CAISR
Centre for Applied Intelligent Systems Research

Aware Intelligent Systems

- Slawomir Nowaczyk
- Kobra Etminani

2023-03-27

CAISR
Centre for Applied Intelligent Systems Research

Presenters

Kobra ETMINANI (Farzaneh)

Associate Professor at HH, ISDD.

Research: Machine Learning

- ML and AI in healthcare domain
- Healthcare informatics

Slawomir NOWACZYK

Professor in Machine Learning, ISDD

Research: Machine Learning & AI

- Representation Learning
- Transfer Learning
- Anomaly Detection
- Predictive Maintenance

CAISR
Centre for Applied Intelligent Systems Research

CAISR

- Department of Intelligent Systems and Digital Design (ISDD)
- Center for Applied Intelligent Systems Research (CAISR).
- Find us at E5, and F5 (mostly)
- Ressources:
  - https://caisr.hh.se (mostly old, but Msc projects are here)
  - https://www.hh.se/caisr (research, members, annual reports, etc)

CAISR
Centre for Applied Intelligent Systems Research

TACDA

- Specialisation: Artificial Intelligence (TACDA)

	Profilering mot Artificiell intelligens (ARIN)			
År 4	Valbar kurs	Artificiell intelligens	Läraktiga system	Bildanalys
	Valbar kurs	Tekniska beräkningar	Intelligenta fordon	Robotik
	Perspektiv på data science		Edge computing och internet of things	Parallelldatorprogr. för bearb. av stora datamängd.
År 5*	Valbar kurs	Examensarbete civilingenjör 30 hp		
	Konstruktion av inbyggda och intelligenta system 15 hp**		Valbar kurs	
	Digital tjänsteinnovation**	Deep learning**		
	Data mining			

Gemensamma kurser

Valbara profilkurser, rekommenderat paket 1

Valbara profilkurser, rekommenderat paket 2

* Termin 7, 9 alternativt hela år 5 kan läsas utomlands

** Alternativt Arbetsplatsförlagd utbildning 15 hp (AFU)

Övriga valbara kurser inom profilen	
Lp 1 (år 4 eller 5)	**Lp 3 (år 5)**
Data mining 7.5 hp (år 5, kräver Artificiell intelligens)	Artificiell intelligens för hälsa 7.5 hp
Digital tjänsteinnovation 7.5 hp	Datorseende i 3D 7.5 hp
Halvledarkomponenter 7.5 hp	Edge computing och internet of things 7.5 hp
Inbyggda realtidssystem 7.5 hp	Intelligenta fordon 7.5 hp
Konstruktion av inbyggda och intelligenta system 15 hp	Tillförlitlig och tidskritisk datakommunikation 7.5 hp
Nätverk för inbyggda system 7.5 hp	
Perspektiv på data science 7.5 hp	
Testning och verifikation av inbyggda system 7.5 hp	
Tillämpad elektromagnetism 7.5 hp	

CAISR
Centre for Applied Intelligent Systems Research

TACIS

- Specialisation: Robotics and autonomous systems (TACIS)

	Profilering mot Robotik och autonoma system (ROAS)			
År 4	Tillämpad elektromagnetism	Tekniska beräkningar	Intelligenta fordon	Bildanalys
	Python - en inkörsport till Machine Learning	Artificiell intelligens	Läraktiga system	Robotik
År 5*	Valbar kurs	Examensarbete för civilingenjör i elektroteknik 30 hp		
	Konstruktion av inbyggda och intelligenta system 15 hp**		Valbar kurs	

Valbara kurser inom profilen

Lp 1 (år 5)
Data mining 7,5 hp
Halvledarkomponenter 7,5 hp
Inbyggda realtidssystem 7,5 hp
Nätverk för inbyggda system 7,5 hp

Lp 3 (år 5)
Artificiell intelligens för hälsa 7,5 hp
Datorseende i 3D 7,5 hp
Edge Computing och Internet of Things 7.5 hp

Teacher

Teacher

HALMSTAD UNIVERSITY

CAISR
Centre for Applied Intelligent Systems Research

Example courses (with aims)

Examples of fundamental courses

- Artificial Intelligence
  - How to allow machines to do "reasoning" and be more intelligent.
- Learning Systems / Machine Learning
  - How to allow machines to learn (from experience/data) how to perform a task.
- Image Analysis
  - How to allow machines to understand images (computer vision).
- etc ...

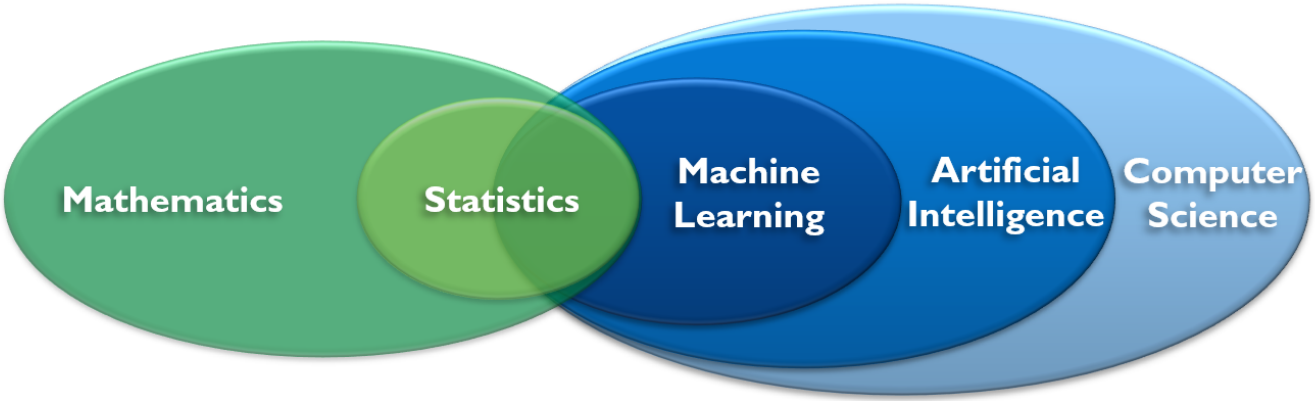
Examples of application -oriented courses

- Artificial Intelligence for Health
  - How to apply AI and ML in the healthcare domain
- Intelligent Vehicles
  - Application to self-organizing fleets, self-driving, autonomous systems etc.
- etc ...

CAISR
Centre for Applied Intelligent Systems Research

What is Machine Learning

- A subfield of artificial intelligence (AI) that gives machines the ability to **learn** and improve from experience.



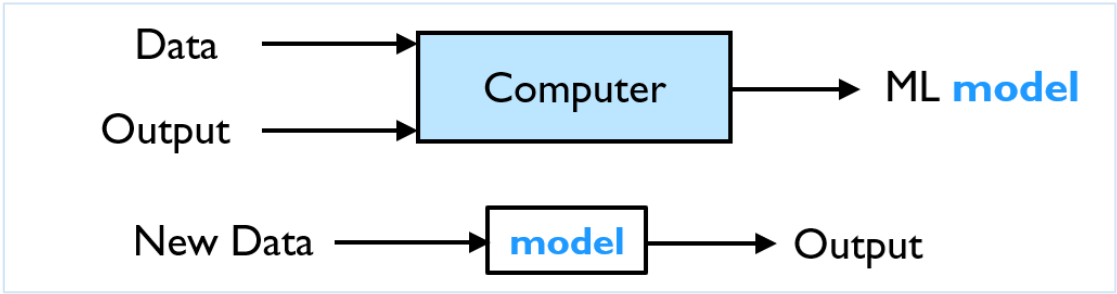
- Instead of explicitly programming a machine to perform a task, we program it to **learn** how to perform the task.

CAISR
Centre for Applied Intelligent Systems Research

What is Machine Learning

- Usual programming

- (Supervised) Machine Learning



- Machine learning algorithms build a **model** from the **training data**, then uses this model to make **predictions** or take decisions.

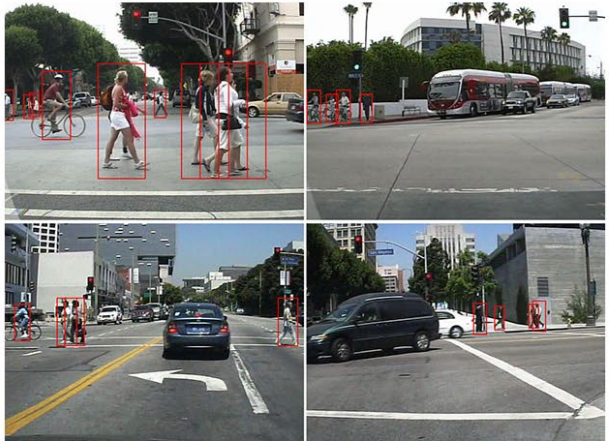
CAISR
Centre for Applied Intelligent Systems Research

What is Machine Learning

Example (self-driving car)

Consider the following problem:

- You have a camera on your car that periodically captures images of the road and send them to your app.
- You want your app to recognize what each image contains (pedestrians, bikes, other cars, etc.)



