ELTE | FACULTY OF INFORMATICS

INTRODUCTION OF THE DEPARTMENT OF ARTIFICIAL INTELLIGENCE

János Botzheim

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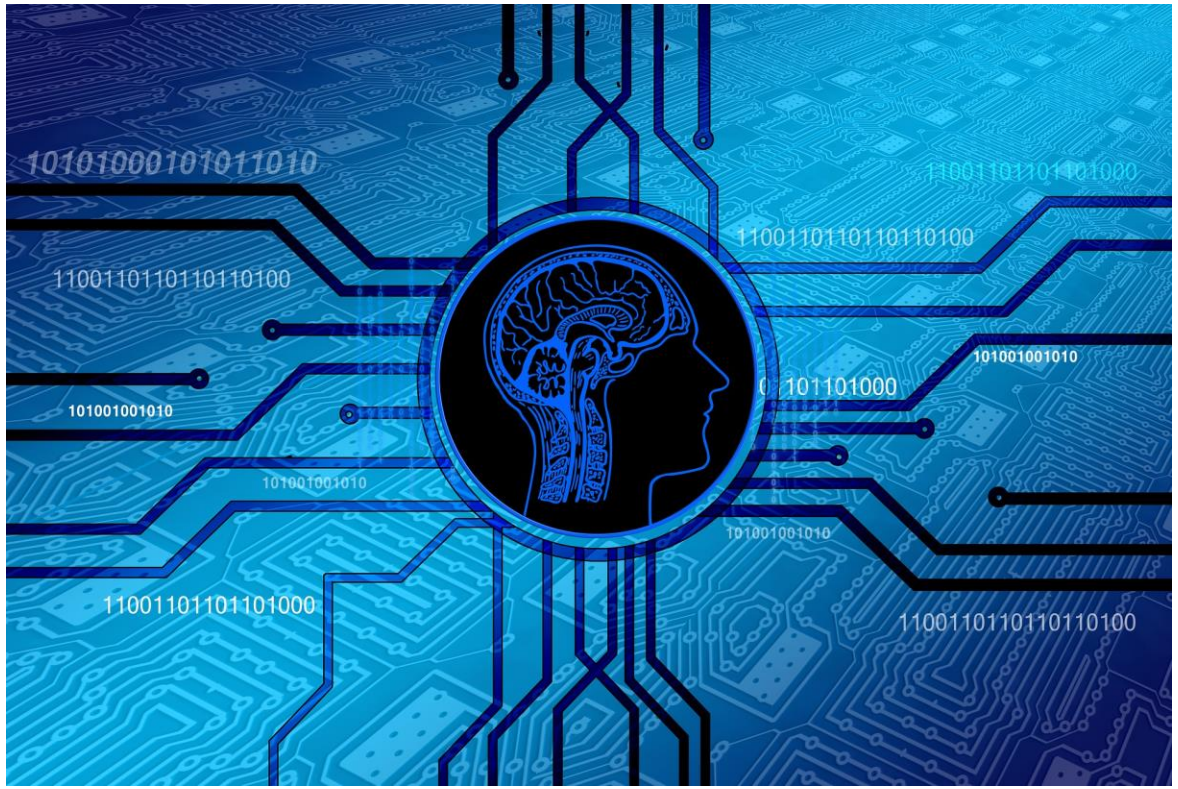
DEPARTMENT OF ARTIFICIAL INTELLIGENCE

BOSCH

Department of Artificial Intelligence



- Founded in 2021
- Industry-academy collaboration
  - A fruitful driver of research and
  - technology education
- Combines scientific rigor with practical relevance
- Excellence not only in research and education, but in innovation as well.

