

Center for Applied Intelligent Systems Research

- Sławomir Nowaczyk
- Amira Soliman

2024-03-27



Presenters

Amira
Soliman



Assistant Professor, ISDD

Research: Machine Learning

- ML and AI in the healthcare domain
- Healthcare informatics

Slawomir
Nowaczyk



Professor in Machine Learning, ISDD

Research: Machine Learning & AI

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


CAISR


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




- Specialisation: Artificial Intelligence (TACDA)

Profilering mot Artificiell intelligens (ARIN)			
År 4	Valbar kurs	Artificiell intelligens	Läraktiga system
	Valbar kurs	Tekniska beräkningar	Intelligenta fordon
	Perspektiv på data science		Edge computing och internet of things
			Paralleldatorprogr. 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

Övriga valbara kurser inom profilen

Lp 1 (år 4 eller 5)

Data mining 7.5 hp (år 5, kräver Artificiell intelligens)

Digital tjänsteinnovation 7.5 hp

Halvledarkomponenter 7.5 hp

Inbyggda realtidssystem 7.5 hp

Konstruktion av inbyggda och intelligenta system 15 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

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

Intelligenta fordon 7.5 hp

Tillförlitlig och tidskritisk datakommunikation 7.5 hp

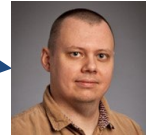
* Termin 7, 9 alternativt hela år 5 kan läsas utomlands

** Alternativt Arbetsplatsförlagd utbildning 15 hp (AFU)

- 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



Example courses (with aims)

Examples of fundamental courses

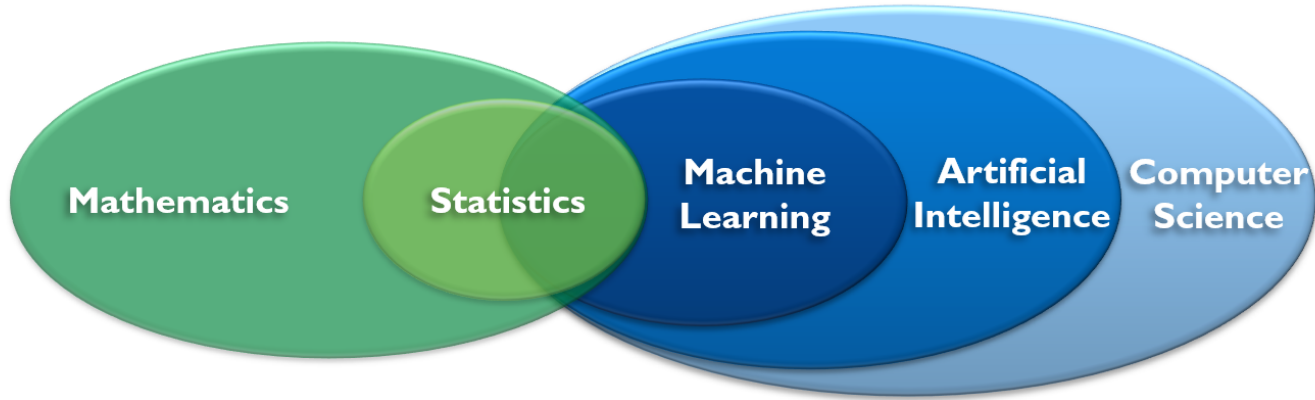
- **Artificial Intelligence**
 - How to allow machines to do “reasoning” and be more intelligent
- **Learning Systems**
 - How to allow machines to learn (from experience/data) how to perform a task
- **Image Analysis**
 - How to allow machines to understand images (computer vision)

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, and more

What is Machine Learning

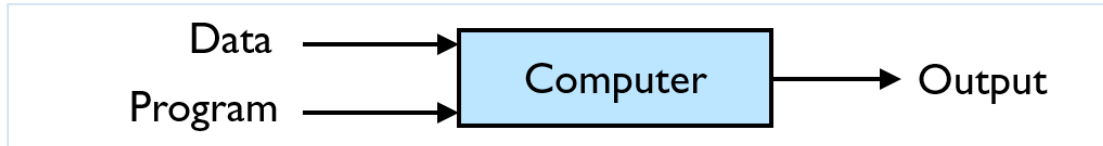
- A subfield of artificial intelligence (AI) that gives machines the ability to **learn** and improve from experience.



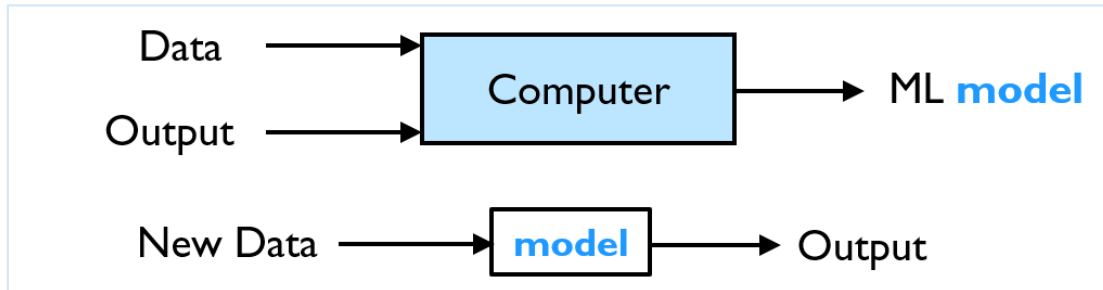
- Instead of explicitly programming a machine to perform a task, we program it to **learn** how to perform the task.

What is Machine Learning

- Usual programming



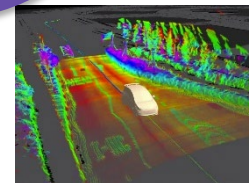
- (Supervised) Machine Learning



Intelligent Vehicles

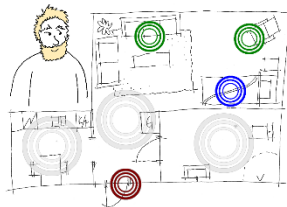


Predictive Maintenance



Aware and Intelligent Systems

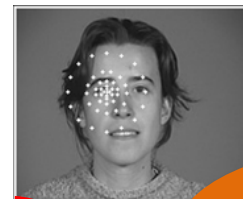
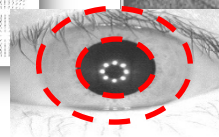
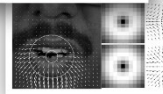
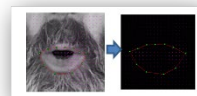
Healthcare Technology



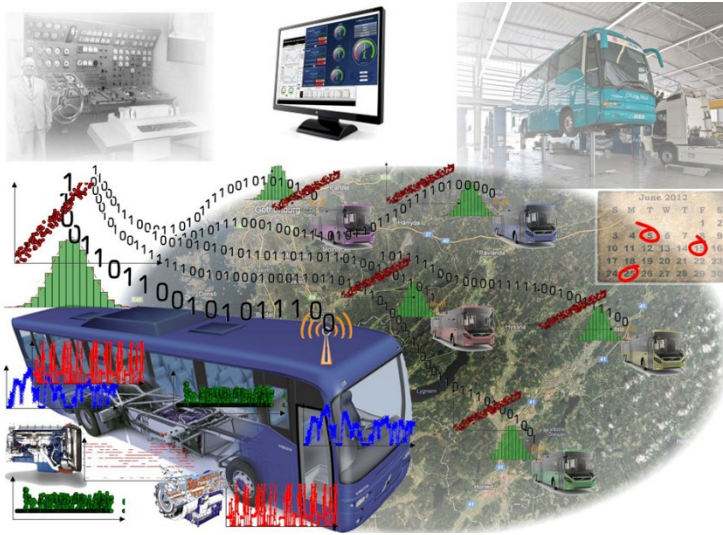
Information driven care

Others, e.g.