Why do we need machine learning:

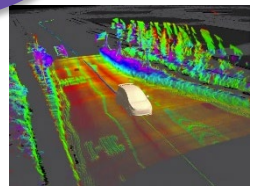
- It is extremely hard to solve this without machine learning.
- We can not manually define/code general rules that allow us to recognize what an image contains.

CAISR
Centre for Applied Intelligent Systems Research

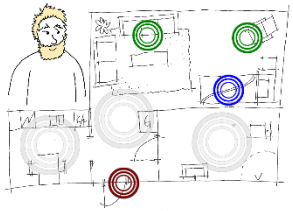
Aware and Intelligent Systems

Intelligent Vehicles

Predictive Maintenance



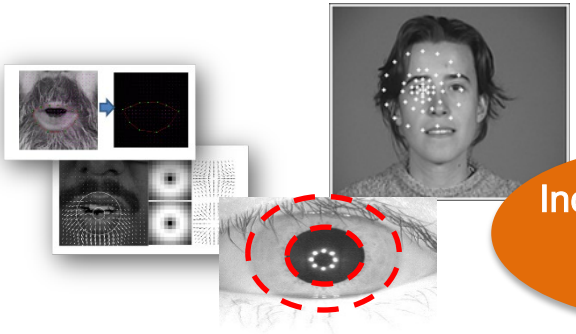
Healthcare Technology



Information driven care

Others, e.g.

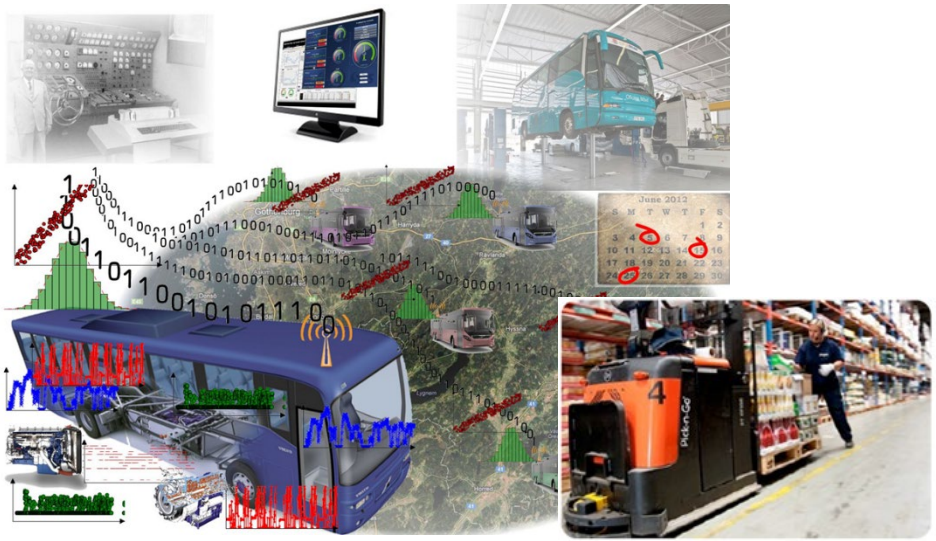
- Biometrics
- Smart Energy



Increased security with facial recognition

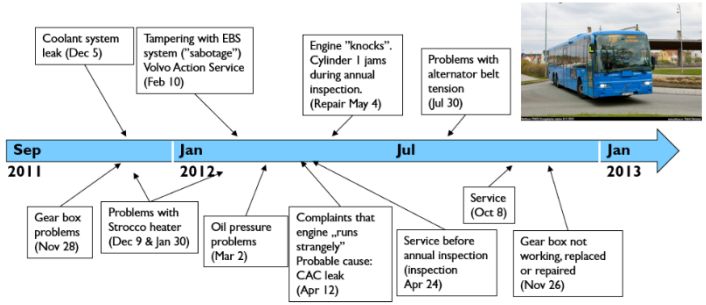
CAISR
Centre for Applied Intelligent Systems Research

Research related to Intelligent Vehicles

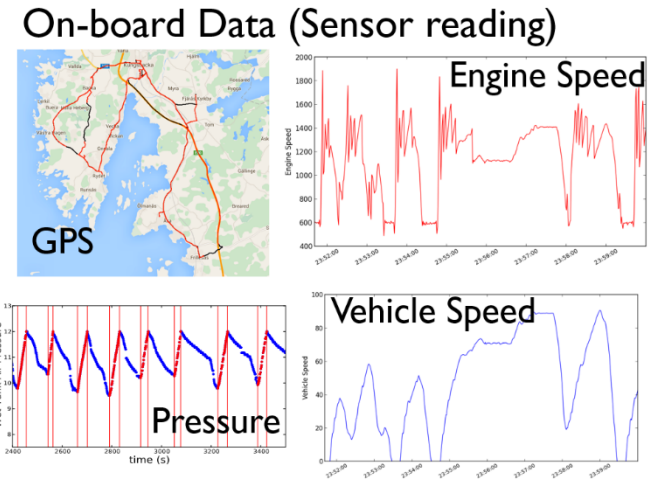


CAISR
Centre for Applied Intelligent Systems Research

Predictive Maintenance for Trucks and Buses



- Predicting need for maintenance of a vehicle based on on-board sensor data.
- A five year pilot study on Volvo buses in Kungsbacka

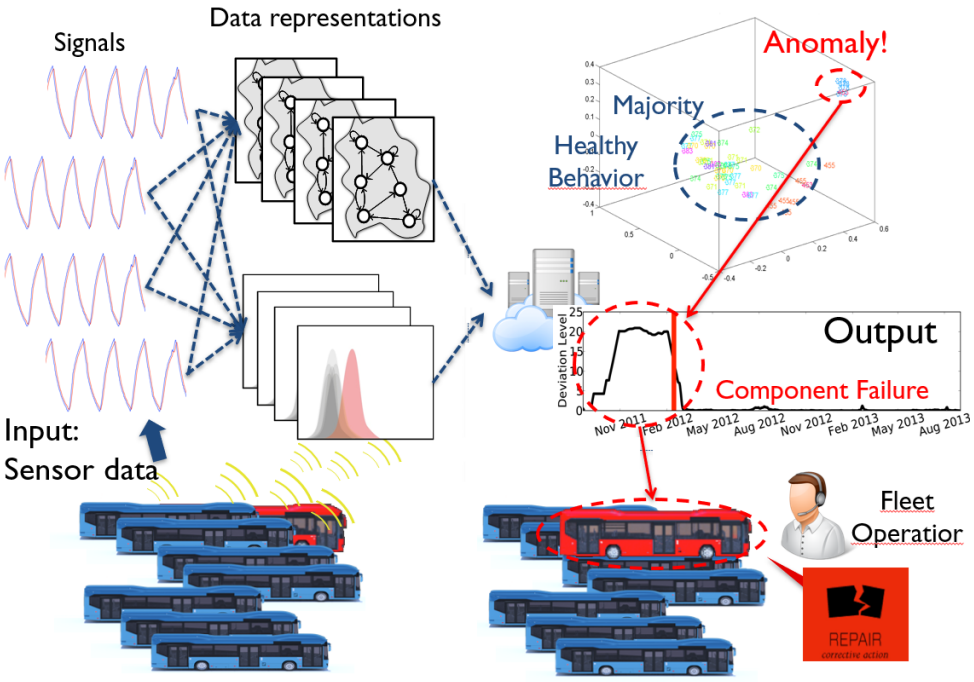


- Monitoring of vehicle operation to detect anomalies.
- Unsupervised approach towards vehicle diagnostics and maintenance.
- Combining various sources of data:
  on-board data, drivers' comments, maintenance logs, etc.

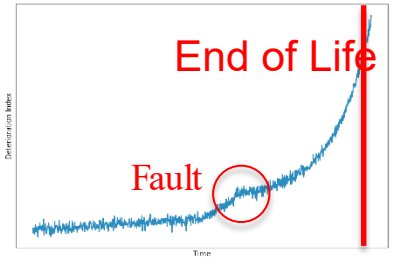
VINNOVA
Knowledge Foundation
VOLVO

Autonomous Condition Monitoring System

Detecting anomalies by comparing a bus against a fleet of similar buses.



