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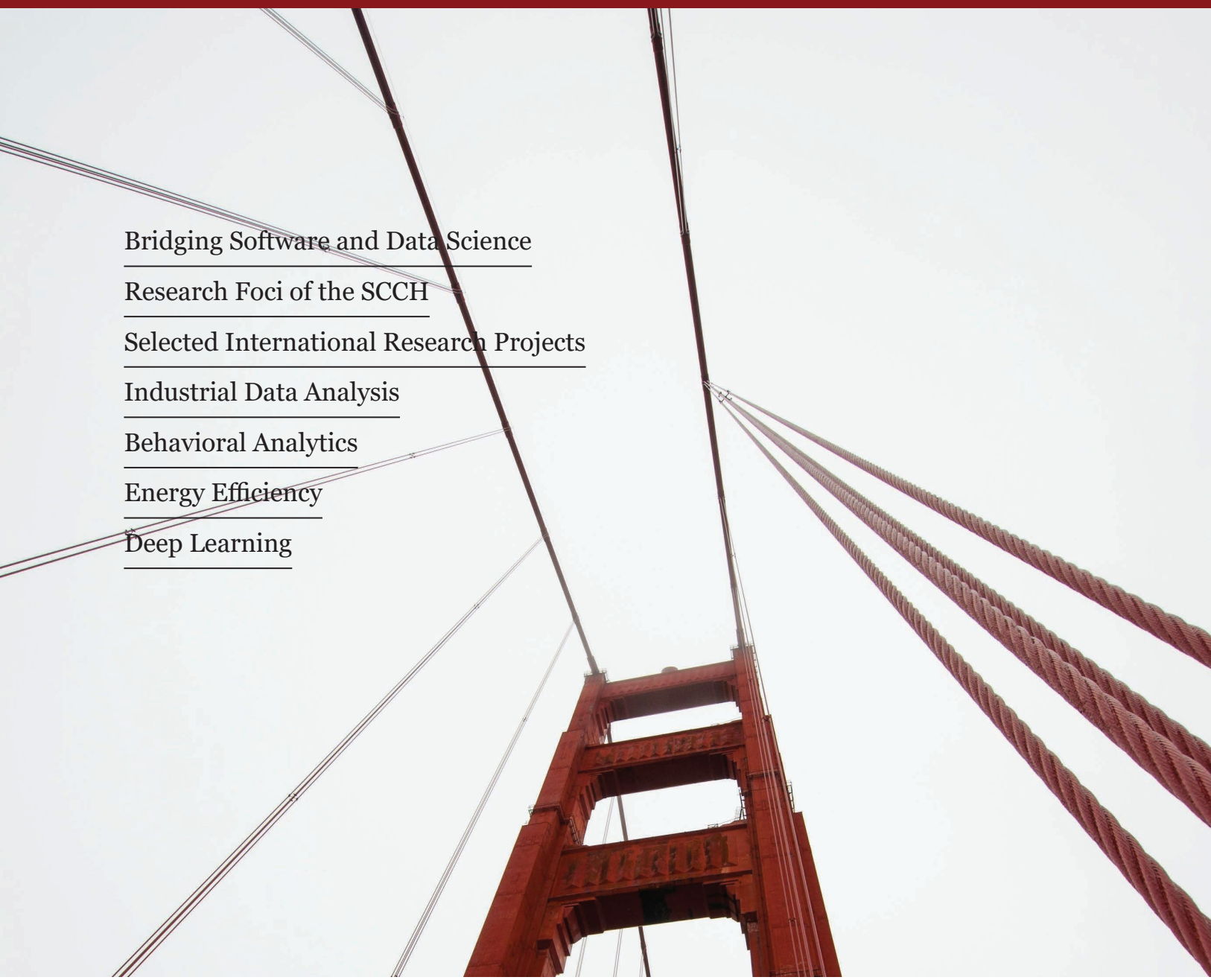
BRIDGE · IT

FIT FOR INDUSTRY 4.0



Bridging Software and Data Science

Research Foci of the SCCH

Selected International Research Projects

Industrial Data Analysis

Behavioral Analytics

Energy Efficiency

Deep Learning

SCCH – SOFTWARE COMPETENCE CENTER HAGENBERG GMBH WWW.SCCH.AT

s c c h
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hagenberg

BRIDGING SOFTWARE SCIENCE AND DATA SCIENCE

We live in the era of information technology, which shapes and changes our lives, our economy and our society. Information technology is essentially driven by software and data. Today software and data is everywhere, in the mobile phone, TV, computer, car, in banking and production systems. With the advent of artificial intelligence (AI), data, however, is more than "fuel" for software, and software is more than processing data.