- Biometrics
- Smart Energy



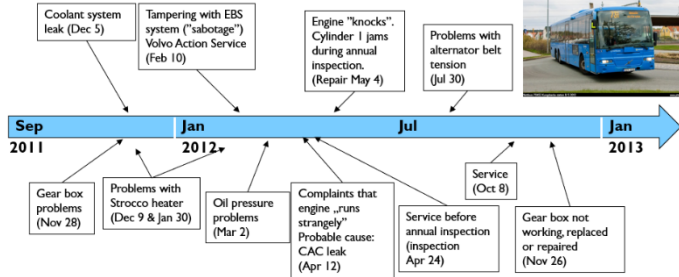
Increased security with facial recognition



Research related to Intelligent Vehicles

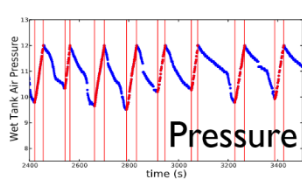


Predictive Maintenance for Trucks and Buses



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

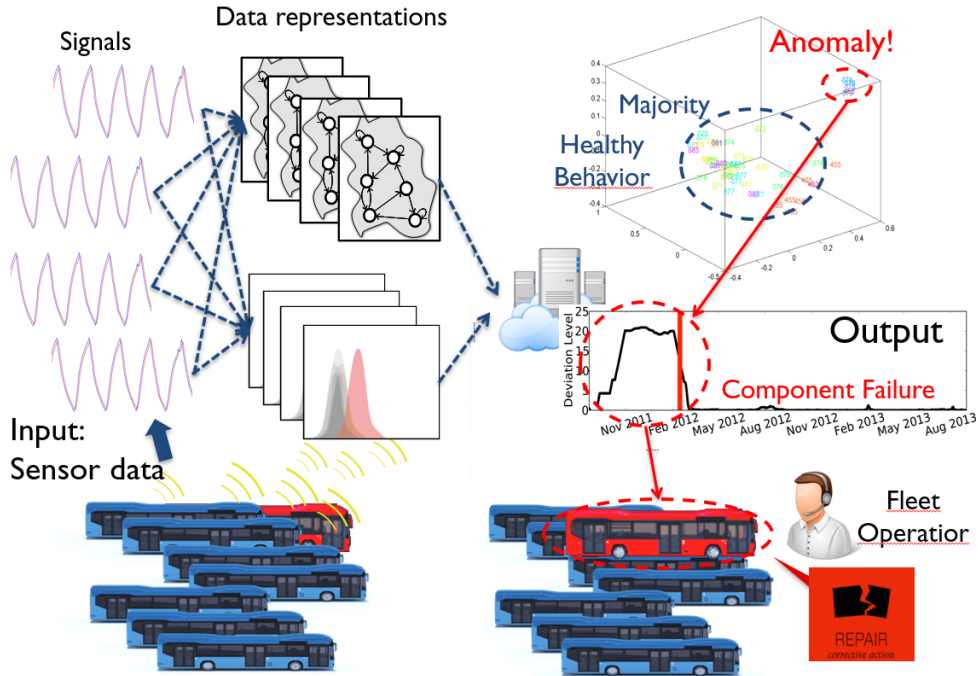
On-board Data (Sensor reading)



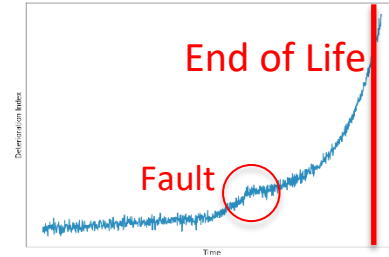
- Monitoring of vehicle operation to detect anomalies.
- Unsupervised approach towards vehicle diagnostics and maintenance.
- Combining various sources of data: on-board data, drivers' comments, maintenance logs, etc.

Autonomous Condition Monitoring System

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



Predicting remaining useful life



Other related project

- **EVE: Extending life of Vehicles** within Electromobility 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™

