientation- based 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.

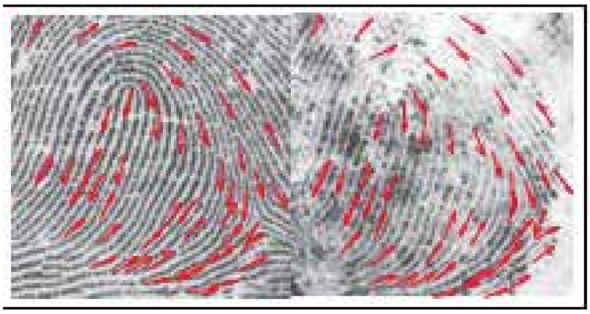

Figure 3: Forensic fingerprints minutia correspondence example, NIST-sd27

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): BIO- METRICS 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: BB-for2Bayesian Biometrics For Forensics.

References

[1] Fernando Alonso-Fernandez, Julian Fierrez, Daniel Ramos, and Joaquin Gonzalez-Rodriguez. Quality-based 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. 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 detection 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, 2:2: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 S*wedish 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 performance 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,* IEEE Computer Society Conference on Computer Vision and Pattern Recognition workshops, pages 83–88, 2012.

ReDi2Service (Remote Diagnostics Tools and Services)
Service development

M. Åkesson, A. Akram, S. Chowdhury
Man and Information Technology laboratory, Halmstad University, Sweden

1. Background and Motivation

The design of maintenance prediction and diagnostics services for a sustainable system is challenging and lead to manufacturing-service dilemma. The project, therefore, also include two PhD studies regarding related service design and value networks.

Alacritous innovations in digital technology are rapidly transforming the landscape for contemporary business and the ways to represent these through related value networks. The concept of digital products' use has aggrandized the scope of maintenance of the vehicles with the help of remote diagnostics. Given the new paradigm, the vehicle industry is stretching its scope from manufacturing to services industry. However, this shift augments number of challenges and opportunities. Moreover, it has been exacting to identify business models and form value networks that enable profitable business in terms of sustainability.

The traditional manufacturing industry is based on value chain which is underpinned by particular value creating logic. Adopting a value network perspective provides an additional insight that is more suitable to new economy, especially those involved in digital products. This brings attention to their contextual use while bringing the customers' perspective into focus. This customer perspective has not been addressed in traditional manufactured product business. As digital services have open innovation nature, it is essential to know the value of the offered services on the basis of customers' needs as well as the offerings of these services in a systematic way.

As an endeavor to move from traditional preventive maintenance towards predictive maintenance based on advanced digital technology, remote diagnostics services fall into the category of those digitally innovative services where services are acquired through digitalization of existing products or services. Remote diagnostics services will also digitalize the existing mode of maintenance services of vehicles. Digitalized services are combination of physical products (digital artifacts) and services rendered from the physical products. So, to design the remote diagnostics services we have to understand the logic of these services because the logic of digitalized services will be different from the conventional manufacturing products or conventional services such as hotel service. So, one of the objectives of this research is to understand the logic of digitalized services which are the results of digital innovation in the context of remote diagnostic services in the vehicle industry.

The logic of digitalized services is influenced by the concept of digital innovation characteristics such as re-programmability, homogeneity of data and self- referential nature of digital technology. Based on the discussion on service logic and goods logic from the service management field, it can be said that understanding the logic of digitalized services (in this case, remote diagnostics services) include various aspects such as determination and meaning of value, role of customers, role of physical products (digital artifact) etc. One of the aims is to involve customers as the co-creators of services and that will help us to understand the customer requirement and further developing a framework for co-creation of digital services. To understand the service quality aspect, we are to going to investigate the value determination aspect as that will ensure that the services create value for the customers. Vehicular remote diagnostics services are basically linked with two physical products: the device and the vehicle. To deliver the services, both the vehicle and embedded device will play significant role. Understanding that role is also crucial for designing essential services. Overall, designing services will encompass various aspects and all we focus is to create value for the customers as well as the service providers.

This digital service innovation in particular is of great importance since the vehicle industry has great potential to expand its business and found new and extended boundaries and relationships with other stakeholder in the networks they are attached to. Core challenges and opportunities for digital service innovation will lead us to the study of its influence on the business and innovation environment i.e. the value network.

2. Methodology

The project involves exploring the opportunities and challenges associated with these digital technologies as well as analyzing value networks. It is conducted in a collaborative manner between research community and practitioner from the industry as such that it can be characterized as action-oriented research methodology. Accordingly, many activities are performed in a cyclic way to ensure to validity and reliability of data. These activities include conducting semi-structured interviews, analyzing value networks, conducting workshops, and attending meeting. Different kinds of empirical material that was collected during these activities include audio interviews, value network maps, observations, project documents, e-mail correspondences, and field and meeting notes.

All the activities and collected empirical material are aimed at the following:

- Exploring the opportunities and challenges associated with the digital service innovation;
- Conducting 'Future Workshops' to build scenarios by keeping in mind next 5 years services (the purpose of scenarios is to visualize the possible service with these digital technologies)
- Participating in 'Service Design/Conceptualization Workshops' (to co-create service out of the future workshops)

On the basis of the data collected, we aim at providing illustrations on how existing value network in the vehicle industry is influenced by the service innovation based on remote diagnostics system.

3. Results

The ReDi2Service project is an on-going project and several opportunities and challenges are identified along the way. The empirical material collected during different activities mentioned above serve the basis of 'Future Workshop' to build scenarios. Some of these scenarios will be further co-designed with customers and technology provider to exemplify the possible services.

PUBLICATIONS

[1] A. Akram and M. Åkesson, " Value network transformation by digital service innovation in vehicle industry", 15th Pacific Asia Conference on Information Systems, Brisbane, Australia, July 7-11, (2011)

[2] S. Chowdhury and M. Åkesson "A proposed framework for identifying the logic of digital services", 15th Pacific Asia Conference on Information Systems, Brisbane, Australia, July 7-11, (2011)

[3] S. Chowdhury and A. Akram, "E-maintenance: Challenges and Opportunities", 34th Information Systems Research Seminar in Scandinavia, Turku, Finland, Aug. 16-19 (2011)

[4] A. Akram and M. Åkesson, "A research agenda to study how digital service innovation transform value network", 34th Information Systems Research Seminar in Scandinavia, Turku, Finland, Aug. 16-19 (2011)

[5] S. Chowdhury and A. Akram, "E-maintenance as a prospective customer value generating IT-enabled Resource: An exploration of challenges and opportunities" submitted for European Conference on Information Systems 2012

ReDi2Service (Remote Diagnostics Tools and Services)
Technical research

S. Byttner[1], N. Karlsson[2], S. Nowaczyk[1,2], R. Prytz[2] and T. Rögnvaldsson[1]

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 is aimed towards developing distributed embedded agents for fault detection, fault isolation, diagnostics and wear prediction. This abstract describes the technical part of the research conducted in this project.

1. Background and Motivation

The last decades have seen a very strong development in vehicle electronics. A modern car, truck or bus has a large number of embedded processors and computers on-board. The vehicles have field buses (e.g. CAN) where system signals (sensors, control commands, fault codes, etc.) are communicated all the time. Software agents embedded into the hardware on the vehicles can listen to these signals and learn the typical patterns of these signals and detect deviations from the normal, provided that the vehicles have a possibility to represent and communicate their signal patterns with each other or with back-office applications that can summarize the fleet behavior. The back-office application can be connected to maintenance databases and thus learn how different deviation patterns are associated with specific faults.

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 then implemented on-board. Building such models is expensive in terms of man hours and experiments and compromises have to be made since it is not economically possible to model all usage profiles and all climate conditions. Also, the traditional approaches require that faults are thought of beforehand and that accurate models of the systems can be built – models that are accurate also under faulty conditions. Utilizing telematic technologies it is possible to envision a solution where a large number of vehicles are monitored in real-time, with embedded software agents on the vehicles, and thus can fleets of vehicles be used as a "real time laboratory" where the operation of the equipment is monitored under real usage conditions and "normal" behavior is determined from groups of similar vehicles. The idea is to have a self-discovering system; a system that learns how equipment wears and breaks, by observing the equipment over a long time.

2. Methodology

The project has both a hardware and software aspect. The hardware aspect is the development of a hardware (VACT) that listens to the data streams on the vehicles (city buses and/or heavy load trucks) and the telematics gateway for transmitting the information to a back-office application. The software aspect is both the software running on the "clients" (i.e. in each VACT module), the embedded agents and the software in the back-office application.

The technical algorithmic methodology is a mixture of machine learning and statistical methods. The fault detection problem can be split into three separate (or semi-separate) parts:

- finding the interesting signals and relationships to monitor (not requiring an overview of all vehicles);
- comparing these relationships (with an overview of all vehicles);
- nd then to determine which systems that don't behave normally.