AI is the innovation factor for this ongoing and accelerating technological transformation. This is an endemic process that is not limited to the new economy. Though there is not so much media resonance regarding software, it is in the end software that makes it work. Therefore, software science and data science, in which data driven AI is part of, has to be thought together! While software engineering is considered as an established technology, though its impressing progress AI

With the term AI we address a bunch of data-driven technologies that distill information and knowledge from data such as big-data analytics, smart analytics, machine learning and deep learning as special but very prominent subfield of machine learning. AI brings added value in various perspectives: It allows the exploration of huge amount of data for discovering anomalies, causal interdependences or improved matches that are intractable for humans due to the overwhelming amount or high-dimensionality of the data. By this, AI brings additional autonomy to all types of physical and virtual artefacts and opens the door to a wave of innovations and opportunities.
As pointed out by McKinsey, software is the basis and still lacks the maturity of an engineering discipline. The reason for this are still unsolved problems regarding security (e.g., adversarial examples) and privacy protection (e.g., reconstruction of privacy data by generative adversarial networks), safety in terms of guarantees for its input-output behavior (lack of confidence measures) and development efficiency in terms of debugging, reusability and down-sizing to specific computational hardware platforms. With AI also a new paradigm in designing and creating artefacts such as software systems is emerging. Just as tools are used to refine and create new tools, software and AI are also used to enable the next generation of AI-based software systems. With this equal footing in software and data

BRIDGING SOFTWARE SCIENCE AND DATA SCIENCE

science, SCCH tackles key challenges and potentials in this development:

- SCCH tackles **high-quality software-based services**: predictive maintenance in industry, predictive behavioral analytics in surveillance, predictive analytics in personalized healthcare and predictive software analytics for software quality assurance,
- SCCH's concern ist about **quality of such services**, that is the quality of the underlying AI- and data driven models and the software that makes these services work;
- SCCH's strategy for **innovation is driven by unlocking the trapped value in software artifacts and data,** e.g., by privacy preserving collaborative AI.

THE MISSION OF THE SCCH

The mission of SCCH is to carry out applied research in close collaboration with its scientific and industrial partners on bridging the gap between cutting edge AI technologies and the industrial requirements for an engineering discipline by fertilizing software engineering technologies for AI-based software systems and vice versa.
In this context SCCH focusses on research into AI-driven software systems and engineering by addressing:

- security and safety of AI-based software systems (privacy preserving collaborative distributed learning architectures)
- transferable machine intelligence (overcoming the limitation in the availability of annotated data; reusing pre-trained models)
- software engineering for AI-based software systems

FIELDS OF APPLICATIONS

SCCH's main fields of applications are:

- data-intensive systems: predictive maintenance in manufacturing and chemical industry; medical imaging; behavioral analytics in mobile and security environments
- software-intensive systems in banking and automation industry
- software-quality, testautomation, software-analytics, software-redocumentation

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RESEARCH FOCI

OUR RESEARCH

Research at Software Competence Center Hagenberg (SCCH) concentrates on equal footing in Data Science and Software Science. The synergy of Data Science and Software Science at SCCH is a success factor.

SAE SOFTWARE ANALYTICS AND EVOLUTION

SAE employs modern analytical and design approaches in Software Engineering with the goal of facilitating the creation and continuing development of complex technical software systems over long time frames while simultaneously ensuring utmost quality. This involves analytical and model-based approaches for automatic generation of software from domain models as well as potential end-user programming via domain-specific programming languages. The various research aspects in the research focus SAE pursue the long-range vision. of tool-supported analysis of program code and storage of the results in abstract, long-lasting domain models. These models then serve the enterprise in the efficient generation of test cases and technical documentation as well as in automatic porting to other software technologies and programming languages.