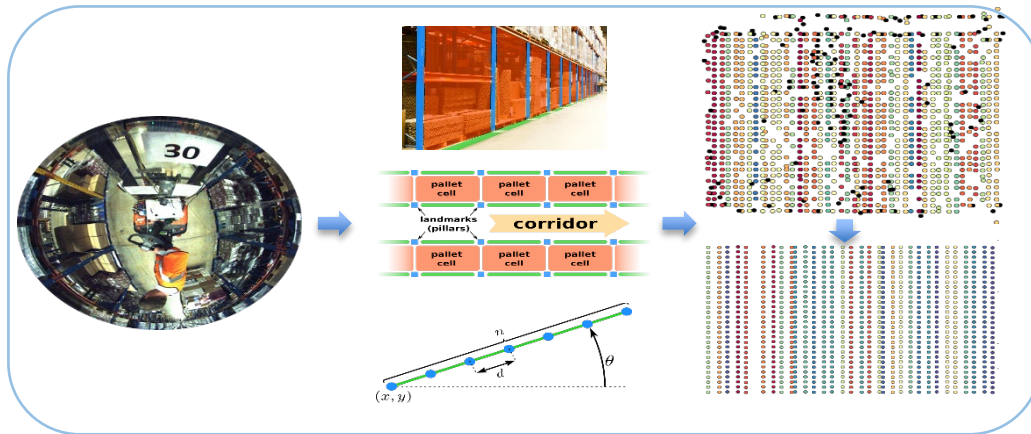
TOYOTA

TOYOTA MATERIAL HANDLING EUROPE

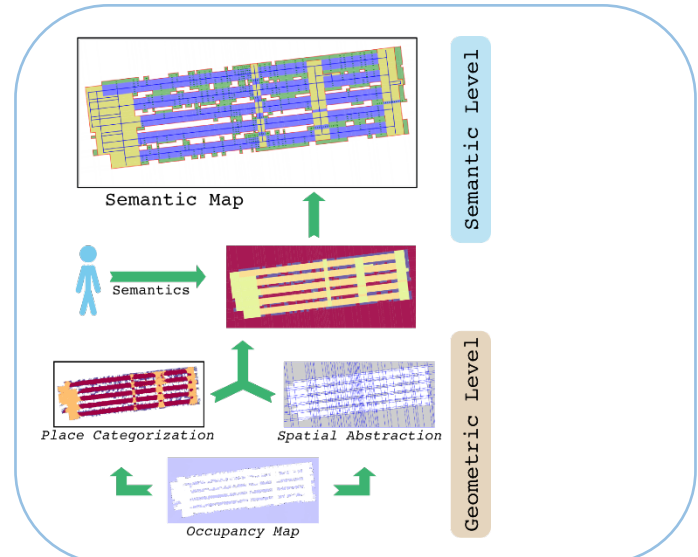
OPTRONIC

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

AI-based Perception for Autonomous Driving

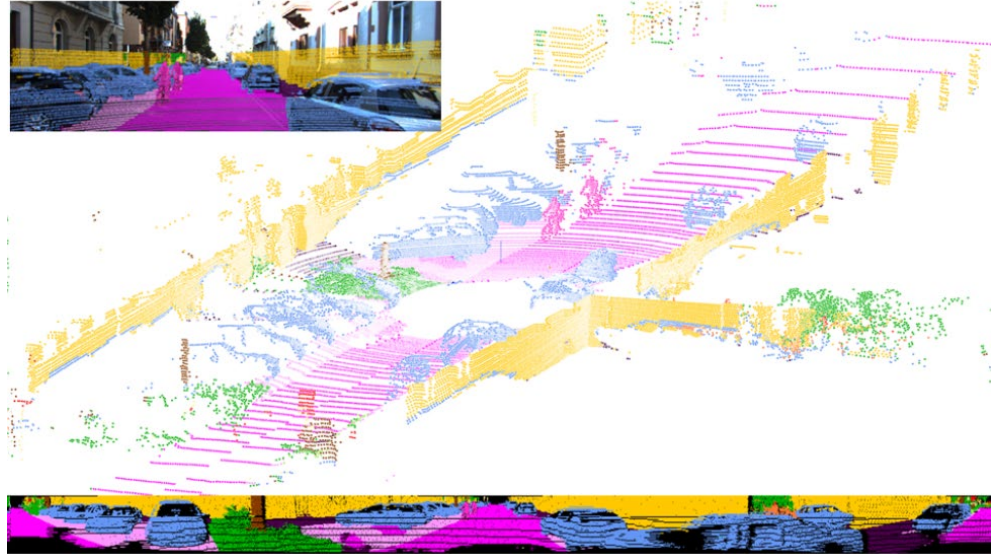
LiDAR (Light Detection and Ranging)

- 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.



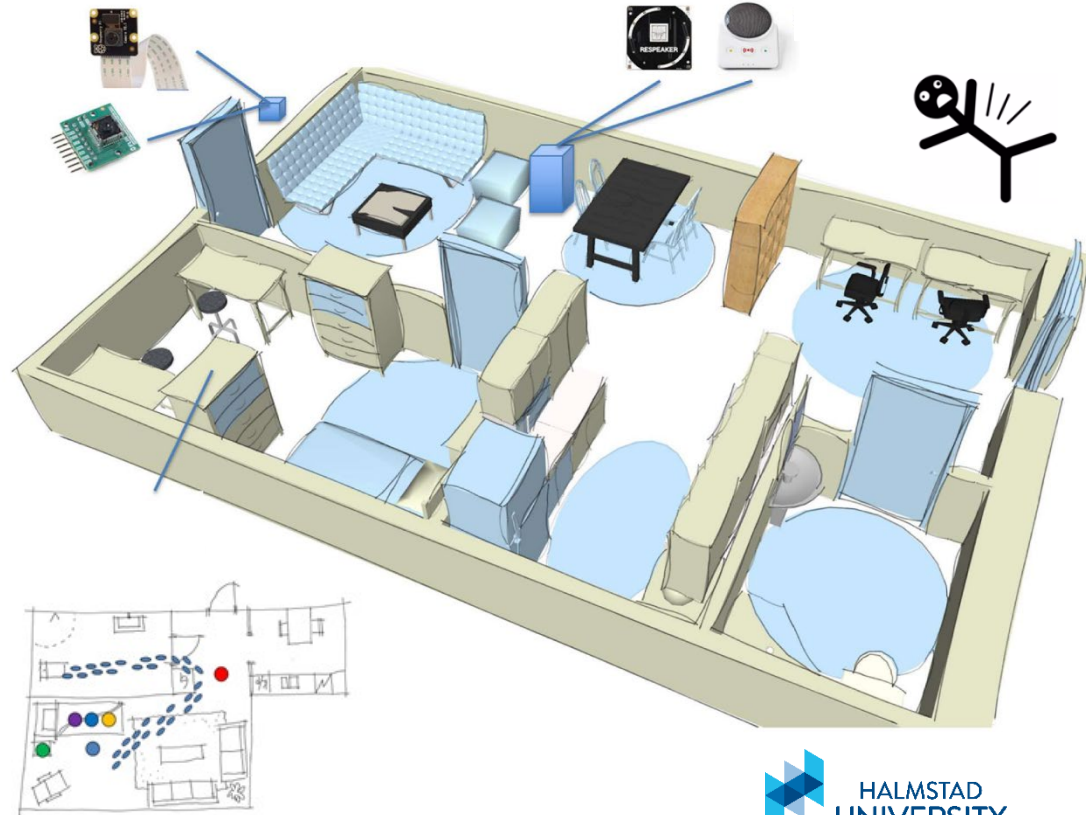
Others areas:

- ❖ Smart home environments
- ❖ Smart energy
- ❖ Biometrics



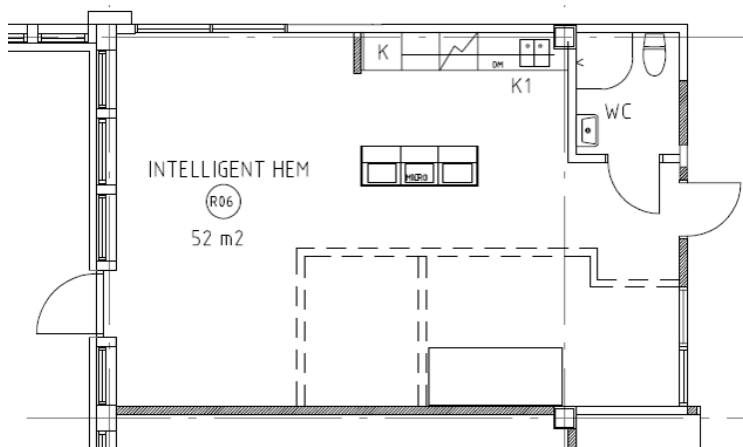
Situation Awareness for Ambient Assisted Living