These issues were explored in a previous project, Remote Diagnostics and Monitoring (RDM), that lead to the ReDi2Service project. The diagnostics and wear monitoring problem can be approached with both an active and a passive approach:

- passive – observe parameter relationships over time (on the fleet, on test vehicles, in simulations) and build up a knowledge base that is then used for, e.g., case based reasoning, pattern recognition, etc.;
- active – download software onto the vehicle for specific fault finding, or start a simulation off-board (at the back-office) and try to replicate the observed deviation. The latter requires high quality simulation models and it is questionable if these exist today.

There are several research questions in this, e.g. how to autonomously determine "interesting" relationships to monitor without knowing what a fault looks like, how to determine which systems that deviate, analyzing if this could replace traditional (expert driven) monitoring approaches, how to do the diagnostics with a distributed intelligence approach (i.e. how a fleet of vehicles can be used to build diagnostic models and aid in the search for a fault).

3. Results

A new hardware system (VACT) for listening to signals onboard vehicles has been designed and built, intended to be used for an approximately 2-year longitudinal study on city buses (end of 2011 until end 2013). The system is currently installed and logging data from 19 buses at a bus operator in Kungsbacka. Service records are collected continuously for these vehicles for matching with observed deviations in onboard data. Observed deviations on some components have so far been noted manually, and there is current ongoing work with validating the deviations (i.e. determining the true cause). A fault injection experiment is planned to be conducted on a separate bus during the Spring of 2013 to further help verify the behavior of certain components when they are exposed to wear or damage.

PARTNERS AND SPONSORS

The project is done in cooperation with Volvo Technology, and the project manager is Niclas Karlsson. The project external sponsors are Volvo GIB-T and VINNOVA.

PUBLICATIONS

[1] G. Vachkov, S. Byttner, M. Svensson. Battery aging detection based on sequential clustering and similarity analysis. Submitted to the 6th IEEE International conference on Intelligent systems. September 2012, Sofia, Bulgaria.

[2] S. Nowaczyk, R. Prytz, S. Byttner. Ideas for fault detection using relation discovery. Submitted to SAIS 2012. May 2012, Örebro, Sweden.

[3] N. Karginova, S. Byttner, M. Svensson. Data-driven methods for classification of driving styles in buses. SAE World Congress 2012, Technical paper 2012-01-0744. April 2012, Detroit, USA.

[4] M. Svensson, T. Rögnvaldsson, S. Byttner, M. West, B. Andersson. Unsupervised deviation detection by GMM - A simulation study. 8th IEEE International Symposium on Diagnostics for Electrical Machines, Power Electronics and Drives, September 2011, Bologna, Italy.

[5] R. Prytz, S. Nowaczyk, S. Byttner. Towards relation discovery for diagnostics. Proceedings of the First International Workshop on Data Mining for Service and Maintenance, pp. 23 - 27. August 2011, San Diego, USA.

[6] S. Byttner, G. Vachkov, M. Svensson. Incremental classification of process data for anomaly detection based on similarity analysis. IEEE Symposium on Computational Intelligence. April 2011, France.

[7] A. Mosallam, S. Byttner, M. Svensson, T. Rögnvaldsson. Nonlinear relation mining for maintenance prediction. IEEE Aerospace conference. March 2011, Big Sky, Montana, USA.

[8] S. Byttner, T. Rögnvaldsson and M. Svensson. Consensus Self-organized MOdels for Fault Detection (COSMO), Engineering Applications of Artificial Intelligence (2011), doi:10.1016/j.engappai.2011.03.002.

[9] S. Byttner, M. Svensson and T. Rögnvaldsson. Finding the Odd-One-Out in Fleets of Mechatronic Systems using Embedded Intelligent Agents. ISBN 978-1-57735-458-1. AAAI Spring symposium 2010, Stanford, USA.

Fuel FOT Energy Efficient Transport

Marcus Elmer[1], Iulian Carpatorea[2] and Sławomir Nowaczyk[1,2]
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Analysis of 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

Volvo Group Advanced Technology & Research have collected large amounts of real-world data during the projects euroFOT and Customer Fuel Follow-up. The goal of fuelFEET 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.

Such a framework will allow ranking and clustering drivers from a fuel consumption performance perspective, as well as provide 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.

Volvo Predictive Maintenance Solution

field study

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3. CAISR, Halmstad University, Sweden

Volvo, and in particular Volvo Technology, has been developing methods for predictive maintenance and for detecting abnormal system behaviour for several years. This project is a field study aiming to evaluate available algorithms in the context of long-haul trucks.

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. It is also becoming feasible to embed software agents into on-board hardware, with the goal of listening to this data and learning to distinguish between normal and faulty operation, as well as to estimate component wear and evaluate quality of control parameterisation.

The typical approach to system monitoring of various equipment, including vehicles, is typically based on the reference model built off-line, by domain experts, from design and test data. Access to real-world data through telematic technology allows us to supplement this model with knowledge of history and behaviour of other vehicles operating under similar conditions. Data gathered on-board one truck can be compared against other vehicles in the same fleet, and deviations can be detected as soon as a particular system starts to operate differently from its own expected behaviour, not necessarily from the globally acceptable profile.

2. Methodology

The project started with design and implementation of data logging equipment. One requirement on the system was to have it completely automatic once deployed, with all the data from trucks being transferred over wireless network. Since it is not possible, at this stage, to continuously transmit all the important signals, a decision was made to only log data at “interesting” moments, based on certain trigger conditions.

Such triggers include starting the engine, running at high torque and low speed, and similar situations. The idea behind those is that both faults and wear are most clearly visible when the system is under stress. The appropriate definition of those trigger conditions is not an easy task, since they need to be designed in such a way that enough data from various conditions is captured to provide necessary description of vehicle behaviour, but at the same time they need to limit the total amount of data so that it stays manageable.

The data collected in the project will be analysed using artificial intelligence and data mining methods, based on the ideas explored in previous projects. The plan is to start by obtaining "normal" value characteristics of each signal, as well as finding interesting relationships between signals. Those aggregated attributes can then be compared across vehicles and across different times in order to determine the meaning and causes of detected deviations.

An assumption in the project is that six months of data collection may not be enough to see concrete results in increased uptime but it should give us an understanding of the similarities and differences between trucks, as well as self-organised model of how various signals relate to each other. Such vehicle characterisation is going to be an important step in moving towards the successful use of such methods in a product.

3. Results

The data logging equipment is now installed and working on 10 long-haul Volvo trucks in the USA, and we have several weeks of data available. Initial analysis of this data has been performed, but there are still discussions regarding which components we should focus the data mining efforts on, and what are the exact form of results that we should be aiming for.

It is also still unclear how big of an issue the "snapshot" nature of the data will turn out to be, since preliminary results show that the frequency of different triggers is quite uneven between different vehicles, which makes the data more difficult to compare. The techniques to handle this issue are currently under investigation.

Next Generation Test Methods for Active Safety Functions (NG-TEST)

Jawad Masood[1] Roland Philippsen [2] Walid Taha [3] and Tony Larsson [4]

***Abstract*— Recently, active safety systems have started to appear in production automobiles, and they will be a significant factor in eliminating road accidents with serious or fatal outcome. As opposed to passive safety systems such as seat belts and ABS, which protect mainly the occupants of vehicles, vulnerable road users can only be protected by active safety systems such as collision mitigation by automatic emergency braking. Currently, one of the major bottlenecks for widespread deployment of active safety systems is the challenge of validating and verifying them. Even though there are some isolated testing tools and methodologies, there is no common framework and the individual tools are of rather limited applicability. NG-TEST is designed to address the issue of validation and verification by effectively and efficiently defining the tool chain for ADAS testing.**

I. BACKGROUND

Passive safety systems have significantly increased road safety during past decades. There verification is to large extent done virtually with the help of simulations. Active safety systems play an important role for mitigating or avoiding accidents. Today they are going from research and limited implementation towards broad implementation where they need to address increasingly complex situations. It require extensive testing during design, validation and verification stages.

Although no general methodology for testing active safety systems has been established, there is a Code of Practice for the design and evaluation of Advanced Driver Assistance Systems [1], [2]. It recommends assessments using simulations, driving simulators, professional drivers on test tracks, and field-operational tests (e.g. car clinics with naive subjects). These methods are to be used during different development phases, and they complement each other.

- **Simulations:** in-house or third-party models of sensors, vehicles, drivers, road infrastructure, surroundings, and environment conditions (leveraging e.g. Matlab®/Simulink®/Stateflow®[3]) are frequently used during initial development. Examples of such design tools for active safety systems are [4], [5], [6].
- **Driving simulators:** track tests expensive and time consuming, which explain a growing interest in (entirely or partly) simulated environments. Specific traffic scenarios are created by augmenting reality or a recording [7], [1]. The EU project imviter [8] investigates virtual replacement for real test required in current and future automotive safety regulations.
- **Test tracks:** numerous projects and initiatives deal and dealt with test track procedures for active safety. The importance of driver models and the utility of self-propelled targets can be considered well established. Tests where both the host and target vehicles are autonomously driven are useful in scenarios too dangerous for test drivers, or when drivers cannot attain sufficient reproducibility [9]. Instrumenting the test grounds (positioning systems, mobile dummy devices, etc) is a major aspect of active safety system testing [10].
- **Field-operational tests:** large-scale tests under normal operating conditions [11] have proven useful for evaluating and demonstrating active safety functions.