DAS DATA ANALYSIS SYSTEMS

DAS develops methods for automatic data analysis (sensor data, etc.) for the purpose of knowledge acquisition, model refinement, and optimization. The spectrum of applications includes process analysis, process optimization, fault detection and diagnosis, virtual sensors, disruption prognosis and optimized control systems in the process industry and in production, production and maintenance of machines, and energy management.

KVS KNOWLEDGE-BASED VISION SYSTEMS

KVS develops analysis methods for spatial-temporal data (images, videos, trajectories) via computational intelligence, especially deep learning, along with methods from mathematical and geometric modeling. Particular application interests include (bio)medical image processing in nano-, micro- and macro-ranges with the analysis and quantification of changing structures (concentration of nano-particles, cells, cell clusters, organs), tracking-based behavioral analysis in sports and security domains (e.g., tactical analysis for soccer; predictive and knowledge-based methods for evaluating the relevance of alarms in a video monitoring system) as well as optical and multisensory quality and measurement tasks with special requirements regarding precision, performance and robustness.

SSA SECURE SOFTWARE ANALYTICS

SSA integrates the topic of security with the area Data and Software Science. The expertise and research in Software Engineering, especially Software Testing and Software Analysis is applied, to detect and avoid security problems. Thus already in the production of software, security is treated as a quality attribute; this achieves multiple-level security. SCCH's research involves the engineering of software systems based on artificial intelligence. The use of software in security-critical systems demands solutions that ensure functionality solutions.

SELECTED RESEARCH PROJECTS

CURRENT RESEARCH

INDUSTRIAL DATA ANALYSIS

Evolutionary optimization of material usage in power transformer manufacturing (MOFOCS)

Missing data imputation in the context of industry 4.0 (DASEM)

Comprehensive fraud detection in the social insurance system (PROKNOW)

BEHAVIORAL ANALYTICS

Robust risk-based screening and alert system for passengers and luggage (TRESSPASS)

Connecting Austria (Austrian Flagship Project)

ENERGY EFFICIENCY

Large-scale use of prosumer flexibility in short-term electricity markets, taking into account prosumer interests (FLEX+)

Electricity storage management (ESTORE-M)

DEEP LEARNING

Software framework for runtime-adaptive and secure deep learning on heterogeneous architectures (ALOHA)

Central Moment Discrepancy for domain-invariant representation learning (DASRES)

A hybrid approach for acoustic scene classification using deep convolutional neural nets and factor analysis (FEXFE)

EVOLUTIONARY OPTIMIZATION OF MATERIAL USAGE IN MANUFACTURING

KEYWORDS: SMART FACTORY, OPTIMIZATION, POWER TRANSFORMERS, CUTTING STOCK PROBLEM, STOCHASTIC-LOCAL SEARCH

ABSTRACT

The manufacturing process of a power transformer core (consisting of hundreds of metal sheet layers) involves:
- Optimal slitting of a set of available metal coils into bands of desirable width
- Additional customer constraints of properties of the final product

The proposed optimization framework provides flexibility with respect to the constraints and objectives. A learning system provides the necessary predictions for different transformer properties based on the current slitting plan. A crucial step was the integration of all related data (e.g. raw material attributes, measurements of the incoming control, purchase data, quality attributes of previously produced transformers ...)..

The moFOCS (Modelling, Prognosis, Forecast and Control of Systems) project focuses on predicting and optimizing process and product parameters in the area of industrial manufacturing. This is accomplished by the development of virtual sensors that employ machine learning and transfer learning methods as well as by the development of evolutionary stochastic optimization methods. Examples of results are:
- Learning framework for predicting properties of produced products and learning the causality of used material to resulting product properties
- Domain specific language for data processing pipelines to manage large variety of analysis workflows
- Prototype of a data provenance system for data processing pipelines which ensures the traceability between deployed models

This project is supported by the Austrian Research Promotion Agency.