- 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 Intelligent Home

Fully functional research apartment equipped with sensors



PIR Pressure Contact Robot



- 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

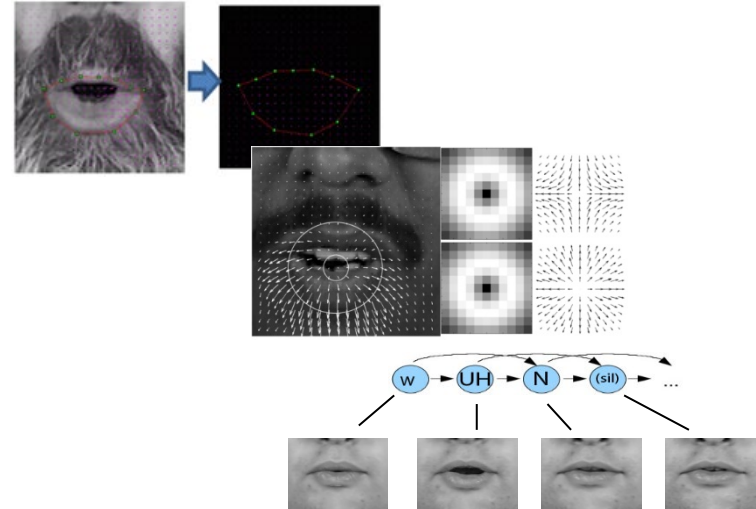
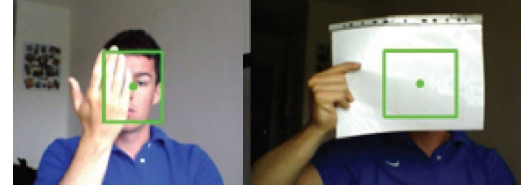
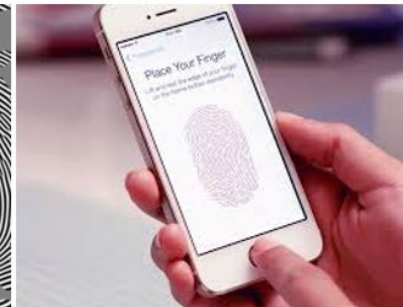
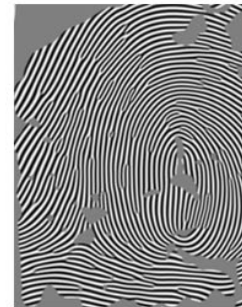
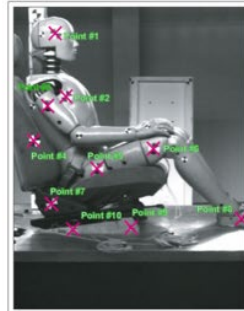
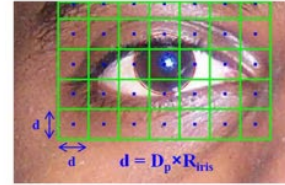
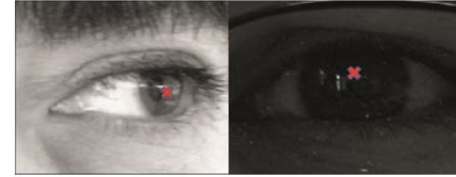
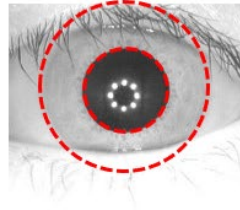


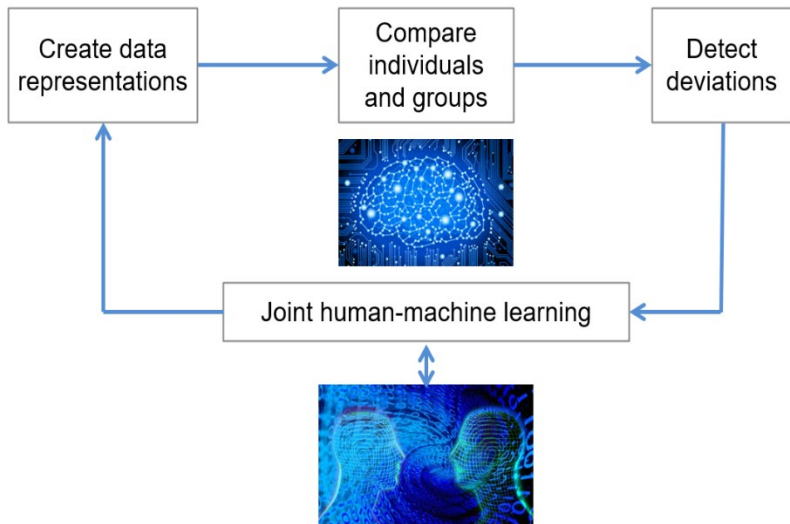
Image Biometrics

- Eye detection
- Iris segmentation
- Personal recognition

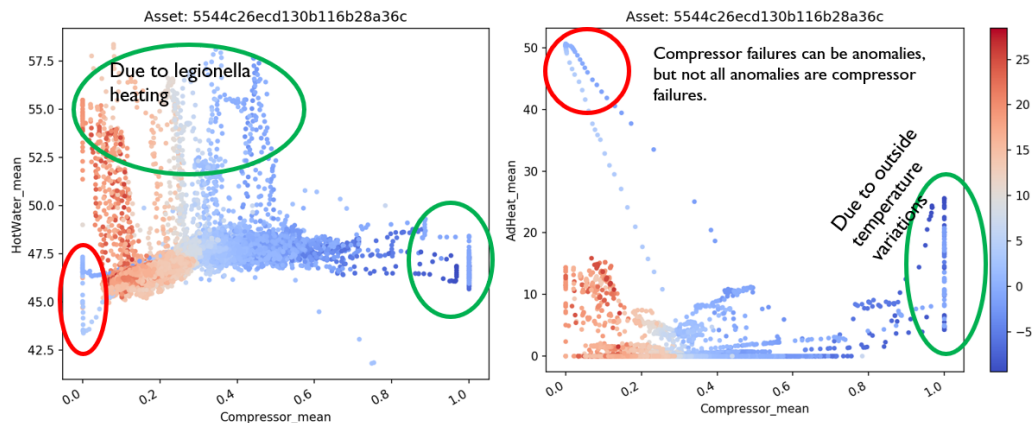
- Applications
 - Mobile devices
 - Driver monitoring
 - Human-machine communication



SeMI: Self-Monitoring for Innovation



— Relevant anomalies (compressor failure)
— Irrelevant anomalies (not compressor failure)