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II. OBJECTIVE

Improving efficiency and robustness in the testing by extending the share of simulations. Establish an integrated tool chain to streamline active safety systems validation and verification throughout the process from conceptual design to operational tests. This framework shall become the benchmark for maintaining the safety-related forerunner position of the Swedish automotive industry.

III. PROJECT STRUCTURE

The NG-Test project is started on January 1, 2012, and will run for three years with a total budget of SEK 54'500'000 that is co-funded by Sweden's Innovation Agency (VINNOVA) under the Strategic Vehicle Research partnership (FFI) and the project consortium. The project is partitioned into nine work packages, realized by a number of different tasks and deliverables as shown in fig.1. The main activities during work packages are:

WP1,WP2,WP3 are important in order to run the project and to make sure that the results are nursed, but are not the core of the project.

WP3 defines the project details from the findings in WP2.

WP4 is developing the parts that are common for the different verification and validation environment. It enables the coupling between the different methods for verification and validation.

WP5 develops the simulation environment platform for desktop simulations and simulators.

WP6 develops a platform and equipment for fully automated scenarios on the test track.

WP7 creates a mobile test platform in which reality is extended to include virtual objects or environment with an interface to any active safety function to address real driver response in real vehicles. This method will make validation possible in the earlier phases of development process.

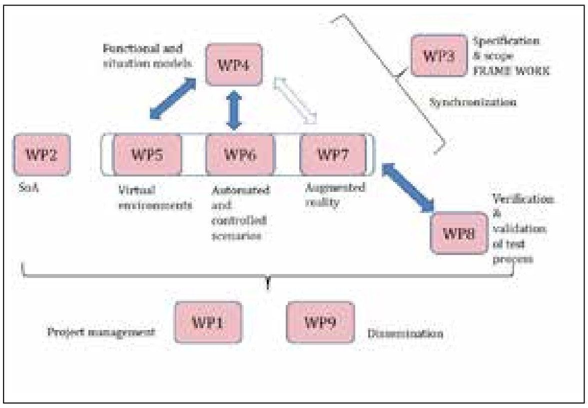

Fig. 1. NG Test Project Structure

IV. Project Partners

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

V. Halmstad University Role

Halmstad University main contributions in WP4 and WP5 will be 830 and 150 man hours respectively. While contributions in WP6, WP1, WP2, WP3 and WP9 will be 300, 80, 80, and 120 man hours respectively.

VI. Approach

Methodology for high-fidelity virtual testing:

- Need to stay broad and cover all major aspects as shown in fig.2. We divide ADAS Virtual Testing into four major areas namely computation, embodiment, physics and virtual testing. Each area consists of system component/object. The lines represent the information flow between two system components. The generic ADAS architecture shown in fig.2 can represents the information flow for three modes (normal, warning and assist).
- Generate series of increasingly complex models as shown in fig.3. To effectively define tool chain for testing ADAS system, it is necessary to identify different complexity axis during testing process. We identify two major complexity axes in methodology and modeling. The level of complexity in methodology increases as we moves from function to modeling e.g. Collision Imminent Braking (ADAS Function) can have more than one critical scenario cases (Testing vehicle approaching a stationary object or Testing vehicle approaching a moving object etc.) to be tested. The modeling axes of complexity increases as we moves from basic set of models to advance set of models e.g. Under one scenario case we can model the system component (vehicle mechanics) based on one dimension model (basic) to three dimensional model (Advance).
- The immediate next step is to start filling empty boxes in fig.3 with models and parameters. We have decided to exploit ADAS lateral function. ACUMEN® (Language for modeling Cyber-Physical Systems) will be used as initial tool.

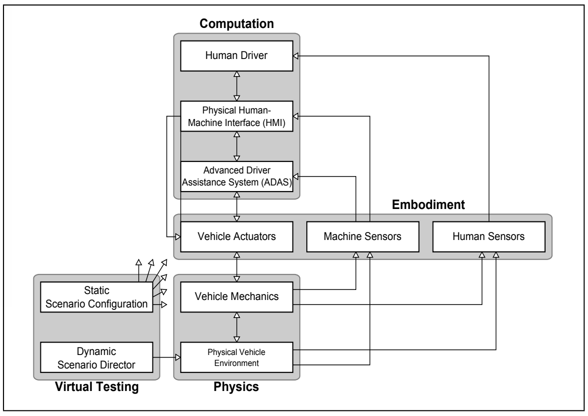

Fig. 2. Generic ADAS Architecture

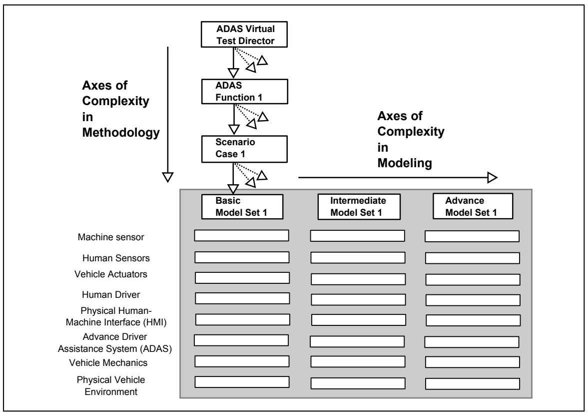

Fig. 3. Axes of Complexity in Virtual Testing

References

[1] Y. Laschinsky, K. von Neumann-Cosel, M. Gonter, C. Wegwerth, R. Dubitzky, and A. Knoll. Evaluation of an active safety light using virtual test drive within vehicle in the loop. In *Industrial Technology (ICIT), 2010 IEEE International Conference on*, pages 1119 –1112, march 2010.

[2] O. Gietelink, J. Ploeg, B. De Schutter, and M. Verhaegen. Development of advanced driver assistance systems with vehicle hardware-in-the-loop simulations. *Vehicle System Dynamics*, 44(7):569–590, 2006.

[3] Mathworks, http://www.mathworks.se/, 2011.

[4] Modelon, http://www.modelon.com, 2011.

[5] Dymola, http://www.3ds.com/products/catia/portfolio/dymola, 2011.

[6] Prescan, http://www.tass-safe.com/en/products/prescan, 2011.

[7] J. Nilsson, A.C.E. Odblom, J. Fredriksson, A. Zafar, and F. Ahmed. Performance evaluation method for mobile computer vision systems using augmented reality. In *Virtual Reality Conference (VR), 2010 IEEE*, pages 19 –22, march 2010.

[8] The imviter project, http://www.imviter.com, 2011.

[9] Hans-P. Schöner, S. Neads, and N. Schretter. Testing and verification of active safety systems with coordinated automated driving. In *Proceedings of the 21st International Technical Conference on the Enhanced Safety of Vehicles ESV*, 2009.

[10] Test center autoliv, http://www.testcenter.autoliv.com, 2011.

[11] FESTA Consortium et al. Festa handbook. *FESTA Support Action. Field opErational teSt supporT Action. D*, 6, 2008.

Innomerge

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

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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 prototype trucks (developed specifically for the Indian market) was started in 2012, and analysis of data and adaptation of diagnostic algorithms is expected to start in 2013.

Partners in the project

Volvo Group Advanced Technology & Research, Volvo Trucks, Volvo Construction Equipment, Chalmers University of Technology, Halmstad University, Andreassons Åkeri AB, S Blomquist Entreprenad AB.

Automatic Inventory and Mapping of Stock (AIMS)

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Introduction

Call for automation increases everyday, by the growth of societies and their excessive demands for productions and services. Along with this increase of request, *automated* and *robotic* systems not only make them possible, but also reduce the service and production costs. With such a necessity, automation is an essence of every huge frameworks these days, such as industries, huge malls, warehouses, etc.

Motivation

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 systems 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.

Objective

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

- Mapping and Localization: required for vehicle navigation and storing the location of articles in environment. Mapping here may refer to both *metric* and *topological*, in 2D and in 3D.
- Recognition and Clustering: in order to classify articles in the warehouse, as well as identifying environmental features for localization and topological mapping purpose.
- 3D Perception: concerns evaluation of the articles' quantity, as well as beneficial to obstacle avoidance.
- Dynamic Map Maintenance: semantic map is composed of several dimension, including elements which are varying with respect to time. These elements mainly belong to inventory list or obstacles and must be updated frequently.
- Multi Agent Coordinating: beneficial to equip all available vehicles with sensors and collect data more frequently. This will guarantee covering a big environment effectively and faster.