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MISSING DATA IMPUTATION IN THE CONTEXT OF INDUSTRY 4.0

KEYWORDS: MISSING DATA, DATA QUALITY, DATA PREPARATION, MULTIPLE IMPUTATION

ABSTRACT

A core demand of Industry 4.0 is to gather insights from historical and operative company data. In industrial settings, such datasets are often compromised by missing data (MD), e.g., because of a sensor breakdown.
We propose a methodology for systematically treating MD, especially MD patterns and underlying mechanisms, in the industrial domain. The aim is to support data analysts with the application of data analytics methods and to reduce a bias of the results, despite the presence of missing values. An automated workflow that highlights MD patterns and suggests optimal solutions for (multiple) imputation of missing values is in its focus. The developed approach contributes to the company partner's objective of improving and continuously monitoring of their industrial data quality.

The project daSEM (Automated (Big) Data Engineering, Processing and Semantic Models) focusses on the design and development of computational techniques and tools for deriving implicit knowledge from information by means of automated (big) data engineering, semi-automatic data integration, application of big data processing technologies and semantic knowledge modeling. With respect to the project objectives, state-of-the-art big data management and processing approaches and conceptualizations are evaluated including prototypical implementations for automated data and knowledge processing workflows in the context of data warehousing and business intelligence. Additionally, patterns of missing data are investigated in order to apply machine learning models and data quality management methods for, e.g., imputing missing values based on the characteristics of downstream data analysis methods.

This project is supported by the Austrian Research Promotion Agency.

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COMPREHENSIVE FRAUD DETECTION IN THE SOCIAL INSURANCE SYSTEM

KEYWORDS: SOCIAL FRAUD DETECTION, FEATURE EXTRACTION, MULTI-TASK LEARNING, LEARNING TO RANK, MODEL INTERPRETABILITY

ABSTRACT

The Austrian social insurance system is continuously working on measures against social fraud. Within the COMET project proKNOW SCCH supports this undertaking via data driven approaches for social fraud detection in the area of employment. During the last years individual regional models have been developed that monthly estimate the risk level of each employer for the most relevant economic sectors. Currently, we are working towards a fully automated all-in-one model. Combining methods from the fields of multi-task learning and learning to rank allows us to meet specified requirements like comparability over regions as well as optimal performance with respect to from models deduced scoring lists.

The project proKNOW (Discovery of Knowledge and Structure in Industrial Processes) focuses on the development of approaches for automated knowledge extraction and structure learning for novel industrial use cases such as optimization in discrete manufacturing, maintenance work and social fraud detection. Together with one of our company partners we work on the development of a set of fitting indicators for social fraud detection. Concerning the use cases for the production industry we are researching and developing systems for monitoring processes and analysing process data in order to detect anomalies in processes and to point them out at an early stage.

This project is supported by the Austrian Research Promotion Agency.

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ROBUST RISK BASED SCREENING AND ALERT SYSTEM FOR PASSENGERS AND LUGGAGE

KEYWORDS: BORDER CONTROL, SCENE ANALYSIS, DEEP LEARNING, PREDICTIVE BEHAVIORAL ANALYTICS

ABSTRACT

In risk-based border management the greatest challenge is the estimation of the risk for each individual traveller. The success and applicability of any risk-management process greatly depends on the accuracy of these estimates. In TRESSPASS we propose an analytic framework for modelling risk and a systematic approach of quantifying risk based on a set of indicators that can accurately be measured across all 4 tiers with the technologies and processes that the partners in this proposal bring to the project.

The project TRESSPASS (robusT Risk basEd Screening and alert System for PASSengers and luggage) is about to start in May 2018 and aims to

- develop a single cohesive risk-based border management concept
- develop three pivoting pilot demonstrators
- demonstrate the validity of the single cohesive risk-based border management concept by using red teaming and simulations
- prepare for the further development of this concept beyond this project by linking to other known risk-based border management projects (in- and outside EU, within EU research frameworks and on national levels), and describe how their results contribute to a single cohesive risk-based border management concept

This project is supported by the H2020 programme.