Predicting remaining useful life



Other related project

- **EVE**: **E**xtending life of **V**ehicles within **E**lectromobility era.

- The focus is on **Transfer Learning**
  - How to apply a ML model trained on some data (e.g. a vehicle model), to another kind of data (other vehicle models).
  - How to transfer the knowledge learned from one vehicle, to other vehicles.

Automatic Inventory and Mapping of Stock

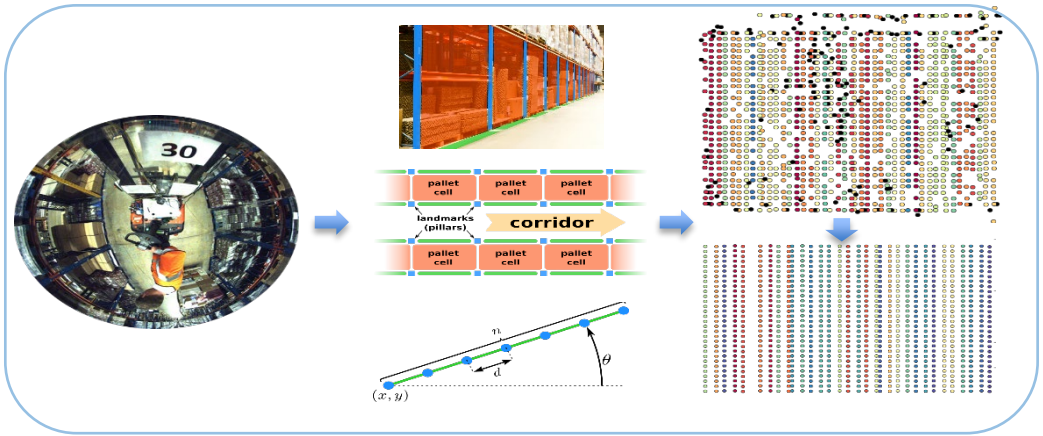
KOLLMORGEN
Because Motion Matters™

TOYOTA
TOYOTA MATERIAL HANDLING EUROPE

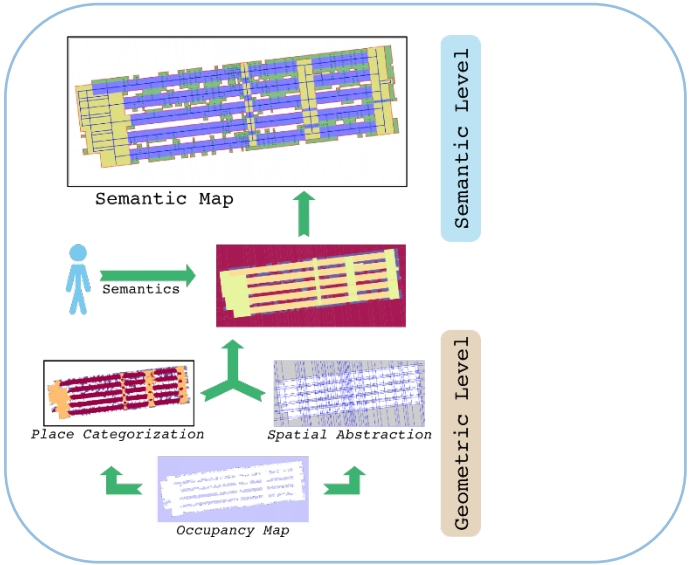
OPTRONIC

Knowledge Foundation

An intelligent warehouse environment that **autonomously builds a map** of articles and infrastructure in a warehouse and **relates article identity** from the warehouse database with the **article's position** (metric) and visual appearance in the warehouse.



Infrastructure map – pillar map



Infrastructure map – layout map

CAISR
Centre for Applied Intelligent Systems Research

AI-based Perception for Autonomous Driving

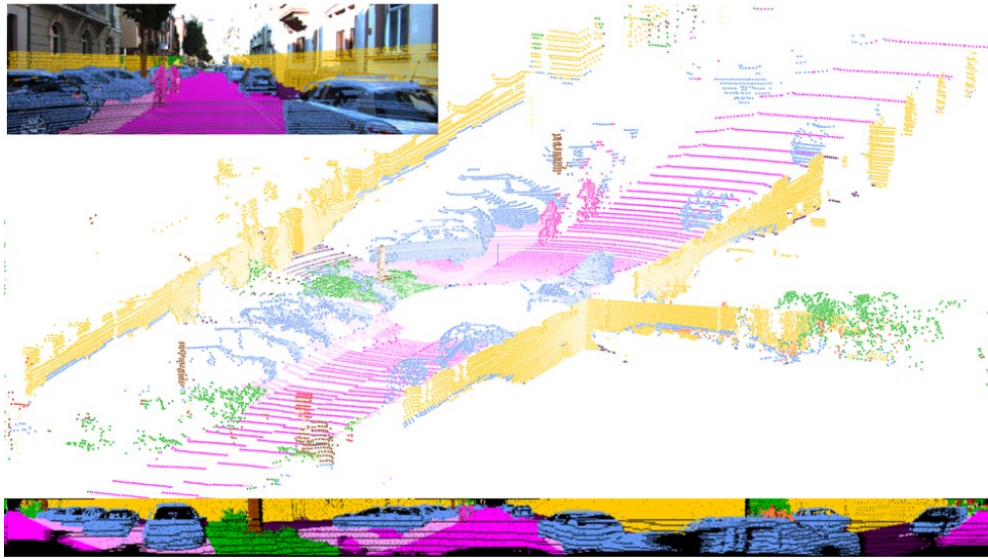
LiDAR (Light Detection and Ranging)

- Uses light to measure ranges (variable distances) by targeting an object with a laser and measuring the time for the light to return.

Semantic segmentation of 3D LiDAR point clouds.

Comparing with camera-based solutions

- Does the combination of the LiDAR + Camera improve objects detection.



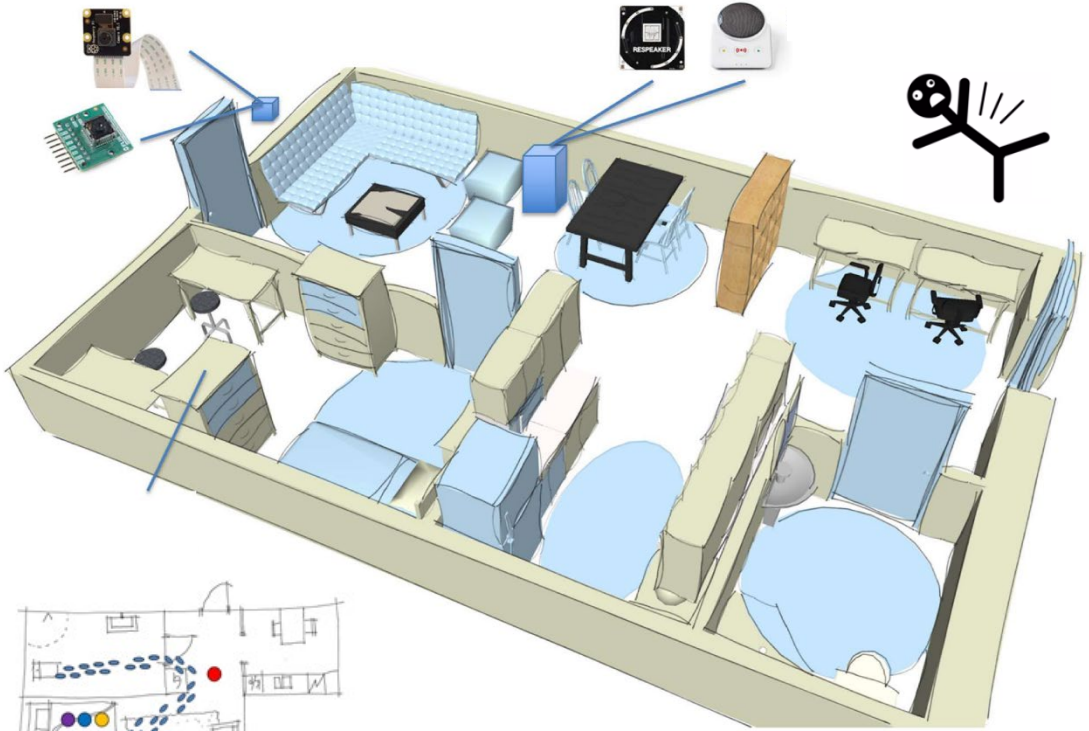
Others areas:

- Smart home environments
- Smart energy
- Biometrics

CAISR
Centre for Applied Intelligent Systems Research

Situation Awareness for Ambient Assisted Living

- *Recognize Activities of Daily Living*
- *Model normal behavior of residents*
- *Identify abnormal behavior of residents based on a combination of various sensors*