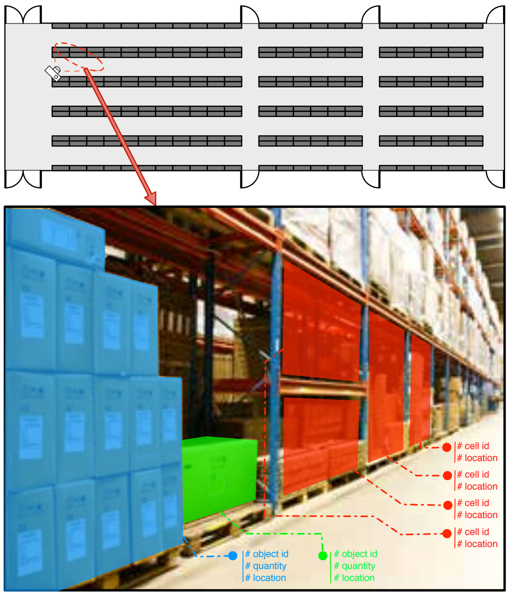


Fig. 1: Demonstration of semantic map's information, accorded with metric map

Results

So far in this project an AVG is set up, a data acquisition platform has been developed and toolchain for 2D metric mapping is proposed. Result of the toolchain will be a 2D planar metric map exploited as the foundation of the semantic map, layout map and localization map. Proposed toolchain is demonstrated in Fig. 2.

The toolchain is made up of 5 consecutive steps:

1) *Logging Data:* a *SICK PLS* LiDAR configured in ROS, is utilized to acquire data.
2) *Scan Matching:* through which an odometry-like information will be forged. Forging odometry is performed to make *"logging data" platform* independent from the vehicle.

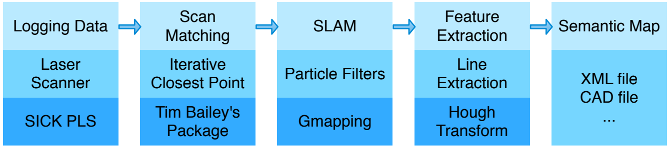
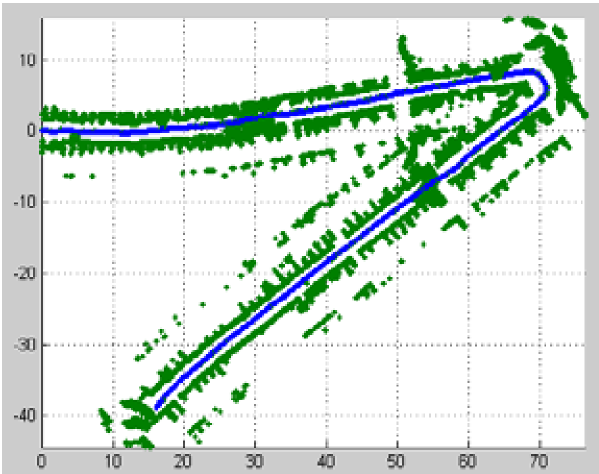
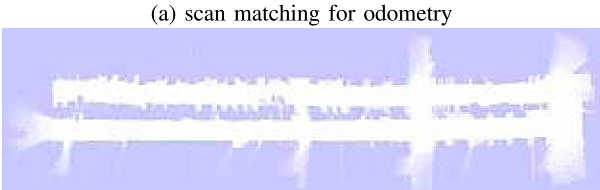


Fig. 2: Work flow, illustrating the toolchain of planar mapping.

3) *SLAM:* online localization was not the purpose but only mapping was, hence the vehicle was not autonomous guided. A method called *Gmapping* based on *Rao-Blackwellized* particle filter has been employed for mapping from range data. Fig. 3 represents results of this method applied to a real warehouse.



(a) scan matching for odometry



(b) mapping

Fig. 3: Scan matching and mapping in a real warehouse

4) *Feature Extraction:* features are useful to perceive semantic elements and construct a semantic map. At this level and having only a metric map in hand, lines are main features that could be detected, as they are capable of characterizing most infrastructure objects (i.e. walls, boxes). A *canny* edge detection followed by a *Hough* transform has been applied to metric map.
5) *Semantic Map:* will contain all dimension of information, from metric map to highest level of semantic elements.

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*.

AccelGait – USING INERTIAL SENSORS TO EVALUATE QUALITY OF GAIT

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Gait analysis (GA) is an important tool in the assessment of several physical and cognitive conditions. The lack of simple and economically viable quantitative GA systems has hindered the routine clinical use of GA in many areas. As a result, patients may be receiving sub-optimal treatment. This project concerns the development of new mobile, cheap and easy to use quantitative GA systems using inertial sensors, which may facilitate the wide-spread adoption of GA as routine clinical practice.

1. Gait Analysis

It is of general consensus that gait analysis can provide information that is essential to the assessment of orthopedic patients. It is an effective way to evaluate and quantify how surgical intervention or other treatments affect a patient's gait [1]. In addition, there is evidence that gait analysis can aid the assessment of cognitive conditions. Certain gait characteristics, for example, can be used in the diagnosis of dementia and may have important implications for discriminating among dementia subtypes [2]. Changes in gait are also associated with aging, and are important when judging the ability of an older person to live independently [3].

A general measure of quality of gait can be obtained from: report questionnaires such as the Gillette Functional Assessment Walking Scale [4]; observational video analysis schemes like the Edinburgh Gait Score [5]; or rating systems such as the Functional Mobility Scale [6]. Although these assessments are useful and practical, they lack precision and objectivity [7].

On the other hand, very precise and objective measurements may be obtained in specialized gait labs, equipped with 3D motion capture (mocap) systems, force plates and other sensors. In-lab assessments are considered state of the art and have been shown essential to the assessment of cerebral palsy [8] and other surgical patients [9]. Nonetheless, these measurements are expensive, difficult to interpret, require special training and are not available to all patients [10]. As a result, many research findings relating gait analysis to medical conditions are not used in routine clinical practice, depriving many patients of potential benefits.

2. Inertial Sensors

As an alternative to gait labs, body-worn inertial sensors, such as accelerometers and gyroscopes, can be used for gait analysis. Inertial sensors have the advantage of being small and cheap. They can be embedded into clothing items or simply placed on the body embedded in a watch-strap or a belt. Another advantage of using inertial sensors is that they are mobile and can gather monitor the patient while performing normal daily activities, for example, at home or outdoors.

Inertial sensors have successfully been used to monitor falls and daily activities [11]; detect the phases of gait and other gait parameters [12] ; describe gait kinematics [13]; among other applications. However, the creation of a comprehensive quality of gait index, using inertial sensors, had not been addressed until now.

3. The Symbolic Approach

We proposed a new approach to the processing and analysis of inertial sensor data, which can improve the use of such sensors for gait analysis. This approach is based on the symbolization of the sensor data into building blocks, which when combined in different ways, represent different gait patterns. Similar approaches have been investigated for activity recognition applications using other sensors such as video [14] and mocap [15]. In this project, the symbolization approach was used in the analysis of inertial sensor data.

4. Activities Undertaken

The goal of this project was to devise a mobile, cheap and easy to use gait analysis system using inertial sensors that provides an objective quality of gait index which reflects the ambulatory condition of the patient. The system should help the assessment of patients at the clinic and also in uncontrolled environments such as the patient's home.

The project was divided into two main phases: development and testing.

- **Development**: This part of the project involved the acquisition of data in a gait lab, equipped with 3D mocap system and two force plates. The data was collected at the Lundberg Clinical Gait at the Sahlgrenska University Hospital in Gothenburg, Sweden. Eighteen healthy subjects were measured while walking with the mocap system and with our inertial sensor system simultaneously. The inertial sensor data was used to calculate a gait symmetry index and a gait normality index. The mocap data was considered ground reference and used to guide the development of the symmetry and normality indices.

- **Testing**: A separate data collection took place at the orthopedic ward of the Sahlgrenska University Hospital in Mölndal, Sweden. Eleven hip-replacement subjects were measured with the inertial sensor system while walking along a 10-meter walkway. The time to complete the walkway and the number of steps taken were recorded. This procedure was repeated on the day of discharge from the hospital, and 3 months later. The patients also filled out a (EQ-5D) questionnaire about mobility, self-care, daily activities, pain/discomfort, and anxiety/depression. The inertial sensor data was used to calculate symmetry and normality indices for the patients at discharge and 3-months later. Results were compared to the questionnaire answers, average speed, average step length, and length of stay at the hospital. The goal of this part of the study was to determine if the proposed symmetry and normality indices reflected the level of recovery of the patients. Results indicated that the normality index, in particular, can potentially help assess the wellbeing and level of recovery of patients.

5. Results

Based on the symbolized signals, new measures of gait symmetry and gait normality were created. The proposed symmetry index was superior to many others in detecting movement asymmetry in early-to-mid-stage Parkinson's disease patients. Furthermore, the normality index showed great potential in the assessment of patient recovery after hip-replacement surgery.

Several publications resulted from this project, one of which was awarded the Best Student Paper prize at the International Joint Conference on Biomedical Engineering Systems and Technologies [VII].

6. Conclusion

This project successfully devised a simple-to-use inertial sensor system, which can provide valuable information about gait symmetry and gait normality. This system can be used to provide quantitative information about quality of gait, and help assess the condition and recovery of patients. The system was validated against a state-of-the-art gait analysis system, and also evaluated in a real clinical environment.

Further investigations are needed in order to turn this into a commercial system. However, this project has demonstrated that such a system is feasible and can provide value to clinical institutions.