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

Research related to AI in Healthcare

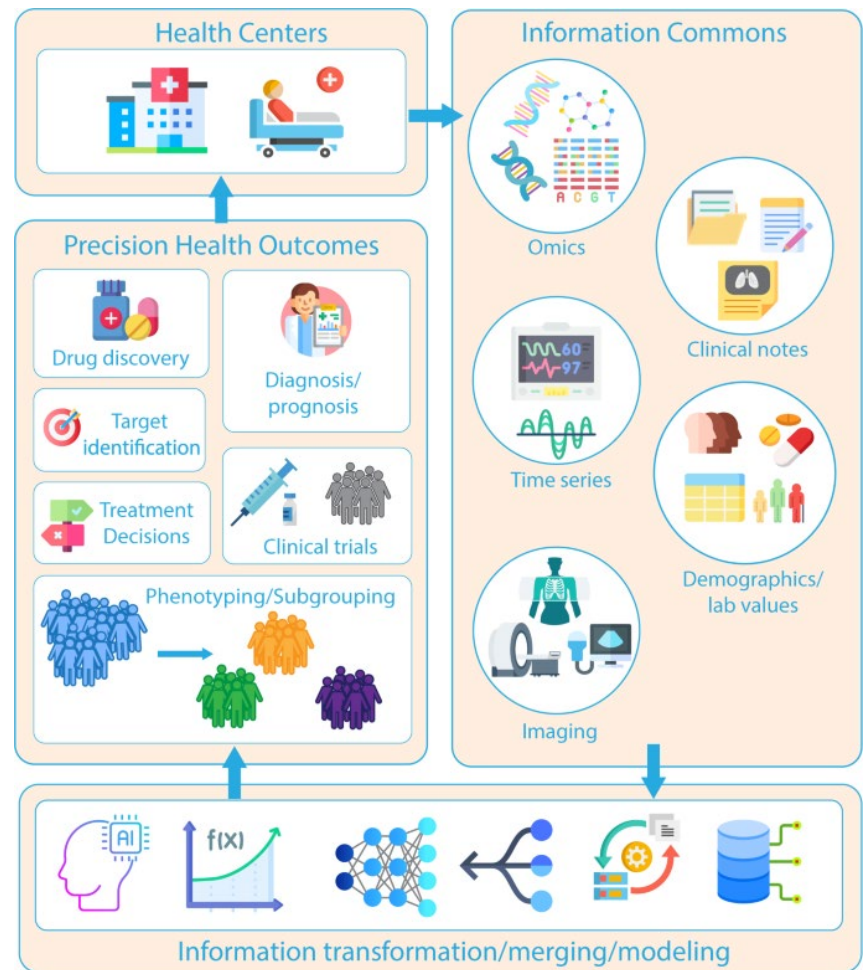




The future is more data-driven

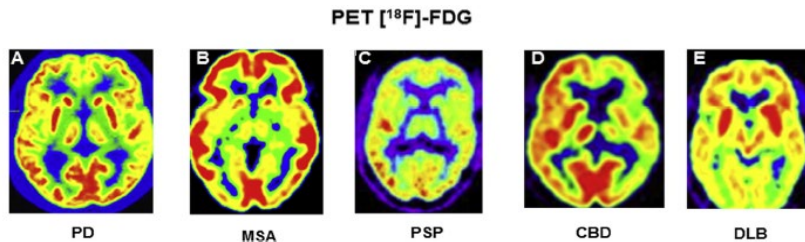
- Information moves in a cyclical pattern from health centers to information commons, where it can be transformed, and algorithmic modeling performed.
- These algorithms provide insight into many different health outcomes such as clinical trials, phenotyping, drug discovery, etc.
- These insights should return to health centers and practitioners to provide the most efficient, evidence-based medicine possible.

Kline, Adrienne, et al. "Multimodal machine learning in precision health: A scoping review." npj Digital Medicine 5.1 (2022): 171.

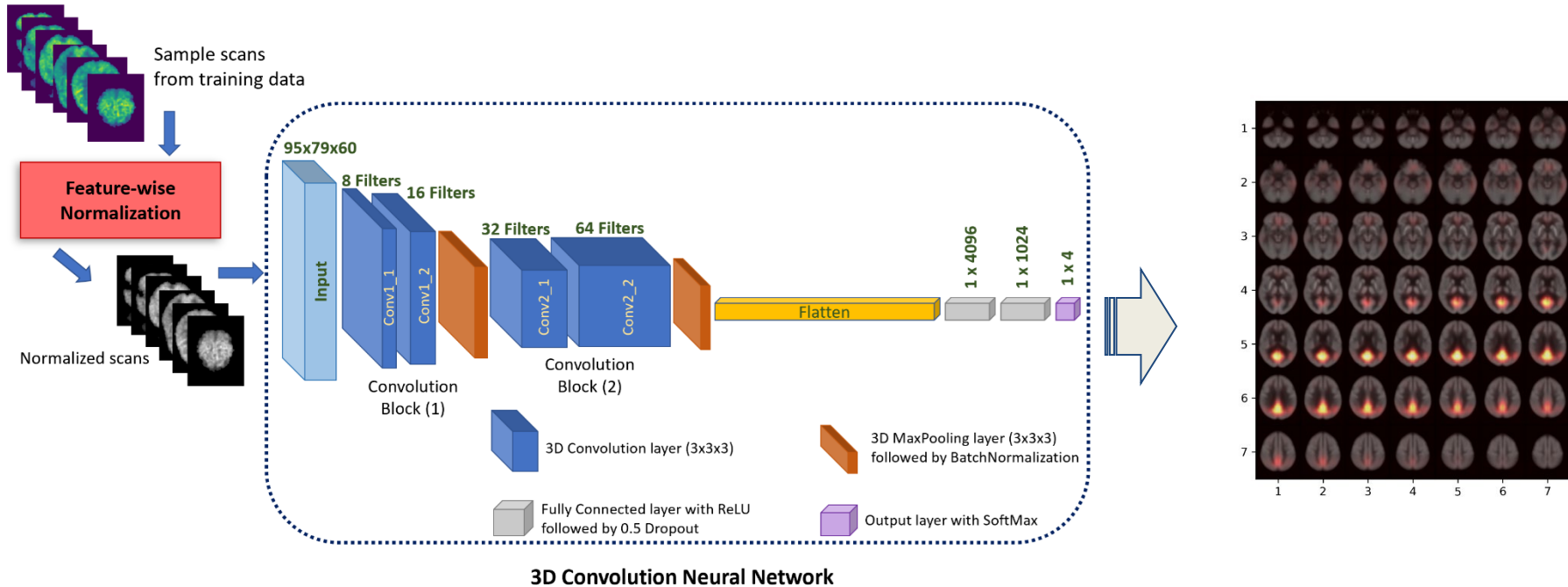


Deep learning and XAI in Neuro-degenerative disorders

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



Deep learning and XAI in Neuro-degenerative disorders



Etminani, Kobra, et al. "A 3D deep learning model to predict the diagnosis of dementia with Lewy bodies, Alzheimer's disease, and mild cognitive impairment using brain 18F-FDG PET." *European journal of nuclear medicine and molecular imaging* (2022): 1-22.