PARTNERS

- National Centre for Scientific Research “Demokritos” (Consortium Leader)
- Center for Adaptive Security Research and Applications
- Center For Security Studies / Hellenic Police
- European Dynamics Belgium SA
- Fraunhofer Ernst-Mach-Institut
- ICTS (UK) Ltd
- Independent Authority For Public Revenue. Custom Service-General Directorate of Customs and Excise Duty
- Infili Technologies PC
- Military University of Technology Poland
- Ministry of maritime affairs and insular policy/ Hellenic Coast Guard
- Netherlands Organisation for Applied Scientific Research
- Piraeus Port Authority
- Polish Border Guard
- RINA
- Royal Netherlands Marechaussee, Dutch border guard Ministry of Defense
- Schiphol Airport Authority
- Space Hellas
- Trinity College Dublin
- University of Freiburg
- Vicarious Perception Technologies BV
- Zanasi & Partners

CONNECTING AUSTRIA

KEYWORDS: PLATOONING, SMART CITY, ENERGY EFFICIENCY, TRAFFIC, MOBILITY

ABSTRACT

The flagship project Connecting Austria brings technology leaders and end-users together to demonstrate and evaluate four specific use cases for semi-automated and energy-efficient truck platoons. Key objectives is the evidence-based evaluation of energy-efficient truck platoons as a pre-requisite for competitive strength of Austrian industries such as logistics, telematics and infrastructure providers, automotive suppliers, as well as vehicle development and cooperative research. The national flagship project's unique contribution is its specific focus on infrastructure issues and on parameterized traffic perspectives when evaluating energy-efficient and semi-autonomous truck platoons. This particularly includes platoons at intersections before entering motorways and after leaving motorways.

In three years, four use cases are explored by 13 company and research partners: Trucks enter the highway and form a platoon; Truck platoon approaches a hazardous location, Truck platoon leaves the highway, T uck platoon crosses an intersection. It is planned to have several test ing grounds in Salzburg, Upper Austria and Vienna. SCCH is a research partner and sees this as an opportunity to apply its expertise in the field of deep learning and in the field of behavioral analytics in use case 4/intersection. This enables SCCH to make a valuable contribution to the safety and efficiency of Platoons. The role of the SCCH is to provide AI-based scene analysis in the mobility environments by employing behavioral analytics

This project is supported by the Austrian Research Promotion Agency.

PARTNERS

- ANDATA
- Automobil-Cluster OÖ (Business Upper Austria – OÖ Wirtschaftsagentur GmbH)
- FH OÖ – Logistikum Steyr
- HiTec Marketing (Projektleitung)
- IESTA – Institut für Innovative Energie- & Stoffaustauschsysteme
- Kuratorium für Verkehrssicherheit (KFV)
- Siemens AG Österreich
- TU Wien (IMM)
- Software Competence Centre Hagenberg (SCCH)
- Swarco Futurit Verkehrssignalsysteme Ges.m.b.H.
- TRANSDANUBIA
- Universität für Bodenkultur Wien (CNL)
- VIRTUAL VEHICLE

LARGE-SCALE USE OF PROSUMER FLEXIBILITY IN SHORT-TERM ELECTRICITY MARKETS

KEYWORDS: E-MOBILITY, ENERGY SUPPLY, OPTIMIZATION ALGORITHMS, INDIVIDUAL INTERESTS, REAL-TIME OPERATION

ABSTRACT

The integration of prosumers into the energy markets is promoted both at the European level, for example in the so-called winter package, but also at the national level in order to actively involve the prosumers in the market and to integrate fluctuating renewable energies by using their flexibility. From a technical point of view, automatically-controllable prosumer components such as heat pumps, electric boilers, battery storage and e-mobility are particularly suitable for this purpose. Surveys in the MBS+ and EcoGrid EU projects have shown that there is a great interest on the prosumers side to make their flexibility available externally, in order to contribute to a rapid energy supply that is affordable for society. Unlike in Austria, there are already existing business models in the area of private flexibility marketing in Germany and Switzerland.