7. Bibliography

[1] R. B. Davis, S. Ounpuu, D. Tyburski, and J. R. Gage, *A gait analysis data collection and reduction technique*, Human Movement Science, vol. 10, pp. 575-587, 1991.

[2] D. Morgan, M. Funk, M. Crossly, J. Basran, A. Kirk, and V. Dal Bello-Haas, *The potential of gait analysis to contribute to differential diagnosis of early stage dementia: Current research and future directions*, Canadian Journal on Aging, vol. 26, no. 1, pp. 19-32, 2007.

[3] W. Zijlstra and K. Aminian, *Mobility assessment in older people: new possibilities and challenges*, European Journal of Ageing, vol. 4, pp. 3-12, 2007.

[4] T. F. Novacheck, J. L. Stout, and R. Tervo, *Reliability and validity of the Gillette functional assessment questionnaire as an outcome measure in children with walking disabilities*, Journal of pediatric orthopedics, vol 20, pp. 75-81, 2000.

[5] S. J. Hillman, M. E. Hazlewood, M. H. Schwartz, M. L. van der Linden, and J. E. Robb, *Correlation of the Edinburgh gait score with the Gillette gait index, the Gillette functional assessment questionnaire, and dimensionless speed*, Journal of Pediatric Orthopaedics, vol. 27, no. 1, pp. 7-11, 2007.

[6] H. K. Graham, A. Harvey, J. Rodda, G. R. Nattrass, and M. Pirpiris, *The functional mobility scale (FMS)*, Journal of pediatric orthopedics, vol. 24, pp. 514-520, 2004.

[7] M. H. Schwartz and A. Rozumalski, *The gait deviation index: A new comprehensive index of gait pathology*, Gait & Posture, vol. 28, no. 3, pp. 351-357, 2008.

[8] F. M. Chang, J. T. Rhodes, K. M. Flynn, and J. J. Carollo, *The role of gait analysis in treating gait abnormalities in cerebral palsy*, Orthopedic Clinics of North America, vol. 41, no. 4, pp. 489-506, 2010.

[9] R. M. Kay, S. Dennis, S. Rethlefsen, D. L. Skaggs, and V. T. Tolo, *Impact of postoperative gait analysis on orthopaedic care*, Clinical Orthopaedics and Related Research, vol. 374, pp. 259-264, 2000.

[10] S. R. Simon, *Quantification of human motion: gait analysis - benefits and limitations to its application to clinical problems*, Journal of Biomechanics, vol. 37, pp. 1869-1880, 2004.

[11] C. Bouten, K. Koekkoek, M. Verduin, R. Kodde, and J. Janssen, *A triaxial accelerometer and portable data processing unit for the assessment of daily physical activity*, IEEE Transactions on Biomedical Engineering, vol. 44, no. 3, pp. 136-147, 1997.

[12] R. Williamson and B. J. Andrews, *Gait event detection for FES using accelerometers and supervised machine learning*, IEEE Transactions on Rehabilitation Engineering, vol. 8, no. 3, pp. 312-319, 2000.

[13] H. Dejnabadi, B. M. Jolles, E. Casanova, P. Fua, and K. Aminian, *Estimation and visualization of sagittal kinematics of lower limbs orientation using body-worned sensors*, IEEE Transactions on Biomedical Engineering, vol. 53, pp. 1385-1393, 2006.

[14] P. Fihl, M. B. Holte, T. B. Moeslund, and L. Reng, *Action recognition using motion primitives and probabilistic edit distance*, in 4th international Conference on Articulated Motion and Deformable Objects, pp. 375-384, 2006.

[28] G. Guerra-Filho and Y. Aloimonos, *A language for human action*, Computer, vol. 40, no. 5, pp. 42-51, 2007.

PARTNERS AND STATUS

· Project funding: The Promobilia Foundation.

· Clinical experiments are performed with Sahlgrenska University Hospital in Gothenburg and Mölndal.

PUBLICATIONS

[I] A. Sant'Anna, W. O. de Morais, and N. Wickström, *Gait Unsteadiness Analysis from Motion Primitives*, 6th International Conference on Gerontechnology - Pisa, June 4-7 2008.

[II] A. Sant'Anna and N. Wickström, *Developing a Motion Language: Gait Analysis from Accelerometer Sensor Systems*, IEEE 3rd International Conference on Pervasive Computing Technologies for Healthcare 2009 - London, April 2009

[III] Sant'Anna, A. and N. Wickström, *A linguistic approach to the analysis of accelerometer data for gait analysis*, Proceedings of The Seventh IASTED International Conference on Biomedical Engineering, BioMed 2010, February 17 – 19, 2010.

[IV] Sant'Anna, A. and N. Wickström, *A Symbol-Based Approach to Gait Analysis From Acceleration Signals: Identification and Detection of Gait Events and a New Measure of Gait Symmetry*, Information Technology in Biomedicine, IEEE Transactions on , vol.14, no.5, pp.1180-1187, Sept. 2010.

[V] Sant'Anna, A., A. Salarian and N. Wickström, *A new Measure of Movement Symmetry in Early Parkinson's Disease Patients Using Symbolic Processing of Inertial Sensor Data*, IEEE Transactions on Biomedical Engineering, vol.58, no.7, pp.2127-35, 2011.

[VI] Sant'Anna, A., N. Wickström, R. Zügner, and R. Tranberg, *A wearable gait analysis system using inertial sensors Part I: evaluation of measures of gait symmetry and normality against 3D kinematic data*, Proceedings of the International Join Conference on Biomedical Engineering Systems and Technologies, 2012.

[VII] Sant'Anna, A., N. Wickström, H. Eklund, and R. Tranberg, *A wearable gait analysis system using inertial sensors Part II: evaluation in a clinical setting*, Proceedings of the International Join Conference on Biomedical Engineering Systems and Technologies, 2012. Best Paper Award.

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

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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 methods and tools for: answering queries, performing 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.

From the collaboration with the partners so far, there are several promising directions of research, which advocates investigating the fusion of several sources of information such as general prior knowledge about the elderly, self-reported surveys, nurse and relatives knowledge about the elderly, and the home environment floor plan.

4 Results

A technical report describing the analysis of attempts to complement the night care service with technology was made public available [4]. Various sensors (both wearable and sensors with a fixed position in the home) were used to collect data from 15 individuals during two–three weeks at night time. The collected patterns were analyzed to find characteristic patterns of behaviour for the individuals as well as similarity between individuals and deviations. The collected data were analysed in terms of scenarios, e.g. describing a visit to the bathroom, see Figure 1. Technical challenges related to data mining and incorporating algorithms into products were identified.

Figure 1: A wake-up scenario in a home environment equipped with several sensors. The coloured dots represent different events such as: waking up, stepping outside the bed, walking to the bathroom etc.

5 Partners and Status

Funding: The Knowledge Foundation.
Companies: Neat Electronics AB.
Other partners: Centre for Health Technology Halland.

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] R. Thörner, M. Persson, J. Lundström, A. Isaksson, and H. Eriksson, *Slutrapport - trygg om natten*, Tech. report, Centre for Health Care Technology Halland, 2012.

2

HMC²- Human motion classification 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 is 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 venues of health promoting treatments and pro-active approaches to better health.

Cycling is a very popular type of sports and physical activity that has a low impact on the cardiovascular system and is therefore suitable for many persons as an exercise. Our project, however, focuses on the people who practice cycling seriously.

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 level 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. From this is energy consumption estimated. The person wearing the sensors can get immediate (or almost immediate) feedback on the energy consumption plus a log of energy consumption during some time back.

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.

Previous studies, concerning static muscle work, have shown that muscle fatigue manifests itself in increased signal amplitude and decreased mean/median frequency. In the context of dynamic muscle work, diverse results were obtained concerning the mean or median frequency change. Instead of relying on mean/median frequency, EMG signals recorded from different muscles of both legs can be characterized by a set of various features. Various relations of these measures computed for different muscles and legs may help revealing muscle fatigue.

3. Results so far

Inertial sensors

A smaller scale data collection has been made and pre-studies performed to assess the applicability of different methods and viability of solutions for characterization of primarily running and walking. Example of what has been studied is estimation is energy expenditure, see Figure 1a, and estimation of step time variability, see Figure 1b. The usefulness of the estimated information is e.g. for sports applications, optimizations of cadence or similar, but can also be for health care application to estimate the gait variability over time for assessment of risk of falling. A larger data collection is under arrangement.

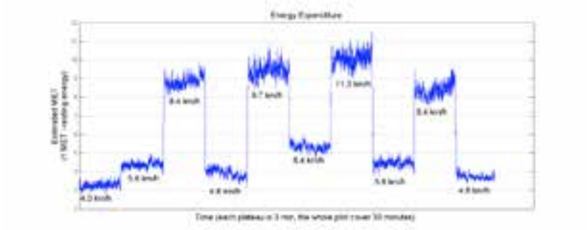

Figure 1a: Estimation of MET (metabolic energy transfer) from accelerometers.