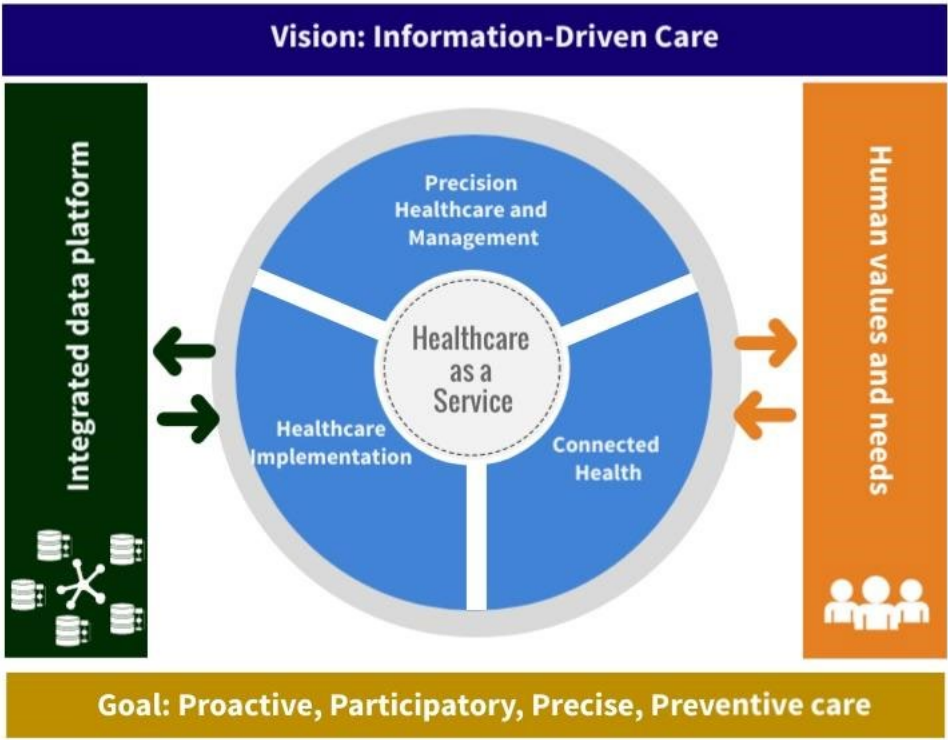
Healthcare system characteristics

Now

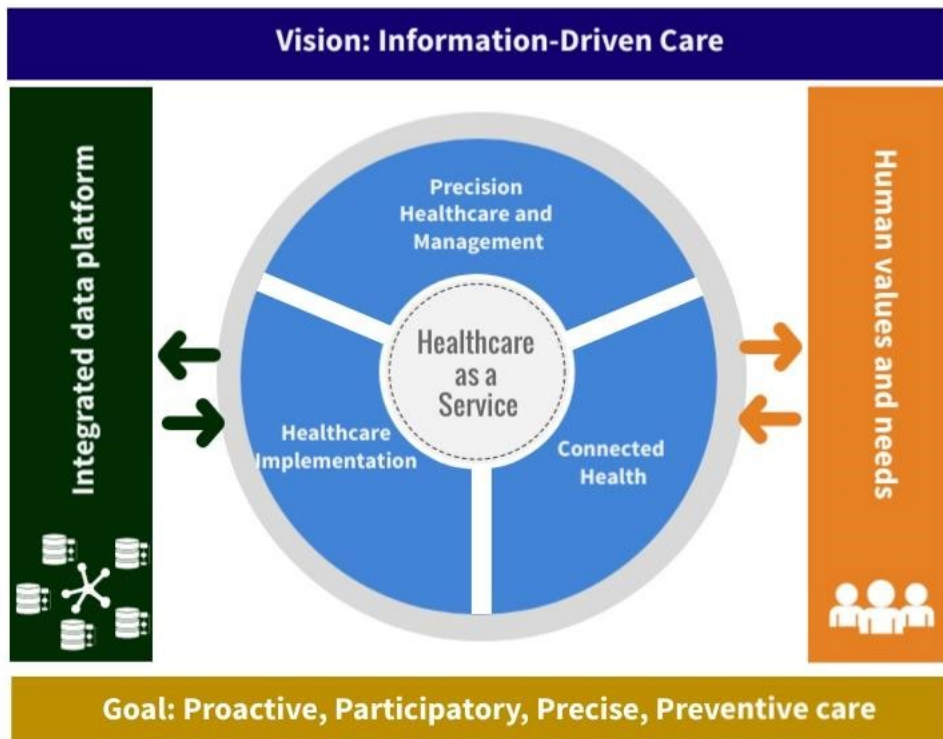


Reforms
needed

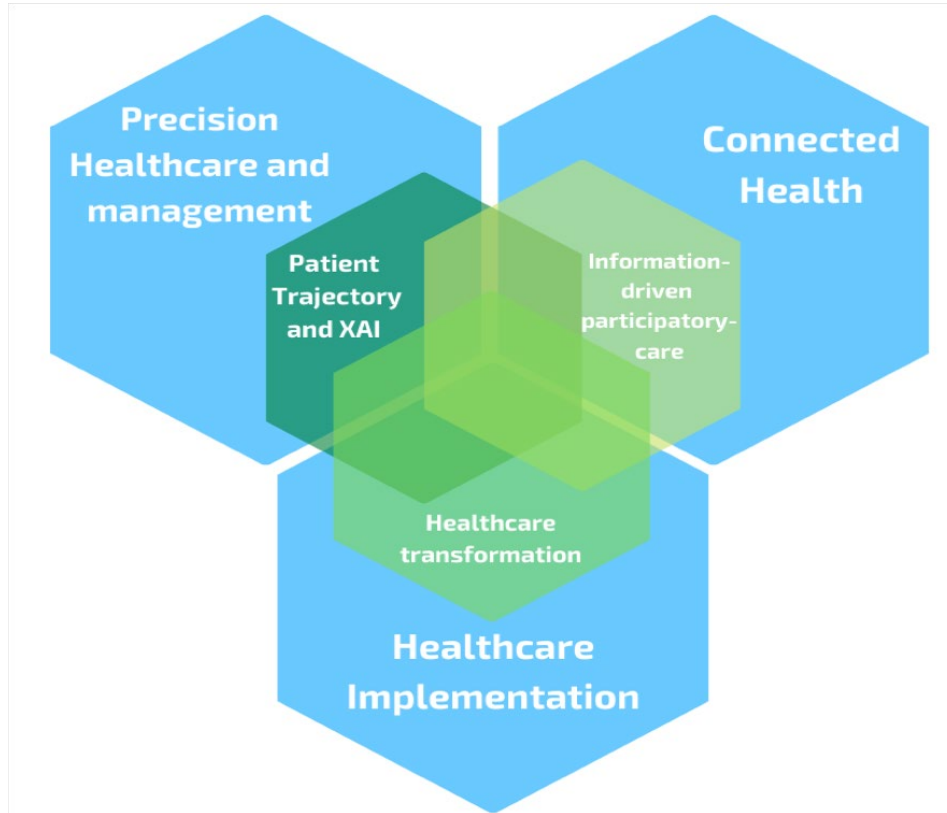
CAISR Health



CAISR Health



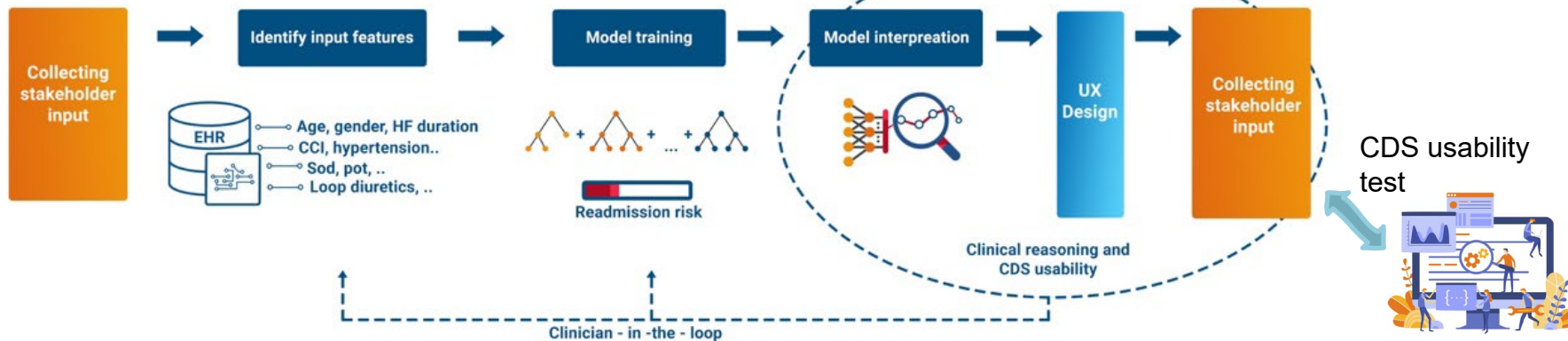
Research areas within CAISR Health



HaRP: CDSS as Interdisciplinary Human-Centered AI

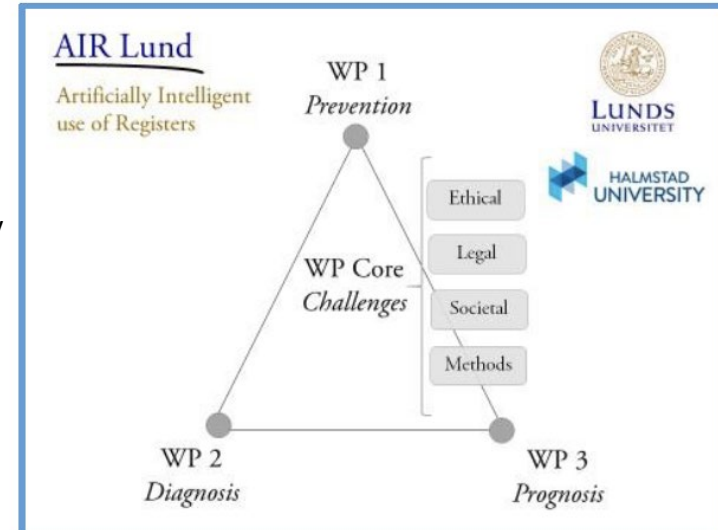


Interview with Clinicians

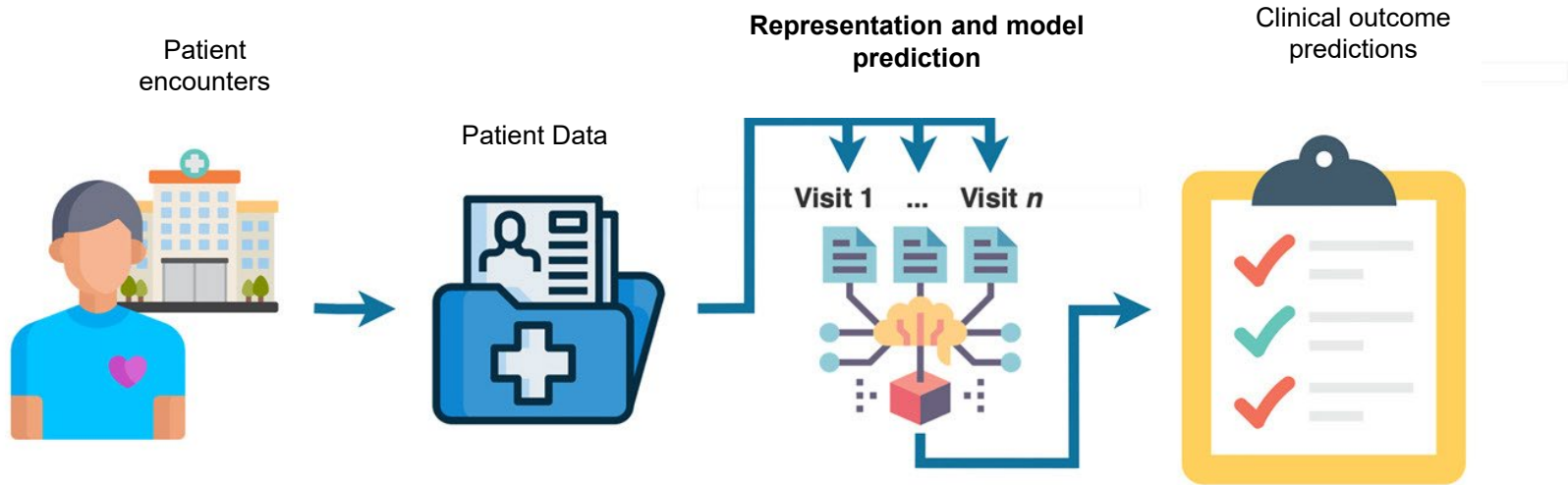


AIR Lund: Artificially Intelligent use of Registers

- ❑ 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

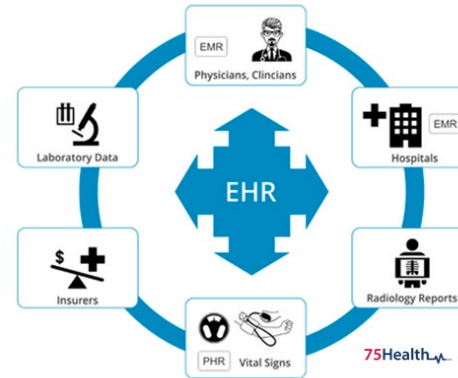


Patient Trajectory



EHR (Electronic Health Record)