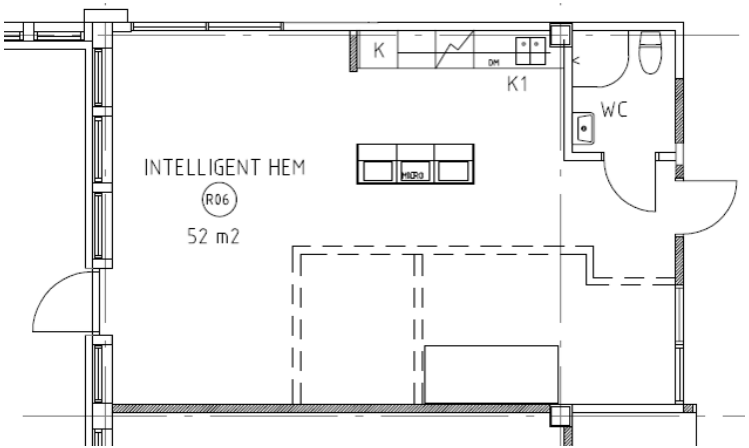
- Detecting deviations in behavior
- Generalizing over different homes and individuals
- Processing online data streams

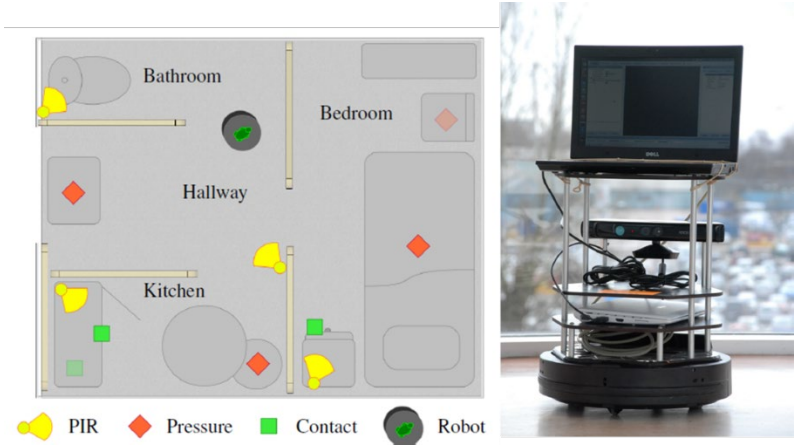
HALMSTAD UNIVERSITY

CAISR
Centre for Applied Intelligent Systems Research

Halmstad Intelligent Home

Fully functional research apartment equipped with sensors



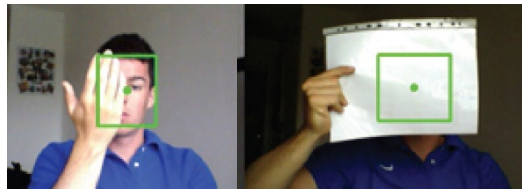


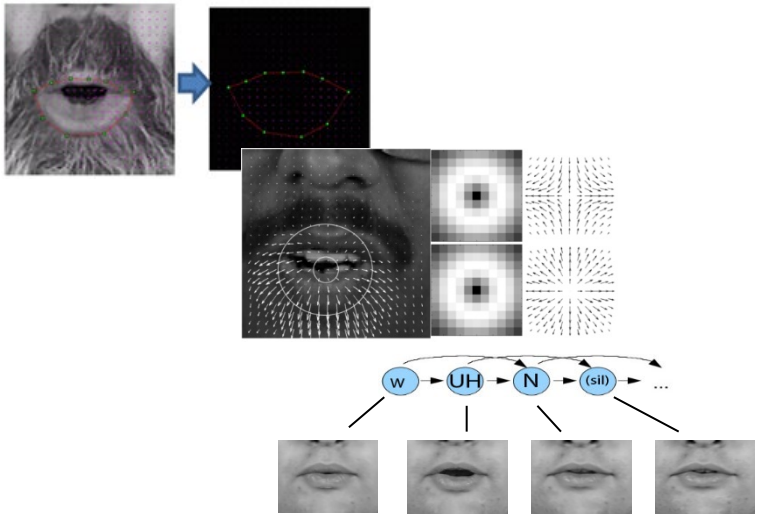
CAISR
Centre for Applied Intelligent Systems Research

Audiovisual Biometrics

Vetenskapsrådet

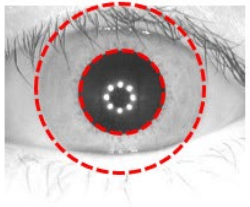
- Tracking and analysis of facial events
  - Face detection and tracking
  - Lip motion and lip reading
- Via optical flow analysis
  (motion from video)
  - Robust features, stability and speed
  - Real time implementation on handheld devices
- Applications
  - Messaging by lip reading (noisy environments)
  - Gesture, expression, emotion and cognitive load
  - Identity and liveness detection by lip motion

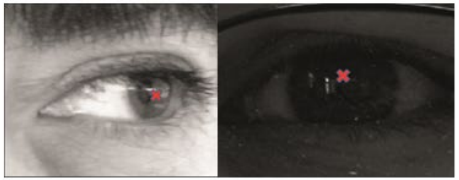




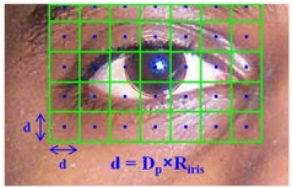
CAISR
Centre for Applied Intelligent Systems Research

Image Biometrics

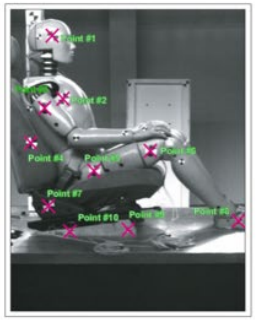


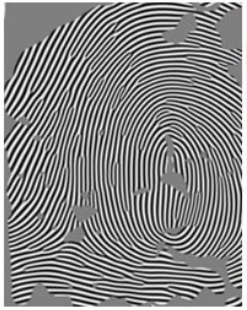


- Eye detection
- Iris segmentation
- Personal recognition



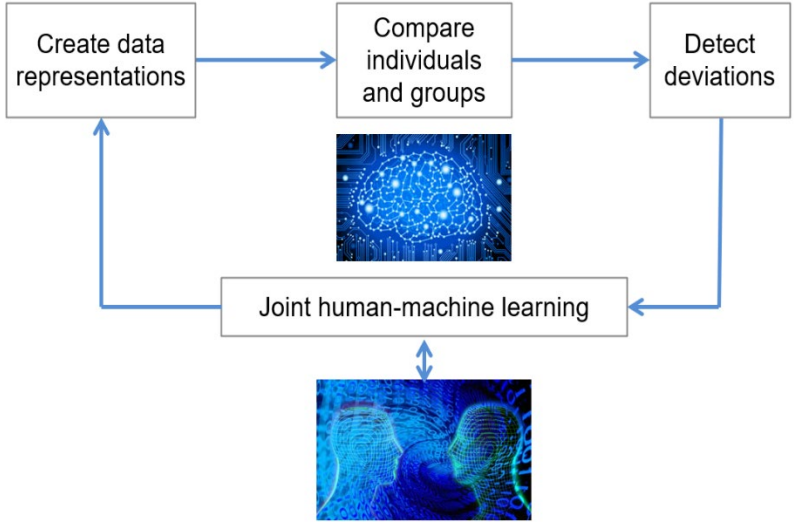
- Applications
  - Mobile devices
  - Driver monitoring
  - Human-machine communication

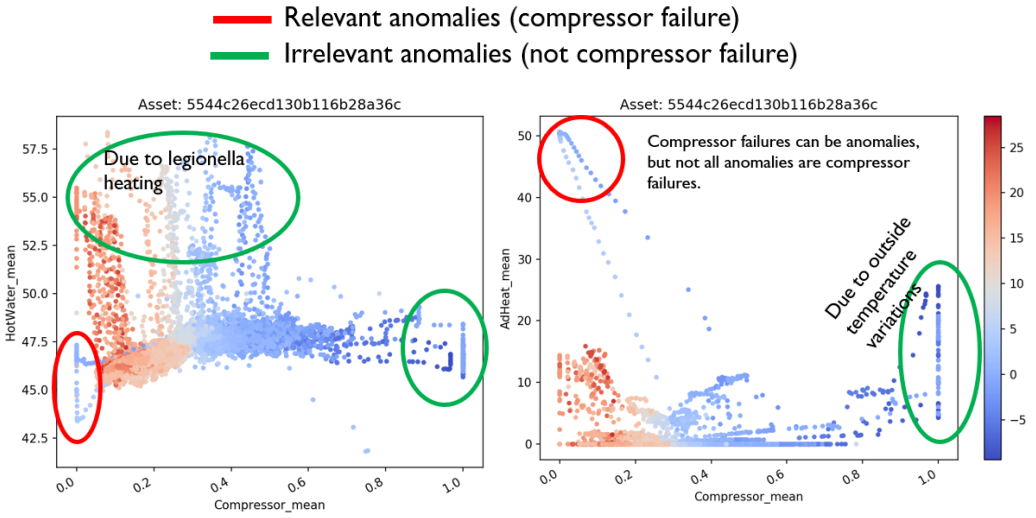




CAISR
Centre for Applied Intelligent Systems Research

SeMI: Self-Monitoring for Innovation





Interaction with experts to learn to detect anomalies that are more relevant for them.