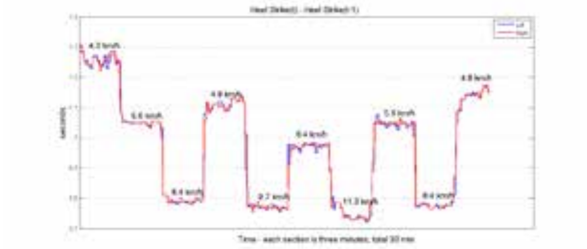

Figure 2b: Estimation of step time from accelerometers. The events (heel strike) is identified and the time between two consecutive events are shown (filtered).

EMG

Eight subjects participated in the data collection experiments conducted at Halmstad University and two subjects in the experiments conducted at the facilities in the Sports Academy of University of Gothenburg. At both occasions progressively increasing and constant loads were used and EMG signals were recorded from four muscles of both legs, eight channels in total. In the Sports Academy, in addition to EMG signals, readings from accelerometers attached to the legs, as well as measurements of heart rate, oxygen consumption, lactate concentration in blood, cadence, and subjective evaluations of fatigue were also taken.

A random forest-based fatigue prediction model was build using data of the first experiment. Feature extraction was based on analysis of 8s. long EMG segments. Fig. 2 illustrates performance of the model, while in Fig. 3 shown are variations of the asymmetry index given by a ratio of EMG energies computed for corresponding muscles.

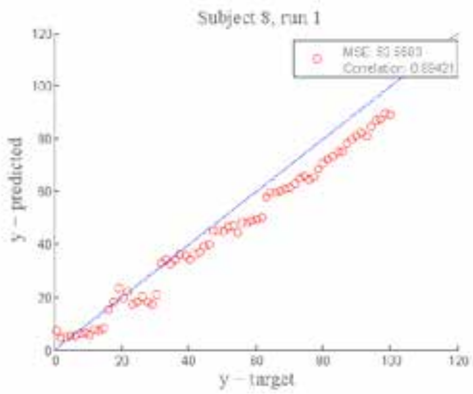

Figure 2. Performance of the fatigue prediction model.

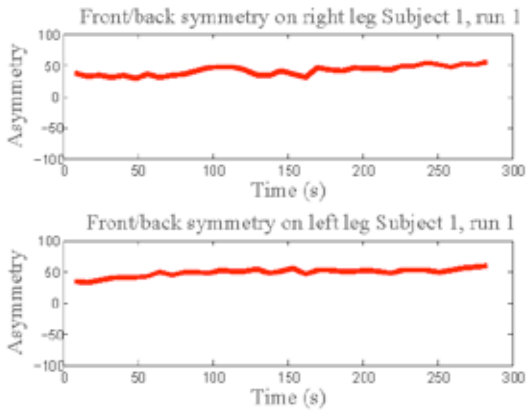

Figure 3. Asymmetry index computed for subject 1.

Analysis of data from the second experiment is based on an EMG pulse-by-pulse basis. Therefore, a reliable method to detect the initial points of every EMG pulse based on temporal changes in signal variance was established. This allows for better identification of transition points in an EMG signal, which may prove valuable when comparisons between different points in time are to be made.

It is expected that the project will result into a wearable device equipped with trainable algorithms for data processing at the sensor (embedded hardware) level and/or in a smart phone, and for the post-training analysis as well.

Studies based on the first experiment data resulted into a Master‘s thesis by Markus Schafflinger defended in June 2012 [1].

4. Partners and Status

Industrial Partners: TAPPA, Free2Move.

Project funding: CAISR profile funding from the Knowledge Foundation, TAPPA, Free2Move, and Halmstad University.

Duration of the project: January 2012 – December 2015.
Project leader is Nicholas Wickström.

Publications

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

Human status and activity during hemodialysis

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2. Redsense Medical AB, Halmstad

The project aims at using a new patented technology for detecting venous needle dislodgement to also be more aware of human activity and status during hemodialysis.

1. Background and Motivation

Redsense Medical is a spin off started in 2006 that focuses on detecting venous needle dislodgement during hemodialysis, especially for the home-dialysis market (people that do the dialysis at home). The company's patented key product is a sensor with optical fibers that is effective, clean, user friendly, and simple to handle. Figures 1 and 2 illustrate the product and application.

Figure 1: The Redsense Medical monitor.

Figure 2: How the monitor is placed.

Dialysis is a process that is done quite frequently, i.e. it becomes standard for the patient, and the patient lies down and rests, even sleeps, while it is done. It takes several hours each time and it is impossible to have staff overlook the process all the time. Venous needle dislodgement is a serious problem with possibly fatal consequences. It can occur when the patient turns over, in his/her sleep, or if the needle is caught without someone noticing [1]. On average, about two persons die per week in the US due to venous needle dislodgement (where this is the verified cause) [2].

The next generation of the Redsense Medical monitor should have a higher level of awareness. The dialysis is a lengthy process that takes several hours and patients do different things while it goes on. The optical signal in the sensor is, to different degrees, affected by many things, e.g. the degree of bending of the fibre, sweat (dampness) and temperature. These effects can be a problem, i.e. the sensor can give a false alarm, and a benefit, i.e. the sensor signal can be used to detect the status of the patient and not only bleeding. A patient that is restless, i.e. moving about a lot, could be detected and monitored extra. A patient that is worried/stressed, i.e. sweating, could also potentially be detected. This is important for both the clinical and the home dialysis setting.

The goal with the project is to collect data during dialysis, when the Redsense monitor is used, and match human activity and status with the sensor signal. This will give information both on effects that need to be handled with the sensor, and developments that can be done with the service the sensor provides.

2. Approach

A new sensor prototype and measuring equipment is developed by Redsense, with new fiber technology and better ability to log data. This prototype will be run in clinical tests where we collect different information: the optical signal, a film of the dialysis and other additional things (pulse, blood pressure, etc.). The data will be analyzed to associate changes in the sensor signal with patient activity and status. The long term goal is to have a "human activity" classifier that uses the sensor signal.

3. Results so far

Redsense Medical developed a new sensor prototype that was available after the first half year of 2012.

The project has unfortunately been cancelled because Redsense Medical AB could no longer participate in the CAISR consortium from January 1, 2013.

References

[1] Sandroni S. "Venous needle dislodgement during hemodialysis: An unresolved risk of catastrophic haemorrhage". *Hemodialysis International* 9:102, 2005.

[2] Sandroni S., et al. "Catastrofic hemorrage from venous needle dislodgement during hemodialysis", *J Am Soc Nephrol* 19:345, 2008.

Partners

Redsense Medical AB (represented by Daniel Engvall, CTO, and Patrik Byhmer, CEO). The project leader at Halmstad University was Thorsteinn Rögnvaldsson

CAISR Publication 2008-2012

Journals

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.

2010

Verikas A, Gelzinis A, Bacauskiene M, Hållander M, Uloza V, Kaseta M. Combining image, voice, and the patient's questionnaire data to categorize laryngeal disorders. Elsevier; Artificial Intelligence in Medicine. 2010;49(1):43-50.

Verikas A, Gelzinis A, Kovalenko M, Bacauskiene M. Selecting features from multiple feature sets for SVM committee-based screening of human larynx. Elsevier; Expert systems with applications. 2010;37(10):6957-6962.

Svensson W, Holmberg U. Estimating Ground Inclination Using Strain Sensors with Fourier Series Representation. New York: Hindawi Publishing Corporation; Journal of Robotics. 2010;2010:1-8.

Uloza V, Verikas A, Bacauskiene M, Gelzinis A, Pribuisiene R, Kaseta M, et al. Categorizing Normal and Pathological Voices : Automated and Perceptual Categorization. New York: Mosby-Elsevier; Journal of Voice. 2011;25(6):700-708.

Sant'Anna A, Wickström N. A Symbol-Based Approach to Gait Analysis From Acceleration Signals : Identification and Detection of Gait Events and a New Measure of Gait Symmetry. New York: IEEE; IEEE transactions on information technology in biomedicine. 2010;14(5):1180-1187.

Bordag L A, Mikaelyan A. Models of self-financing hedging strategies in illiquid markets : Symmetry reductions and exact solutions. Berlin: Springer Berlin/Heidelberg; Letters in Mathematical Physics. 2010;96(1-3):191-207.

Verikas A, Gelzinis A, Bacauskiene M, Uloza V. Towards noninvasive screening for malignant tumours in human larynx. Elsevier; Medical Engineering and Physics. 2010;32(1):83-89.

Verikas A, Kalsyte Z, Bacauskiene M, Gelzinis A. Hybrid and ensemble-based soft computing techniques in bankruptcy prediction : a survey. Springer; Soft Computing - A Fusion of Foundations, Methodologies and Applications. 2010;14(9):995-1010.

Karlsson S M, Pont S C, Koenderink J J, Zisserman A. Illuminance Flow Estimation by Regression. Amsterdam: Elsevier; International Journal of Computer Vision. 2010;90(3):304-312.

2009

Rögnvaldsson T, Etchells T A, You L, Garwicz D, Jarman I, Lisboa P J. How to find simple and accurate rules for viral protease cleavage specificities. BioMed Central Ltd.; BMC Bioinformatics. 2009;10:149-156.