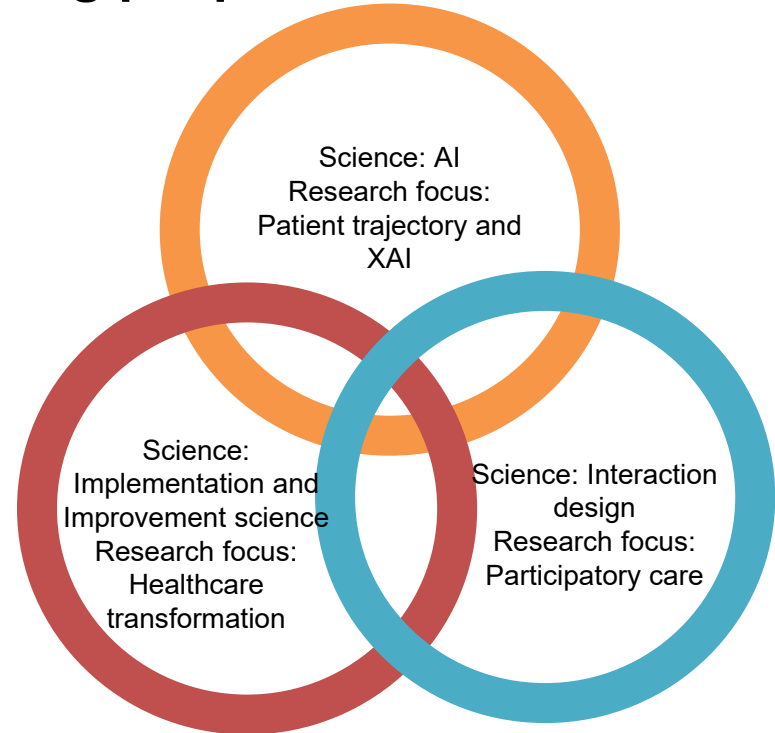
- An **electronic health record (EHR)** is the systematized collection of patient and population electronically-stored health information in a digital format.
- Included in this information are:
 - patient demographics
 - progress notes
 - diagnosis
 - treatments
 - medications
 - vital signs
 - past medical history
 - immunizations
 - laboratory data
 - radiology reports
 - ...



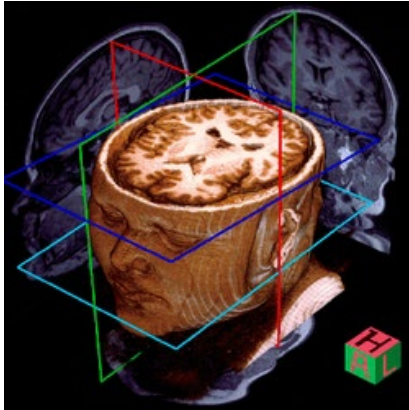
PadAI – AI for better mental health in young people

The **ambition** is to identify at-risk young adults and create appropriate interventions for them, before they receive a psychiatric diagnosis.