EASYSERV connected service
ALFA LAVAL
HMS
ÖRESUNDS KRAFT
hem
HALMSTAD UNIVERSITY

CAISR
Centre for Applied Intelligent Systems Research

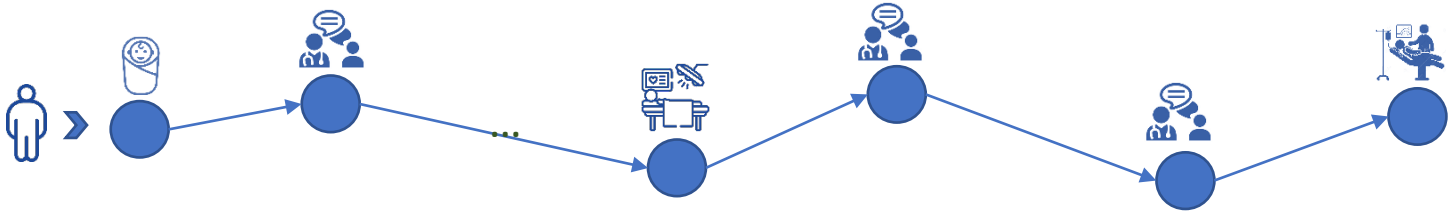
Research related to AI in Healthcare


AGING AT HOME
A.I. FAMILY DOCTOR?
HÖGSKOLAN I HALMSTAD


LIFE IN MOTION
VIRTUAL PERSONAL TRAINER?
HÖGSKOLAN I HALMSTAD


SELF-MANAGEMENT
AWARENESS THROUGH LIFE-LOGGING?
HÖGSKOLAN I HALMSTAD

Patient trajectory



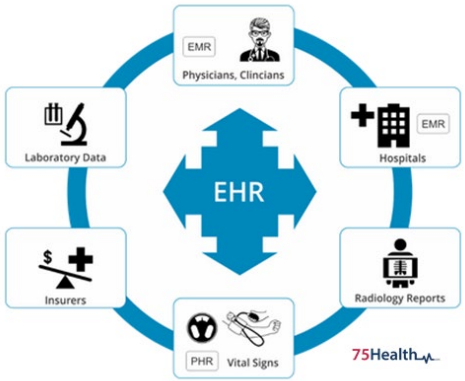
Electronic Health Records (EHR)

Health Data

EHR (Electronic Health Record)

- An **electronic health record** (**EHR**) is the systematized collection of patient and population electronically-stored health information in a digital format.

- Included in this information are:
  - patient demographics
  - progress notes
  - diagnosis
  - treatments
  - medications
  - vital signs
  - past medical history
  - immunizations
  - laboratory data
  - radiology reports
  - …

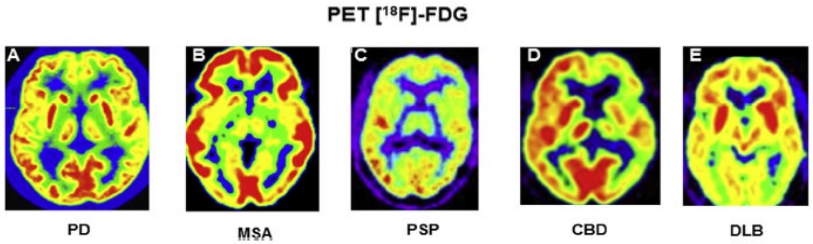


CAISR
Centre for Applied Intelligent Systems Research

Deep learning and XAI in Neuro-degenerative disorders

- ✓ apply deep and shallow learning in 18F-FDG-PET scans for detecting neuro-degenerative disorders
- ✓ visualizing ROIs for domain experts

E-DLB CONSORTIUM



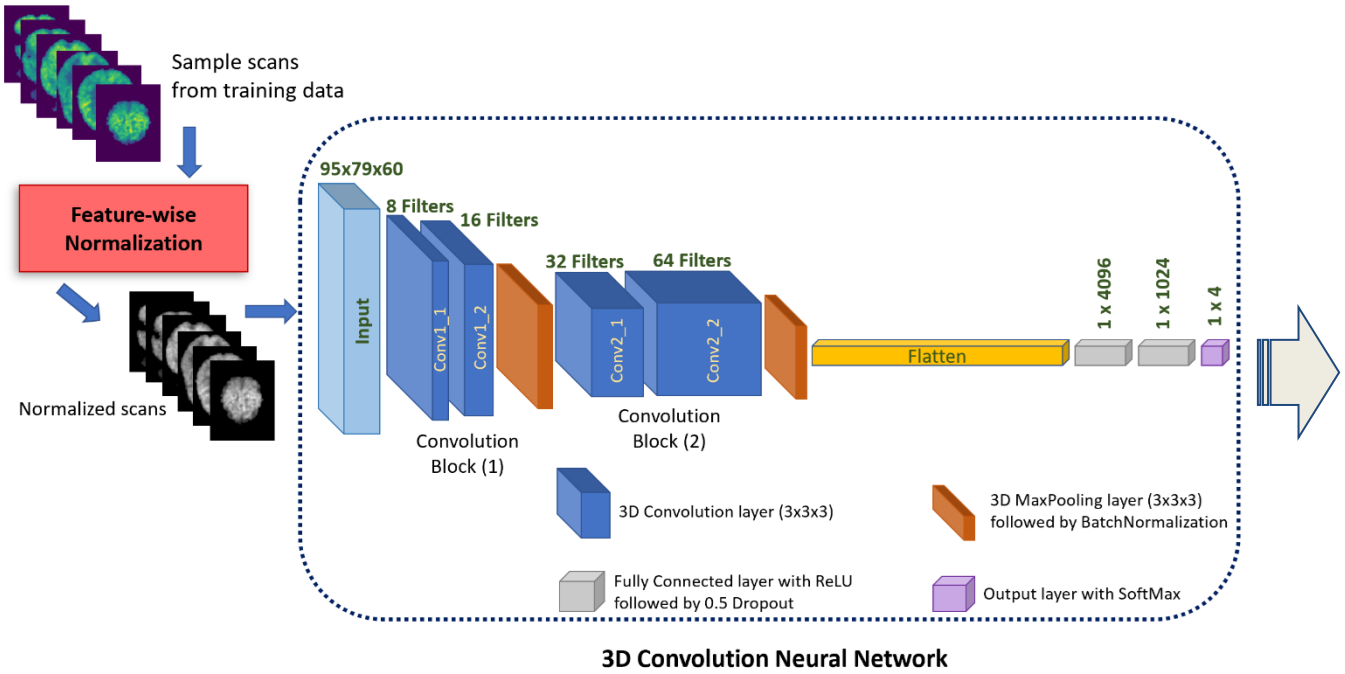
LINKÖPING UNIVERSITY

Contact : Kobra Etminani (kobra.etminani@hh.se)

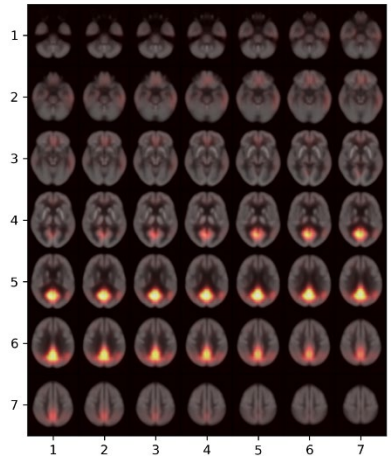
HALMSTAD UNIVERSITY

CAISR
Centre for Applied Intelligent Systems Research

Deep learning and XAI in Neuro-degenerative disorders



3D Convolution Neural Network



Contact : Kobra Etminani (kobra.etminani@hh.se)