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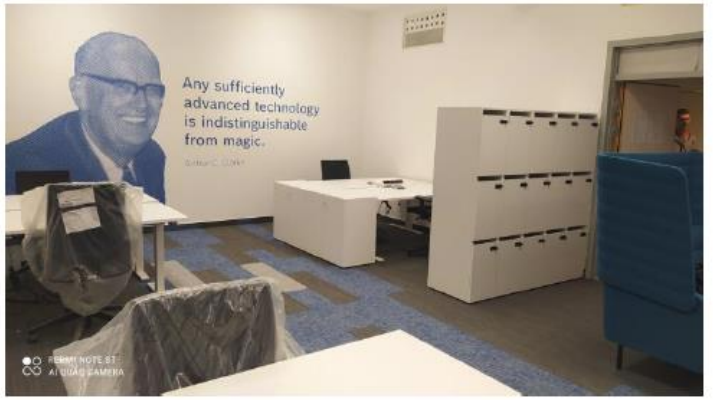
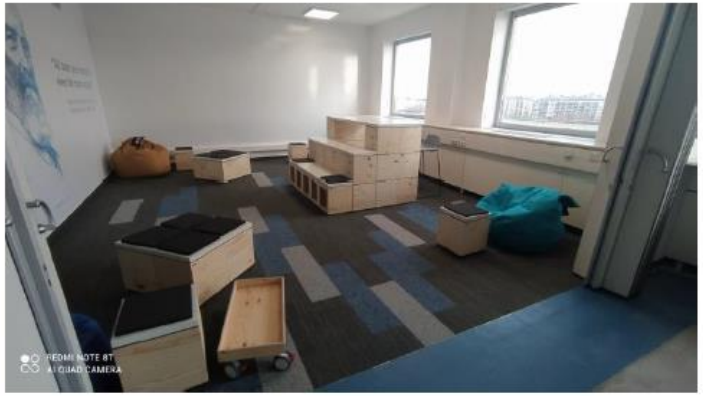
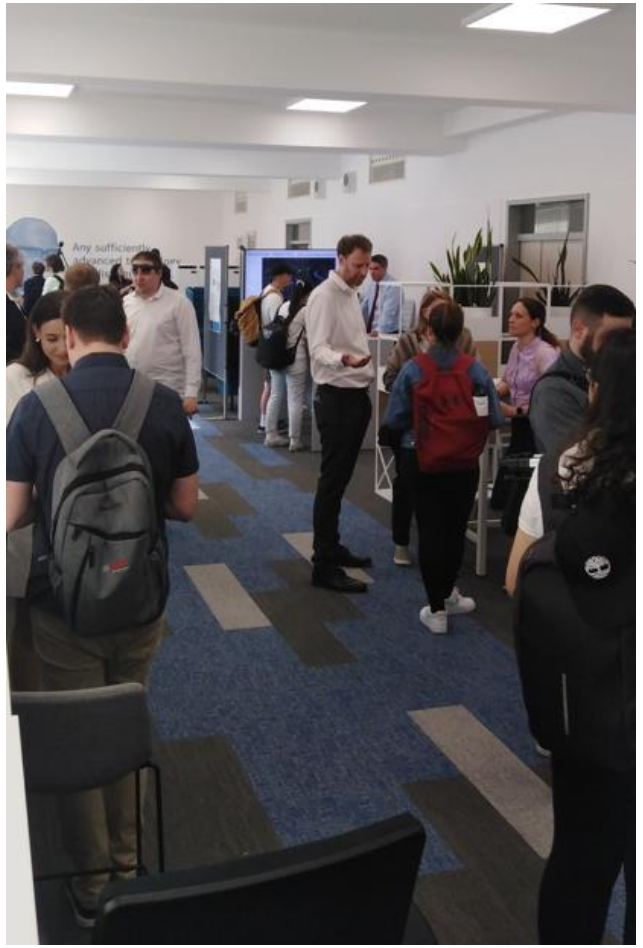
BOSCH