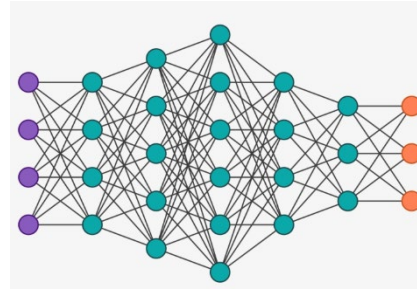
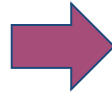
The overall **aim** of this project is to explore, develop, implement and evaluate information-driven technologies (IDT) that can support young people with anxiety/depression



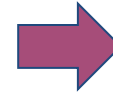
Prioritize informative structures in 3D brain images



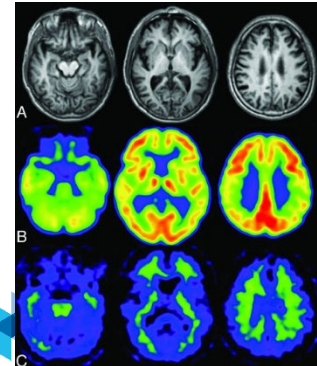
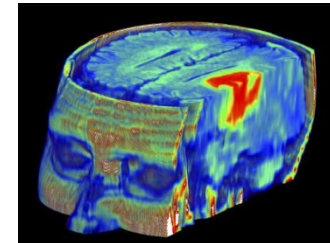
3D PET scan



3D-CNN



- 1-Alzheimer's
- 2-Dementia with Lewy bodies
- 3-Mild Cognitive Impairment
- 4-Normal



CondBEHRT: A conditional probability-based transformer for modeling medical ontology

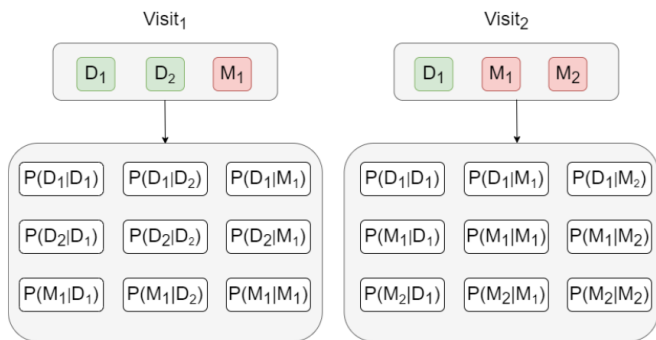


Figure 9: Patient medical history

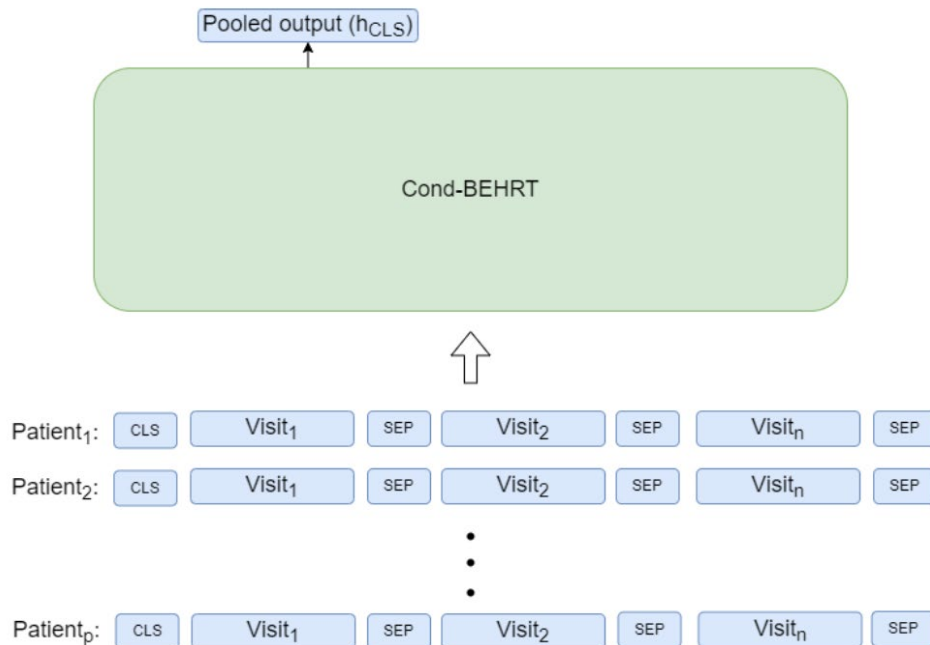


Figure 12: Broad overview of the proposed model

Master Thesis Projects (Examples)



Ongoing Master Thesis Topics

- Machine Learning for Radio Frequency Fingerprinting
- Leveraging LLMs for Clinical Note Annotation and Uncertainty Estimation
- Secure Hardware Accelerators for Machine Learning
- Detecting and Imputing Hidden Missing Values in Time Series Databases
- AI-based detection of walls in building schematics
- V2X Intention Sharing for E-Bikes and E-Scooters
- Advanced Wound Analysis Using Computer Vision and Deep Learning
- Synthetic data generation for time-series electronic health records
- Predicting Energy Consumption for Heavy-Duty Vehicles
- BeTheChange: Video Analysis for Environmental Sustainability
- Predicting suicide risk in the elderly population

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
- ...

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
- ...

Recent Master Thesis Topics

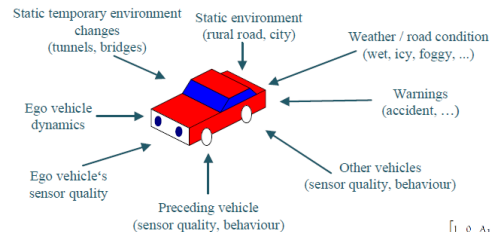
- Prioritize informative structures in 3D brain images
- Feature-wise normalization for 3D medical images
- Representation learning for anomaly detection in district heating
- Anomaly Detection of the Activities of the Elderly Living in the Smart Home
- Joint Human-Machine Exploration of Industrial Time-Series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

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
- ...

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

Thomas
Rosenstatter



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

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

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

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

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

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

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

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

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

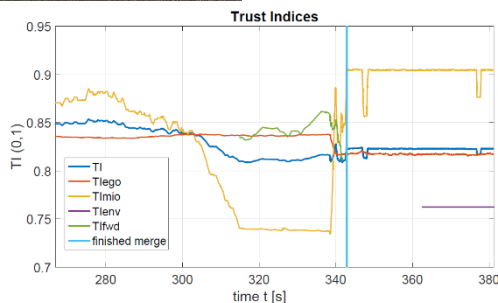
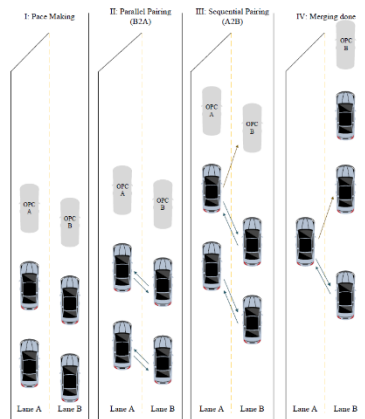


Figure 5.2: The trunk of the competition car with its devices.





[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.

"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.

- MSc thesis won a scholarship of 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.

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

https://caisir.hh.se/Student_projects

Center for Applied Intelligent Systems Research

- Sławomir Nowaczyk
- Amira Soliman

2024-03-27