HALMSTAD UNIVERSITY

CAISR
Centre for Applied Intelligent Systems Research

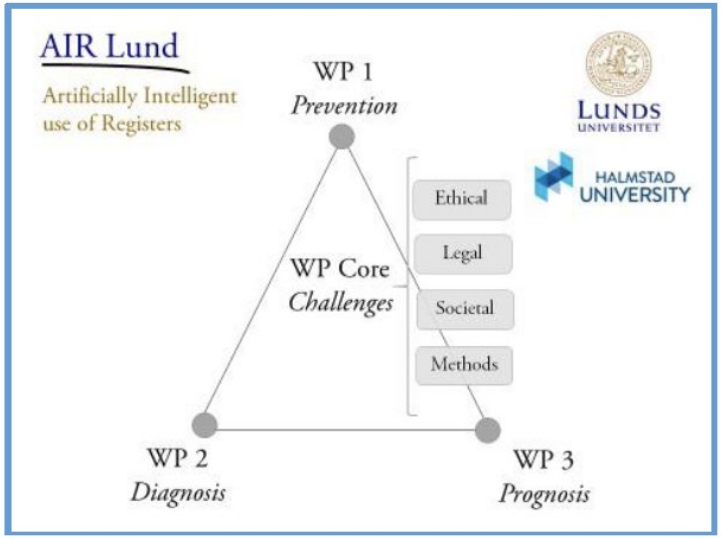
AIR Lund: Artificially Intelligent use of Registers

- cardiometabolic diseases
- assess the added value of machine learning compared to standard statistical approaches for:

1) prevention, where we hope to identify new groups of hidden high-risk individuals and new sets of modifiable risk factors

2) diagnosis, where we in emergency care hope to improve general risk assessment and diagnosis of acute coronary disease

3) prognosis, where we hope to improve long-term predictions and identify new risk patterns that forego adverse patient outcomes and high healthcare needs



CAISR
Centre for Applied Intelligent Systems Research

Healthcare system characteristics

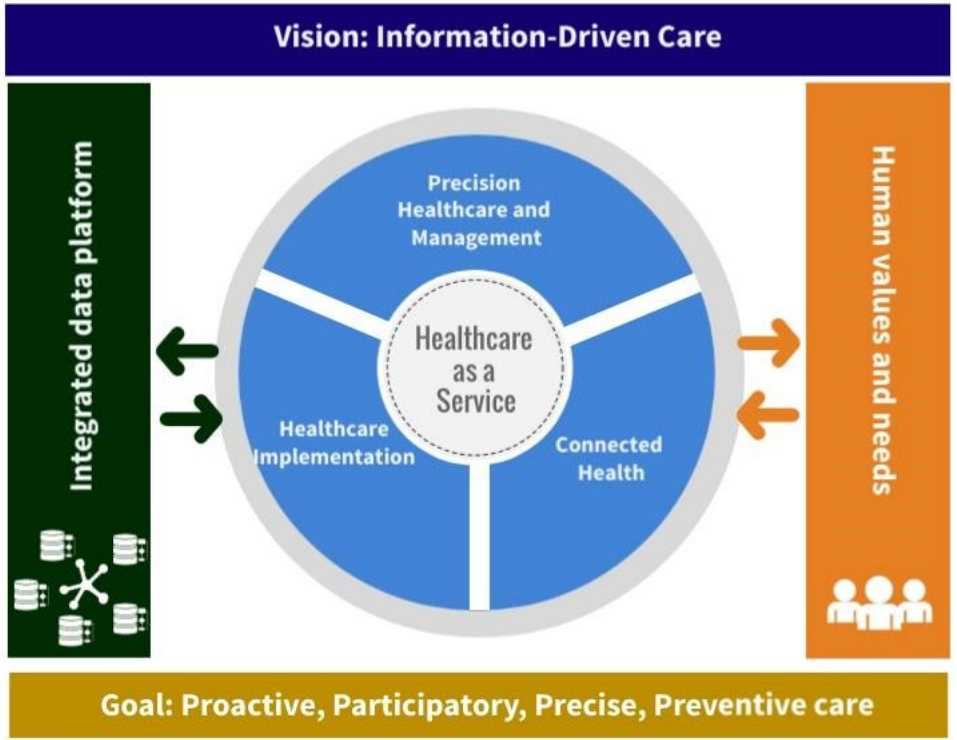
Now

Reforms needed

HALMSTAD UNIVERSITY

CAISR
Centre for Applied Intelligent Systems Research

CAISR Health



Contact : Kobra Etminani (kobra.etminani@hh.se)

CAISR
Centre for Applied Intelligent Systems Research

Region Halland

CAMBIO

Capio

VISIBA CARE

Mölnlycke®

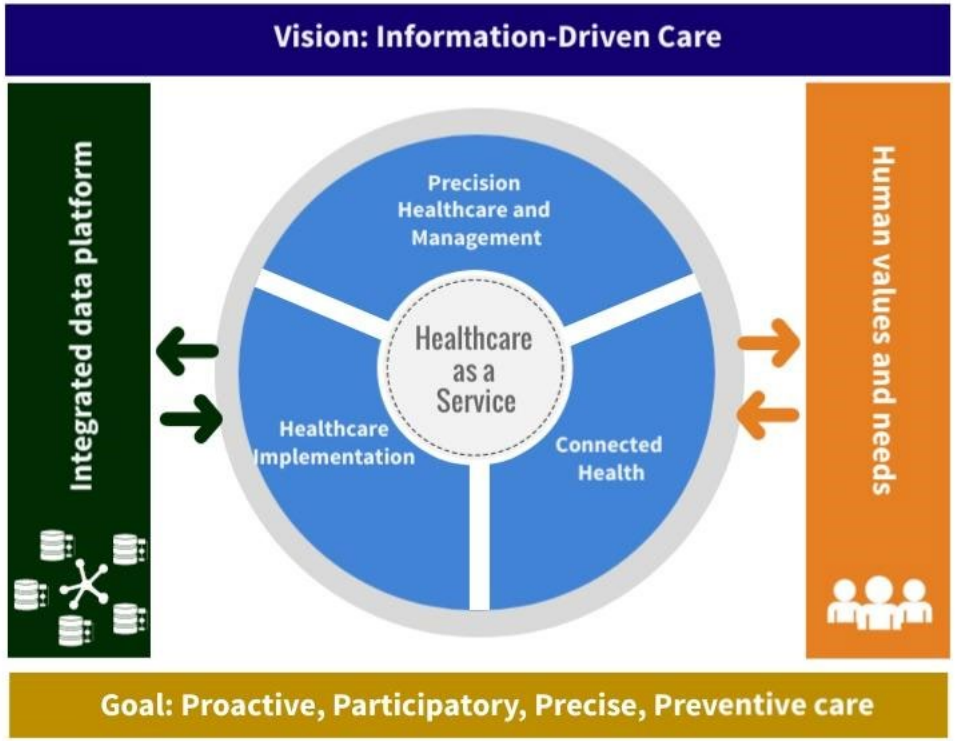
InterSystems

NOVARTIS

BRIGHAM HEALTH
BRIGHAM AND WOMEN'S HOSPITAL

Hallandia V

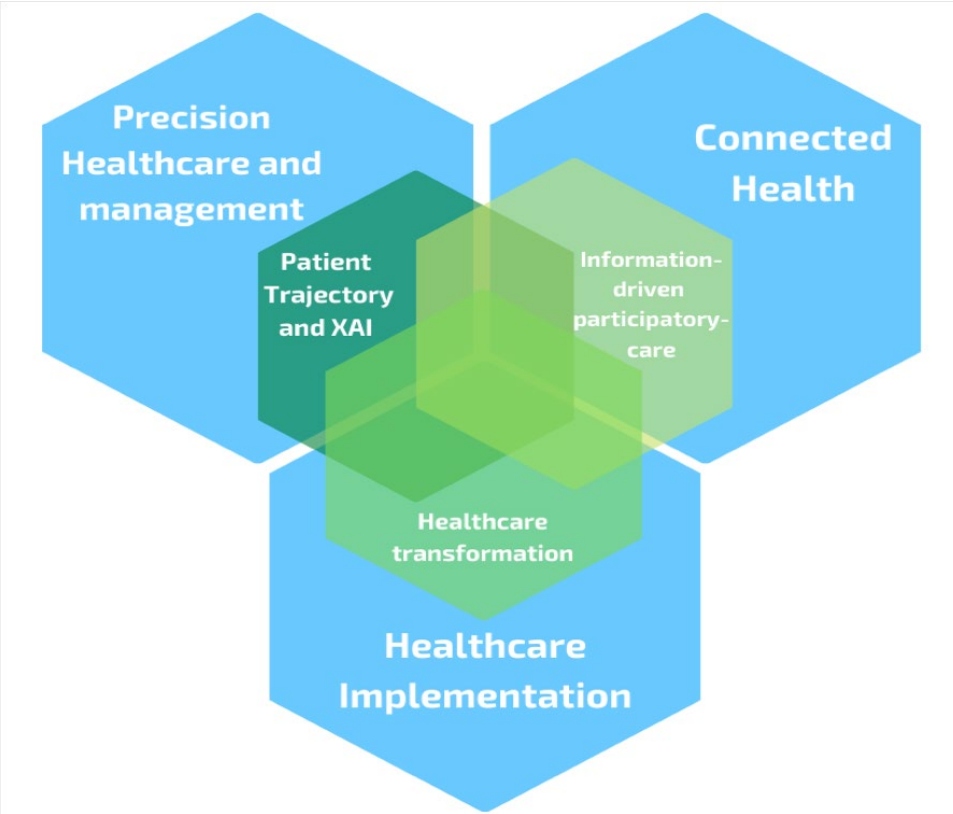
CAISR Health



Contact : Kobra Etminani (kobra.etminani@hh.se)