The project develops scalable optimization algorithms at the aggregator and prosumer level, which take into account not only the interests of the aggregator, but also the needs / interests of the prosumer. Under this premise, an optimal market-wide use and marketing of the existing flexibility in private households is to be made possible for all stakeholders. As an interface to the market, a platform (Flex+ platform) is being developed which is used for the coordination of prosumers and suppliers and is responsible for marketing, planning and forecasting, aggregation as well as the demand for the prosumer flexibility. Based on the results of the real-time operation, remuneration models and tariffs for prosumers are developed and necessary processes for prosumers and companies are implemented along the entire value chain

This project is supported by the Austrian Research Promotion Agency.

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PARTNERS

- AIT Austrian Institute of Technology GmbH (coordinator)
- Technische Universität Wien, Institut für Energiesysteme und Elektrische Antriebe
- Austria Email Aktiengesellschaft
- IDM-Energiesysteme GmbH
- walterkreisel gmbh
- Fachhochschule Technikum Wien
- Software Competence Center Hagenberg GmbH
- WEB Windenergie AG
- World-Direct eBusiness solutions Gesellschaft m.b.H.
- TIWAG-Tiroler Wasserkraft AG
- Technikum Wien GmbH
- ENAMO GmbH
- MS.GIS Informationssysteme Gesellschaft m.b.H.
- Sonnenplatz Großschönau GmbH
- aWATTar GmbH
- FRONIUS INTERNATIONAL GmbH

ELECTRICITY STORAGE MANAGEMENT

KEYWORDS: STORAGE DEVICES, CONTROL ALGORITHM, LIFETIME OF COMPONENTS

ABSTRACT

To increase the self consumption of energy from photovoltaic (PV)-systems, electrochemical energy storages are used. For the operation of such systems energy management is necessary which is not a trivial task. Different strategies can be applied as goals of the energy management but practical controllers usually use only one optimisation goal or are not optimised at all. As a result the maximum efficiency cannot be reached. Energy and economic efficiency is usually calculated for the design point, which is problematic because in operation the system reaches this point rarely. Malfunction and variable operation parameters can be additional problems.

In this project an adaptive scheduling controller will be developed which determines an optimal policy for the use of renewable energy (such as PV), storage devices and certain electricity loads (such as heat pumps). Key element is a dynamic and robust optimisation of the scheduling controller. Through data analysis methods for failure detection will be developed.
Results:

- Development of an adaptive scheduling controller for the use of renewable energy, storage devices and certain electricity loads which incorporates weather- and load-forecasts and robust optimisation.
- Development of specific meteorological energy forecast methods.
- Analysis of energy efficiency of energy systems over the whole lifetime and development of failure detection algorithms.

PARTNERS

- ASIC - Austrian Solar Innovation Center (coordinator)
- Software Competence Center Hagenberg
- Blue Sky Wetteranalysen Traunmüller u. Reingruber OG
- Heliotherm Wärmepumpentechnik Ges.m.b.H.
- Fronius International GmbH

This project is supported by the Austrian Research Promotion Agency.

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ALOHA/DEEP LEARNING

SOFTWARE FRAMEWORK FOR RUNTIME-ADAPTIVE AND SECURE DEEP LEARNING ON HETEROGENEOUS ARCHITECTURES

KEYWORDS: DEEP LEARNING, EMBEDDED SYSTEMS, TRANSFER LEARNING

ABSTRACT

Deep Learning (DL) algorithms are an extremely promising instrument in artificial intelligence. To foster their adoption in new applications and markets, a step forward is needed towards the implementation of DL inference on low-power embedded systems, enabling a shift to the edge computing paradigm. The main goal of ALOHA is to facilitate implementation of DL algorithms on heterogeneous low-energy computing platforms providing automation for optimal algorithm selection, resource allocation and deployment.

The project ALOAH (Software framework for runtime-Adaptive and secure deep Learning On Heterogeneous Architectures) started in January 2018 and has the following aims

- Architecture-awareness (features of the inference architecture are taken into account during the development process).
- Productivity (tool flow implements support for agile development methodologies)
- Adaptivity (adapt to different operating modes at runtime)
- Extensibility (support novel processing platforms to be exploitable beyond the end of the project)
- Security (improve resilience of the system to attacks)
- Parsimonious inference (consider the effects of algorithm simplification on precision, execution time, energy and power)

PARTNERS

- STMicroelectronics (Consortium Leader)
- Universita degli Studi di Cagliari
- Universiteit van Amsterdam
- Universiteit Leiden
- Eidgenössische technische Hochschule Zürich
- Universita degli Studi di Sassari
- PKE Electronics AG
- CA Technologies Development Spain
- Santer Reply
- IBM Israel - Science and Technology
- Systhmata Ypologistikis Orashs Irida Labs
- Pluribus One
- Medymatch Technology

This project is supported by the H2020 programme.