Stasiunas A, Verikas A, Miliauskas R, Stasiuniene N. An adaptive model simulating the somatic motility and the active hair bundle motion of the OHC. New York: Pergamon; Computers in Biology and Medicine. 2009;39(9):800-809.

Verikas A, Gelzinis A, Bacauskiene M, Uloza V, Kaseta M. Using the patient's questionnaire data to screen laryngeal disorders. Elsevier; Computers in Biology and Medicine. 2009;39(2):148-155.

Ejnarsson M, Verikas A, Nilsson C M. Multi-resolution screening of paper formation variations on production line. Amsterdam: Elsevier; Expert systems with applications. 2009;36(2, part 2):3144-3152.

Bacauskiene M, Verikas A, Gelzinis A, Valincius D. A feature selection technique for generation of classification committees and its application to categorization of laryngeal images. New York: Pergamon Press; Pattern Recognition. 2009;42(5):645-654.

Grubinger T, Wickström N, Björklund A, Hellring M. Knowledge Extraction from Real-World Logged Truck Data. Warrendale, PA: Society of Automotive Engineers; SAE International Journal of Commercial Vehicles. 2009;2(1):64-74.

Svensson M, Byttner S, Rögnvaldsson T. Vehicle Diagnostics Method by Anomaly Detection and Fault Identification Software. Warrendale, PA: SAE international; SAE international journal of passenger cars : electronic and electrical systems. 2009;2(1):352-358.

Verikas A, Uloza V, Bacauskiene M, Gelzinis A, Kelertas E. Advances in laryngeal imaging. New York: Springer-Verlag New York; European Archives of Oto-Rhino-Laryngology. 2009;266(10):1509-1520.

2008

Persson M, Åstrand B. Classification of crops and weeds extracted by active shape models. New York: Elsevier; Biosystems Engineering. 2008;100(4):484-497.

Gelzinis A, Verikas A, Bacauskiene M. Automated speech analysis applied to laryngeal disease categorization. Amsterdam: Elsevier; Computer Methods and Programs in Biomedicine. 2008;91(1):36-47.

Englund C, Verikas A. Ink flow control by multiple models in an offset lithographic printing process. Oxford: Pergamon Press; Computers & industrial engineering. 2008;55(3):592-605.

Verikas A, Bacauskiene M, Valincius D, Gelzinis A. Predictor output sensitivity and feature similarity-based feature selection. Elsevier; Fuzzy sets and systems (Print). 2008;159(4):422-434.

Verikas A, Bacauskiene M. Estimating ink density from colour camera RGB values by the local kernel ridge regression. Elsevier; Engineering applications of artificial intelligence. 2008;21(1):35-42.

de Morais W O, Sant'Anna A, Wickström N. A Wearable Accelerometer Based Platform to Encourage Physical Activity for the Elderly. Eindhoven: International Society for Gerontechnology; Gerontechnology : international journal on the fundamental aspects of technology to serve the ageing society. 2008;07(02):129-181.

Sant'Anna A, Ourique de Morais W, Wickström N. Gait Unsteadiness Analysis from Motion Primitives. Eindhoven: International Society for Gerontechnology; Gerontechnology : international journal on the fundamental aspects of technology to serve the ageing society. 2008;7(2):204-.

Guzaitis J, Verikas A. An Efficient Technique to Detect Visual Defects in Particleboards. Vilnius: Institute of Mathematics and Cybernetics, Lithuanian Academy of Sciences; Informatica (Vilnius). 2008;19(3):363-376.

Stasiunas A, Verikas A, Miliauskas R, Stasiuniene N, Bacauskiene M. Physiologically inspired signal preprocessing for auditory prostheses : Insights from the electro-motility of the OHC. Oxford, England: Elsevier; Medical Engineering and Physics. 2008;30(2):171-181.

Englund C, Verikas A. Ink feed control in a web-fed offset printing press. London: Springer London; The International Journal of Advanced Manufacturing Technology. 2008;39(9-10):919-930.

Fronthaler H, Kollreider K, Bigun J, Fierrez J, Alonso-Fernandez F, Ortega-Garcia J, et al. Fingerprint Image-Quality Estimation and its Application to Multialgorithm Verification. New York, N.Y.: IEEE Signal Processing Society; IEEE Transactions on Information Forensics and Security. 2008;3(2):331-338.

Conferences with full-paper review

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-insprired 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.

2010

Byttner S, Rögnvaldsson T, Svensson M. Finding the odd-one-out in fleets of mechatronic systems using embedded intelligent agents. In: Embedded reasoning: intelligence in embedded systems : papers from the AAAI Spring Symposium. 2010 AAAI Spring Symposium, Stanford University, Stanford, CA, United States, 22 - 24 March 2010, Code 81902. Menlo Park, California: AAAI Press; 2010. p. 17-19. Technical report (American Association for Artificial Intelligence), SS-10-04.

Sant'Anna A, Wickström N. A linguistic approach to the analysis of accelerometerdata for gait analysis. In: Proceedings of the seventh IASTED International Conference on Biomedical Engineering: February 17-19, 2010, Innsbruck, Austria. CA: ACTA Press; 2010. p. 8-.

Lundström J, Verikas A. Detecting Halftone Dots for Offset Print Quality Assessment Using Soft Computing. In: 2010 IEEE International Conference on Fuzzy Systems (FUZZ). WCCI 2010 IEEE World Congress on Computational Intelligence, FUZZ-IEEE. Piscataway, NJ: IEEE Press; 2010. p. 1145-1151. IEEE International Conference on Fuzzy Systems, 2010.

Vaiciukynas E, Gelzinis A, Bacauskiene M, Verikas A, Vegiene A. Exploring Kernels in SVM-Based Classification of Larynx Pathology from Human Voice. In: Proceedings of the 5th International Conference on Electrical and Control Technologies ECT-2010, May 6-7, 2010, Kaunas, Lithuania. The 5th International Conference on Electrical and Control Technologies 6-7 May 2010, Kaunas, Lithuania. Kaunas: KUT; 2010. p. 67-72.

Karlsson S, Bigun J. Directionality Features and the Structure Tensor. SSBA 2010 Symposium i bildanalys, Uppsala 11-12 mars. 2010.

2009

Verikas A, Uloza V, Gelzinis A, Bacauskiene M, Pribuisiene R, Kaseta M. Exploiting image, voice, and patient's questionnaire data for screening laryngeal disorders. In: Proceedings of the 3rd Advanced Voice Function Assessement International Workshop (AVFA 2009). Advanced Voice Function Assessement International Workshop. Madrid; 2009. p. 85-88.

Gelzinis A, Vaiciukynas E, Kelertas E, Bacauskiene M, Verikas A, Virgilijus U, et al. Categorizing sequences of laryngeal data for decision support. In: Electrical and Control Technologies: Proceedings of the 4th international conference, ECT 2009. Electrical and Control Technologies: proceedings of the 4th international conference, ECT 2009, May 7 - 8, Kaunas, Lithuania. Kaunas: IFAC Committee of National Lithuanian Organisation; 2009. p. 99-102. Electrical and Control Technologies, 2009.

Bouguerra A, Andreasson H, Lilienthal A J, Åstrand B, Rögnvaldsson T. MALTA : A System of Multiple Autonomous Trucks for Load Transportation. In: Proceedings of the 4th European Conference on Mobile Robots: ECMR'09, September 23 – 25, 2009 Mlini/Dubrovnik, Croatia. 4th European Conference on Mobile Robots (ECMR), 23-25 september, 2009, Mlini/Dubrovnik, Croatia. Zagreb: KoREMA; 2009. p. 91-96.

Ericson S, Åstrand B. A vision-guided mobile robot for precision agriculture. In: Precision agriculture '09: Papers presented at the 7th European conference on precision agriculture, Wageningen, The Netherlands, 6-8 July 2009. 7th European Conference on Precision Agriculture, Wageningen, The Netherlands, 6-8 July, 2009. Wageningen: Wageningen Academic Publishers; 2009. p. 623-630.

Bouguerra A, Andreasson H, Lilienthal A J, Åstrand B, Rögnvaldsson T. An autonomous robotic system for load transportation. In: IEEE Conference on Emerging Technologies & Factory Automation, 2009. ETFA 2009. 2009 IEEE Conference on Emerging Technologies and Factory Automation, ETFA 2009, Mallorca, Spain, 22 - 26 September, 2009. Piscataway, N.J.: IEEE Press; 2009. p. 1-4. IEEE Conference on Emerging Technologies and Factory Automation, 2009.

Byttner S, Rognvaldsson T, Svensson M, Bitar G, Chominsky W. Networked vehicles for automated fault detection. In: 2009 IEEE International Symposium on Circuits and Systems: circuits and systems for human centric smart living technologies, conference program, Taipei International Convention Center, Taipei, Taiwan, May 24-May 27, 2009. 2009 International Symposium on Circuits and Systems, May 24-27, Taipei, Taiwan. Piscataway, N.J.: IEEE Press; 2009. p. 1213-1216.