CAISR
Centre for Applied Intelligent Systems Research

Research areas within CAISR Health

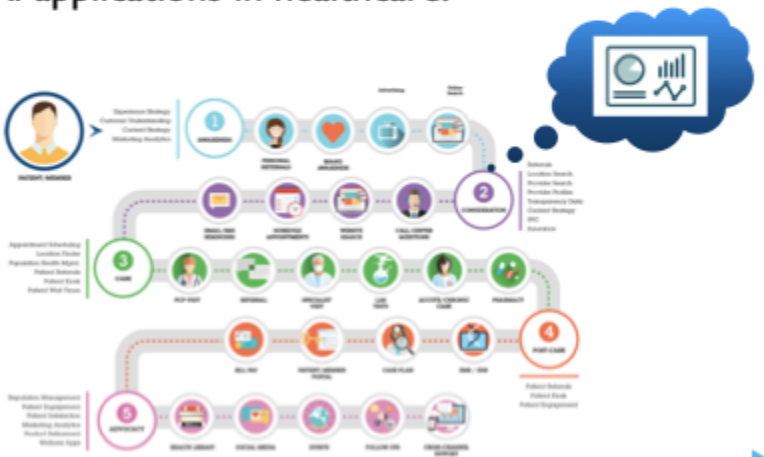


Contact : Kobra Etminani (kobra.etminani@hh.se)

CAIS
Centre for Applied In
Systems Research

SA1- patient trajectories and XAI

- A key prerequisite for **precision healthcare** is patient and disease characterization.
- **Patient trajectories** are a means of illustrating the temporal disease progression and correlations.
- These models often suffer from *inscrutability,* which prevents pervasiveness of AI applications in healthcare.



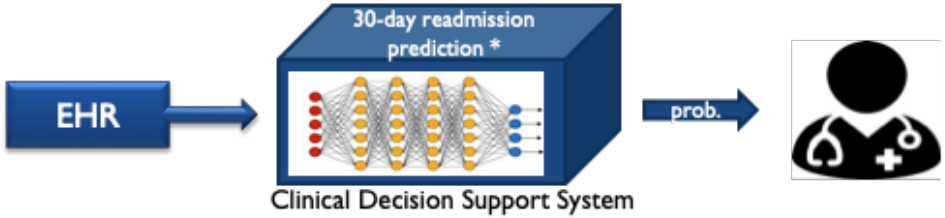
CAISR
Centre for Applied Intelligent Systems Research

Initial projects – Project 1

CAMBIO
InterSystems
Capio
Region Halland
Hallandia V

30-day readmission prediction

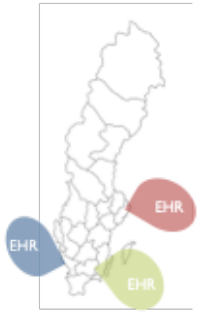
- ✓ hospitalised CHF patients
- ✓ implementation of a clinical decision support system (CDSS)
- ✓ cluster randomised clinical trial



Clinical Decision Support System

Objectives

- challenges of implementation
- method recalibration and completion
- explainable CDSS
- demonstrator



* Ashfaq, A., Sant'Anna, A., Lingman, M., & Nowaczyk, S. (2019). Readmission prediction using deep learning on electronic health records. *Journal of biomedical informatics*, *97*, 103256.

HALMSTAD UNIVERSITY

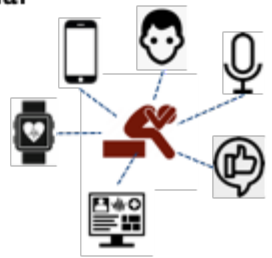
CAISR
Centre for Applied Intelligent Systems Research

Initial projects – Project 2

CAMBIO
InterSystems
Capio
VISIBA CARE
Hallandia V
Region Halland

Mental illness early prediction

- ✓ Between 20 and 40 percent of people in Sweden have mental health problems at any one time, out of which 5-10 percent need psychiatric treatment
- ✓ Based on a recent study in Region Halland using GHQ5 (General Health Questionnaire), near 15 percent of the population living here are suffering from mental illnesses, and women in Halland show greater mental illness.
- ✓ Emotional states can be expressed by a variety of physiological biomarkers including heart rate, blood pressure variations, facial expression and the acoustics of speech.



Objectives

- understand mental illness indicators/predictors
- obtain phenotyped mental illness profiles
- develop explainable prognostic/prediction models as a clinical decision support system
- evaluate the developed models in laboratory and field settings

CAISR
Centre for Applied Intelligent Systems Research

Master Thesis Projects (Examples)

CAISR
Centre for Applied Intelligent Systems Research

Started in 202

Ongoing Master Thesis Topics

- Generative Approach for Multivariate Signals
- Graph Neural Networks for Traffic Flow Forecasting
- Quantifying exercise-induced muscle fatigue by machine learning
- A Comprehensive Experimental Evaluation of Federated Learning Frameworks
- Action Library for Robot Execution
- Graph Neural Networks for cardiovascular disease
- NLP - Automatic Cloze Test Generation for Japanese
- Meta-learning for Multivariate Signals
- Development of a motion controller for a dual-arm robot
- Fair representation learning of electronic health records
- ...

CAISR
Centre for Applied Intelligent Systems Research

Started in 2021

Recent Master Thesis Topics

- Automatic Idea Detection for controlling Healthcare-associated infections
- Deep Networks for Semantic Scene Understanding
- Music style transfer
- Autonomous flying drone for vehicle classification
- Optimising Energy Consumption for Ferries in Collaboration with Cetasol
- LiDAR Denoising
- Transfer Learning for Network Security
- Uncertainty quantification for data-driven clinical decision making
- ...

CAISR
Centre for Applied Intelligent Systems Research

Started in 2020

Recent Master Thesis Topics

- Prioritize informative structures in 3D brain images
- Feature-wise normalization for 3D medical images
- Representation learning for anomaly detection in district heating
- Anomaly Detection of the Activities of the Elderly Living in the Smart Home
- Joint Human-Machine Exploration of Industrial Time-Series using the UCR Matrix Profile
- Deep reinforcement learning in financial markets
- Detecting and Characterizing Dangerous Situation in Traffic
- ...

CAISR
Centre for Applied Intelligent Systems Research

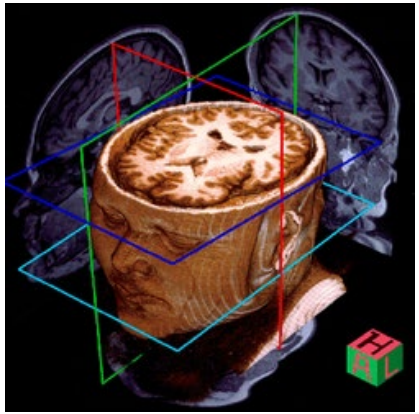
Started in 2019

Recent Master Thesis Topics

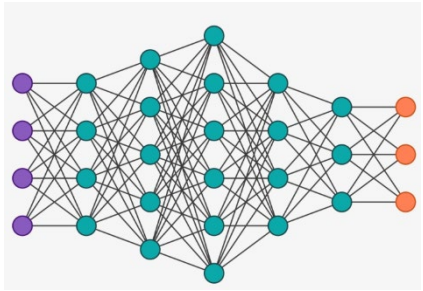
- Analyzing white blood cells in blood samples using deep learning techniques
- Interactive anomaly detection with reduced expert effort
- Forklift Trucks Usage Analysis
- Prediction of neurodegenerative disorders based on brain images
- Bird-detection and classification using sensor fusion
- Protecting bikers in traffic by computer vision
- Transfer Learning for Machine Diagnostics and Prognostics
- Clustering of battery usage pattern for Electric buses
- …