CENTRAL MOMENT DISCREPANCY FOR DOMAIN-INVARIANT REPRESENTATION LEARNING

KEYWORDS: TRANSFER LEARNING, DOMAIN ADAPTATION, NEURAL NETWORKS, MOMENT ALIGNMENT, PROBABILITY METRIC

ABSTRACT

The learning of domain-invariant representations in the context of domain adaptation with neural networks is considered. We propose a new regularization method that minimizes the domain-specific latent feature representations directly in the hidden activation space. Although some standard distribution matching approaches exist that can be interpreted as the matching of weighted sums of moments, e.g. Maximum Mean Discrepancy, an explicit order-wise matching of higher order moments has not been considered before. We propose to match the higher order central moments of probability distributions by means of order-wise moment differences.

Within the project dasRES, this research is done in cooperation with the Department of Knowledge-based Mathematical Systems and the Fuzzy Logic Laboratorium Linz-Hagenberg (JKU-FLLL) of JKU.
The department of Knowledge-based Mathematical Systems and the Fuzzy Logic Laboratorium Linz-Hagenberg (JKU-FLLL) is an institute at the Johannes Kepler University Linz with research topics in

- Fuzzy logic and fuzzy control
- Aggregation functions and dependence structures
- Data mining, machine learning, and knowledge-based modelling
- Image and signal processing

PARTNERS

- JKU-FAW
- JKU-FLLL
- JKU-BIOINF
- KTH Royal Institute of Technology
- Hungarian Academy of Sciences

This project is supported by the Austrian Research Promotion Agency.

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ACOUSTIC SCENE CLASSIFICATION USING DEEP CONVOLUTIONAL NEURAL NETS

KEYWORDS: ACOUSTIC SCENE CLASSIFICATION, DEEP CONVOLUTIONAL NEURAL NETWORKS, FACTOR ANALYSIS, LATE FUSION

ABSTRACT

In Acoustic Scene Classification (ASC) two major approaches have been followed. While one utilizes engineered features such as mel-frequency-cepstral-coefficients (MFCCs), the other uses learned features that are the outcome of an optimization algorithm. I-vectors are the result of a modeling technique that usually takes engineered features as input. It has been shown that standard MFCCs extracted from monaural audio signals lead to i-vectors that exhibit poor performance, especially on indoor acoustic scenes. At the same time, Convolutional Neural Networks (CNNs) are well known for their ability to learn features by optimizing their filters. They have been applied on ASC and have shown promising results. In this paper, we first propose a novel multi-channel i-vector extraction and scoring scheme for ASC, improving their performance on indoor and outdoor scenes. Second, we propose a CNN architecture that achieves promising ASC results. Further, we show that i-vectors and CNNs capture complementary information from acoustic scenes. Finally, we propose a hybrid system for ASC using multi-channel i-vectors and CNNs by utilizing a score fusion technique. Using our method, we participated in the ASC task of the DCASE-2016 and DCASE-2017 challenge. Our hybrid approach achieved 1st rank among 49 submissions in DCASE-2016, and ranked 5th among 76 teams in DCASE-2017.

The aim of the strategic project FExFE (Feature Extraction, Representation and Matching for Frame-Based versus Event Driven Vision) is to gain insights into the complex questions of stability, robustness, solidity and efficiency of image feature extraction, aggregation and representation on the basis of mathematical modelling and analysis.
Research topics are in particular:

- Analysis of the stability and robustness of extraction and representation approaches. Analysis of the costs of concepts for feature extraction and display in terms of energy consumption, bandwidth, memory and processing requirements.

This project is supported by the Austrian Research Promotion Agency.

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- CTU-CMP
- Heriot Watt University

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