Teferi D, Bigun J. Multi-view and Multi-scale Recognition of Symmetric Patterns. In: Image analysis. 16th Scandinavian Conference on Image Analysis, SCIA 2009, Oslo, Norway, June 15-18, 2009. Berlin: Springer; 2009. p. 657-666. Lecture Notes in Computer Science, Vol. 5575.

Alzghoul A, Verikas A, Hållander M, Bacauskiene M, Gelzinis A. Screening paper runnability in a web-offset pressroom by data mining. In: Proceedings of the 9th Industrial Conference on Advances in Data Mining: Applications and Theoretical Aspects. 9th Industrial Conference on Advances in Data Mining: Applications and Theoretical Aspects, ICDM 2009, Leipzig, 20 - 22 July 2009. Berlin: Springer Berlin/Heidelberg; 2009. p. 161-175. Lecture Notes in Computer Science, 5633.

Svensson M, Forsberg M, Byttner S, Rögnvaldsson T. Deviation Detection by Self-Organized On-Line Models Simulated on a Feed-Back Controlled DC-Motor. In: Proceeding Intelligent Systems and Control (ISC 2009). Intelligent Systems and Control 2009, Cambridge, Mass., USA, Nov. 2-4, 2009. Cambridge, Mass.: ACTA Press; 2009.

Assabie Y, Bigun J. HMM-Based Handwritten Amharic Word Recognition with Feature Concatenation. In: Proceedings of the International Conference on Document Analysis and Recognition, ICDAR. 10th International Conference on Document Analysis and Recognition, ICDAR '09, July 26-29, Barcelona, Spain, 2009. New York: IEEE Press; 2009. p. 961-965. International Conference on Document Analysis and Recognition, ICDAR, Article number 5277562.

Sant'Anna A, Wickström N. Developing a Motion Language: Gait Analysis from Accelerometer Sensor Systems. In: Pervasive Health 2009: 3rd International Conference on Pervasive Computing Technologies for Healthcare. 3rd International Conference on Pervasive Computing Technologies for Healthcare - Pervasive Health 2009, PCTHealth 2009, London, 1-3 April, 2009. Piscataway, N.J.: IEEE Press; 2009. p. 1-8.

Guzaitis J, Verikas A, Gelzinis A, Bacauskiene M. A framework for designing a fuzzy rule-based classifier. In: Algorithmic Decision Theory: Proceedings of the 1st International Conference, ADT 2009, Venice, Italy, October 2009. ADT2009, 1st International Conference on Algorithmic Decision Theory, Venice, Italy, October 2009. Berlin: Springer Berlin/Heidelberg; 2009. p. 434-445. Lecture Notes in Computer Science / Lecture Notes in Artificial Intelligence, 5783.

Gelzinis A, Vaiciukynas E, Kelertas E, Marija B, Antanas V, Virgilijus U, et al. Towards video laryngostroboscopy-based automated screening for laryngeal disorders. In: Proceedings of the 6th International Conference “Models and Analysis of Vocal Emissions for Biomedical Applications”, MAVEBA 2009. 6th International Conference “Models and Analysis of Vocal Emissions for Biomedical Applications”, MAVEBA 2009, December 14-16, Firenze, Italy. Florence, Italy: Firenze University Press; 2009. p. 125-128. Proceedings e report, 54.

2008

Assabie Y, Bigun J. Online Handwriting Recognition of Ethiopic Script. In: Proceedings: Eleventh International Conference on Frontiers in Handwriting Recognition, Montréal, Québec - Canada, August 19-21, 2008. Eleventh International Conference on Frontiers in Handwriting Recognition (ICFHR2008), August 19-21, Montreal, Quebec, Canada. Montréal: CENPARMI, Concordia University; 2008. p. 153-158.

Assabie Y, Bigun J. Writer-independent Offline Recognition of Handwritten Ethiopic Characters. In: Proceedings: Eleventh International Conference on Frontiers in Handwriting Recognition, Montréal, Québec - Canada, August 19-21, 2008. Eleventh International Conference on Frontiers in Handwriting Recognition (ICFHR2008), August 19-21, Montreal, Quebec, Canada. Montréal: CENPARMI, Concordia University; 2008. p. 652-657.

Kollreider K, Fronthaler H, Bigun J. Verifying Liveness by Multiple Experts in Face Biometrics. In: IEEE Conference on Computer Vision and Pattern Recognition Workshops: CVPR 2008, Anchorage, Alaska, June 23-28, 2008. IEEE Conference on Computer Vision and Pattern Recognition, Anchorage, AK, June 23-28, 2008. New York: IEEE Press; 2008. p. 1200-1205. IEEE Conference on Computer Vision and Pattern Recognition. Proceedings.

Guzaitis J, Verikas A. ANN and ICA sparse code shrinkage de-noising based defect detection in pavement tiles. In: Information Technologies' 2008, Proceedings. 14th International Conference on Information and Software Technologies, IT 2008, Kaunas, Lithuania, April 24-25, 2008. Kaunas, Lithuania: Kaunas University of Technology Press; 2008. p. 62-71.

Byttner S, Holmberg U. Closed-loop control of EGR using ion currents. In: Proceedings of the 27th IASTED International Conference on Modelling, Identification, and Control, MIC. 27th IASTED International Conference on Modelling, Identification, and Control, 11-13 February, 2008, Innsbruck, Austria. Anaheim: ACTA Press; 2008. p. 7-.

Assabie Y, Bigun J. Lexicon-based Offline Recognition of Amharic Words in Unconstrained Handwritten Text. In: 19th International Conference on Pattern Recognition: (ICPR 2008) ; Tampa, Florida, USA 8-11 December 2008. 19th International Conference on Pattern Recognition, ICPR, Tampa, FL, 8-11 December 2008. New York: IEEE Computer Society; 2008. p. Article number 4761145-. International Conference on Pattern Recognition, 19.

Rögnvaldsson T, Panholzer G, Byttner S, Svensson M. A self-organized approach for unsupervised fault detection in multiple systems. In: 19th International Conference on Pattern Recognition: (ICPR 2008) ; Tampa, Florida, USA 8-11 December 2008. 19th International Conference on Pattern Recognition (ICPR 2008),Tampa, FL, DEC 08-11, 2008. Piscataway, N.J.: IEEE Press; 2008. p. 1-4. International Conference on Pattern Recognition, 2008.

Hedenberg K, Åstrand B. A Trinocular Stereo System for Detection of Thin Horizontal Structures. In: Advances in Electrical and Electronics Engineering - IAENG Special Edition of the World Congress on Engineering and Computer Science 2008. Ao, S.L.. IEEE Computer Society; 2008.

Ericson S, Åstrand B. Visual Odometry System for Agricultural Field Robots. In: Proceedings of the World Congress on Engineering and Computer Science 2008, WCECS 2008, October 22 - 24, 2008, San Francisco, USA. World Congress on Engineering and Computer Science, October 22 - 24, 2008, San Francisco, USA. Hong Kong: International Association of Engineers; 2008. p. 619-624. Lecture Notes in Engineering and Computer Science.

Ericson S, Åstrand B. Stereo Visual Odometry for Mobile Robots on Uneven Terrain. In: WCECS '08 Proceedings of the Advances in Electrical and Electronics Engineering - IAENG Special Edition of the World Congress on Engineering and Computer Science 2008. World Congress on Engineering and Computer Science 2008. Washington: IEEE Computer Society; 2008. p. 150-157.

Hedenberg K, Åstrand B. Obstacle Detection For Thin Horizontal Structures. In: World Congress on Engineering and Computer Science: WCECS 2008 : 22-24 October, 2008, San Francisco, USA. World Congress on Engineering and Computer Science, 22-24 October, 2008, San Francisco, USA. Hong Kong: International Association of Engineers; 2008. p. 689-693. Lecture Notes in Engineering and Computer Science.

Other conference papers

2012-2008

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-.

Kaminska H, Rögnvaldsson T. Assessment of the new scoring function for protein identification by PMF. In: Acta Biochimica Polonica, Supplement 1, 2010. the 2nd Conference of Polish Mass Spectometry Society March 24th-26th, 2010, Poznan, Poland. Warszawa, Poland: Polish Biochemical Society; 2010. p. 34-34. Acta biochimica Polonica, vol. 57, supplement 1.

Åstrand B, Bouguerra A, Andreasson H, Lilienthal A, Rögnvaldsson T. An autonomous robotic system for load transportation. In: Proceedings of the 4th Swedish Workshop on Autonomous Robotics (SWAR). 2009. p. 56-57.

Books/Book chapters

2012-2008

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.

Faraj M I, Bigun J. Lip Motion Features for Biometric Person Recognition. In: Visual Speech Recognition: Lip Segmentation and Mapping. Hershey, PA: Medical Information Science Reference; 2009. p. 495-532.

Alonso-Fernandez F, Bigun J, Fierrez J, Fronthaler H, Kollreider K, Ortega-Garcia J. Fingerprint Recognition. In: Guide to Biometric Reference Systems and Performance Evaluation. London: Springer London; 2009. p. 51-88.

Bigun J. Fingerprint features. In: Encyclopedia of biometrics. New York: Springer-Verlag New York; 2009. p. 465-473.

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