CAISR
Centre for Applied Intelligent Systems Research

Prioritize informative structures in 3D brain images



3D PET scan



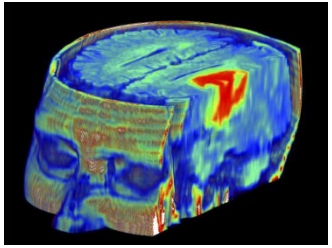
3D-CNN

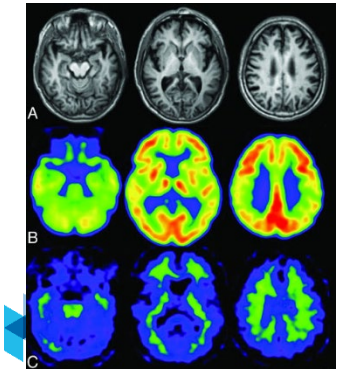
1-Alzheimer's

2-Dementia with Lewy bodies

3-Mild Cognitive Impairment

4-Normal

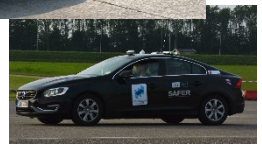


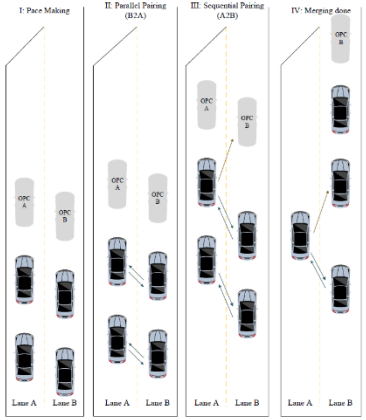


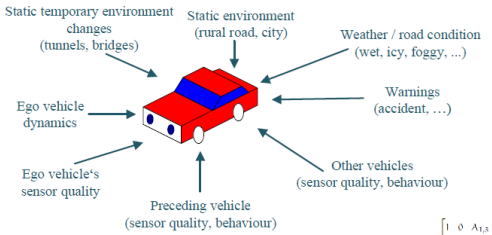
CAISR
Centre for Applied Intelligent Systems Research

Modelling the Level of Trust in a Cooperative Automated Vehicle Control System

Thomas Rosenstatter







$$A = \begin{bmatrix} 1 & 0 & A_{1,3} & A_{1,4} & A_{1,5} & A_{1,6} \\ 0 & 1 & A_{2,3} & A_{2,4} & A_{2,5} & A_{2,6} \\ 0 & 0 & 1 & 0 & \mathrm{sign}(v)\mathrm{T} & 0 \\ 0 & 0 & 0 & 1 & 0 & \mathrm{T} \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \quad (A.1)$$

$$A_{1,3} = -\sin(\varphi)(v\mathrm{T} + a\frac{\mathrm{T}^2}{2}) - \cos(\varphi)(v\dot{\varphi}\frac{\mathrm{T}^2}{2} + 2a\dot{\varphi}\frac{\mathrm{T}^3}{6}) \quad (A.2a)$$

$$A_{1,4} = \cos(\varphi)\mathrm{T} - \sin(\varphi)(\dot{\varphi}\frac{\mathrm{T}^2}{2}) \quad (A.2b)$$

$$A_{1,5} = -\sin(\varphi)(v\frac{\mathrm{T}^2}{2} + 2a\frac{\mathrm{T}^3}{6}) \quad (A.2c)$$

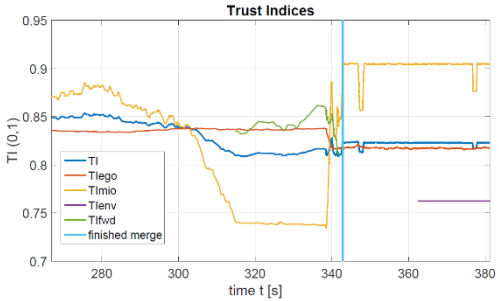
$$A_{1,6} = \cos(\varphi)\frac{\mathrm{T}^2}{2} - \sin(\varphi)(2\dot{\varphi}\frac{\mathrm{T}^3}{6}) \quad (A.2d)$$

$$A_{2,3} = \cos(\varphi)(v\mathrm{T} + a\frac{\mathrm{T}^2}{2}) - \sin(\varphi)(v\dot{\varphi}\frac{\mathrm{T}^2}{2} + 2a\dot{\varphi}\frac{\mathrm{T}^3}{6}) \quad (A.2e)$$

$$A_{2,4} = \sin(\varphi)\mathrm{T} + \cos(\varphi)(\dot{\varphi}\frac{\mathrm{T}^2}{2}) \quad (A.2f)$$

$$A_{2,5} = \cos(\varphi)(v\frac{\mathrm{T}^2}{2} + 2a\frac{\mathrm{T}^3}{6}) \quad (A.2g)$$

$$A_{2,6} = \sin(\varphi)\frac{\mathrm{T}^2}{2} + \cos(\varphi)(2\dot{\varphi}\frac{\mathrm{T}^3}{6}) \quad (A.2h)$$



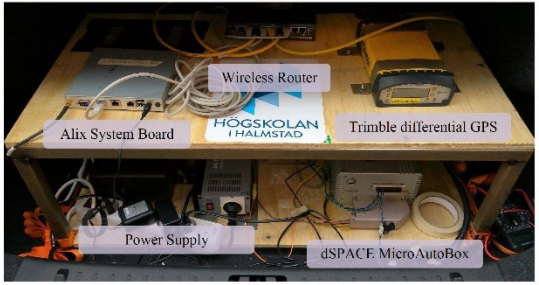


Figure 5.2: The trunk of the competition car with its devices.

STAD
RSITY

CAISR
Centre for Applied Intelligent Systems Research

Swedish AI Society | SAIS

Swedish Artificial Intelligence Research

[Link to the thesis report]

SAIS Best AI Master's Thesis Award 2017

The SAIS board is happy to award Thomas Rosenstatter, Högskolan i Halmstad, the 2017 SAIS Master's Thesis Award

The thesis introduces a **trust system** that allows an autonomous vehicle, in this case a car, to make **more reliable and safe decisions** by taking into account current information about its context (the surrounding vehicles etc.). This work was partly evaluated as part of the winning team in the Grand Cooperative Driving Challenge 2016. The thesis addresses a topic that is timely and of high practical relevance in today's AI community. The thesis is well written and has the potential of both impacting future research in the field, and practical applications. Presentation of the thesis at the SAIS workshop will surely create some interesting discussions.

HALMSTAD UNIVERSITY

Drone Detection and Classification using Machine Learning and Sensor Fusion

"The thesis is in the areas of machine learning and presents a system for multi-sensor-based drone detection and classification as well as a drone detection dataset. The thesis is well written, comprehensive and technically sound, with interesting results, not least in terms of the practical feasibility of multi-sensor-based drone detection. The thesis also offers an interesting outlook and constitutes a good starting point for future work."

Student stories /

Best AI Master's Thesis Award 2021

Fredrik Svanström, a previous student at the Master's programme in Embedded and Intelligent Systems, has received the best AI Master's Thesis Award from the Swedish AI Society, SAIS. Congratulations!

The thesis is about detection of unauthorised drones at for example airports. Fredrik Svanström designed and built an automatic drone detection system that utilises machine learning and sensor fusion, which means that data from several different sources are combined. Besides the common video and audio sensors, the system also includes a thermal infrared camera and a receiver for aircraft transponder data. All collected data used to train and validate the system is published in an open database.

CAISR
Centre for Applied Intelligent Systems Research

- MSc thesis won a scholarship c SEK 50,000 from Getinge Sterilization AB.

- ” **Visual Transformers for 3D Medical Images Classification: Use - Case Neurodegenerative Disorders** ” by Pooriya Khorramyar.

Pooriya Khorramyar från Masterprogrammet i inbyggda intelligenta system belönades med, utöver stipendiet, utexpostatyetten som är framtagen av Högskolans Fab Lab.

https://www.hh.se/information/nyheter/nyheter/2022-09-02-studenter-belonades-med-100-000-kronor-for-sina-halsoinnovationer.html

HALMSTAD UNIVERSITY

You can find more examples of Msc Thesis projects (drafts) on:

https://caisr.hh.se/Student_projects

CAISR
Centre for Applied Intelligent Systems Research

Aware Intelligent Systems

- Slawomir Nowaczyk
- Kobra Etminani

2023-03-27