Offices and rooms

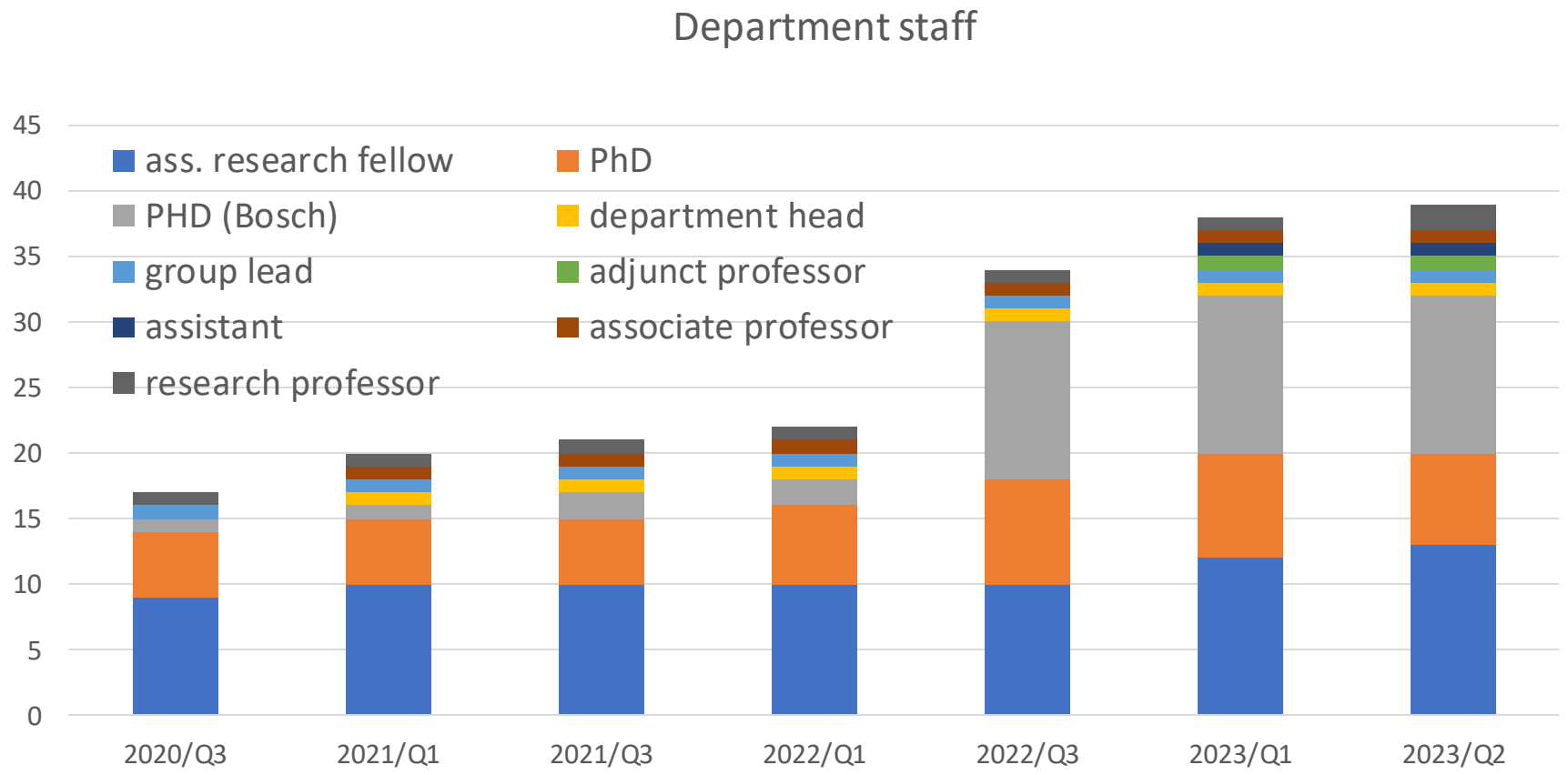




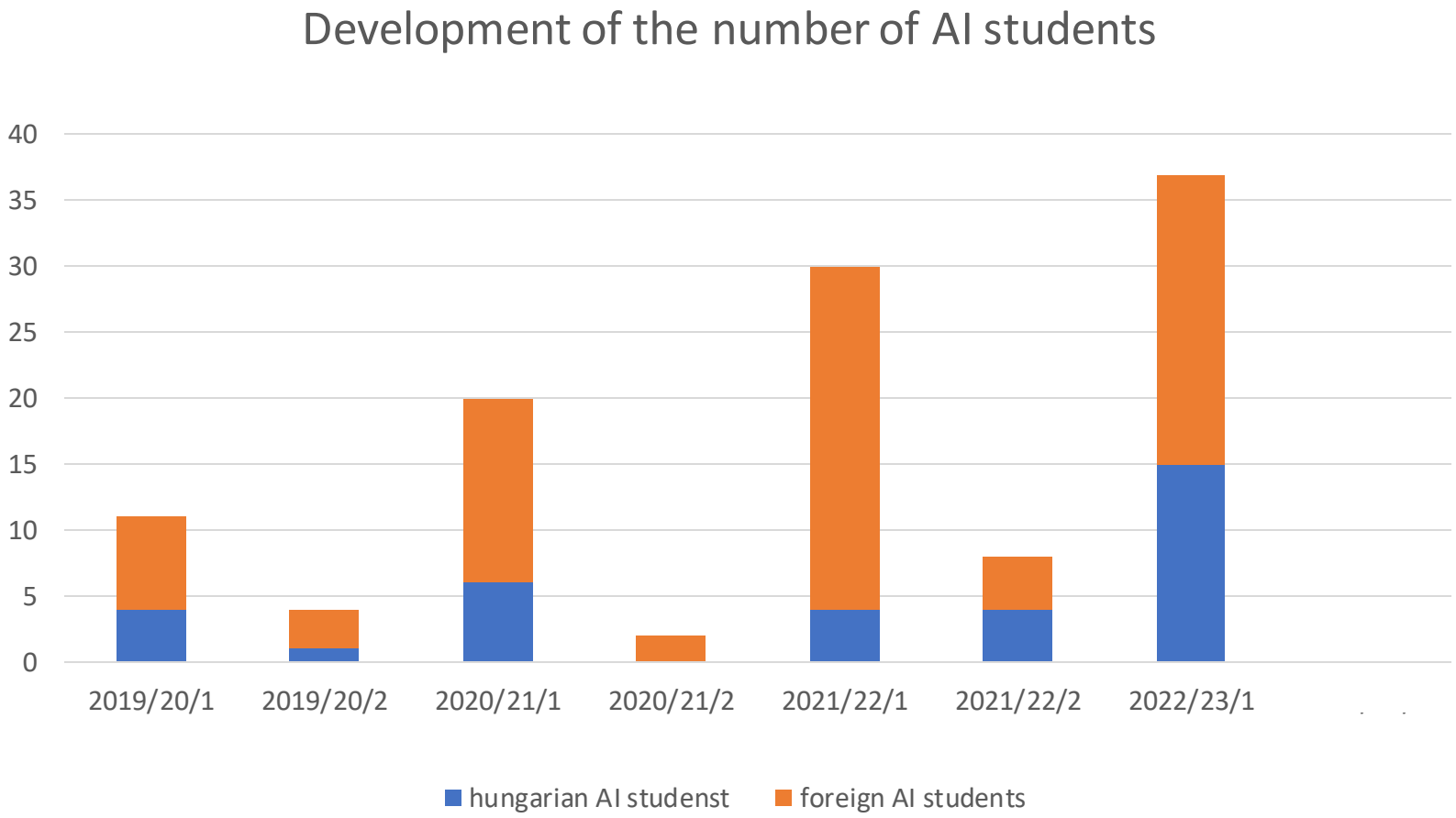
Official opening ceremony in 2021 May



Department staff



Students


Development of the number of AI students
40
35
30
25
20
15
10
5
0
2019/20/1
2019/20/2
2020/21/1
2020/21/2
2021/22/1
2021/22/2
2022/23/1
hungarian AI studenst
foreign AI students

Department of Artificial Intelligence

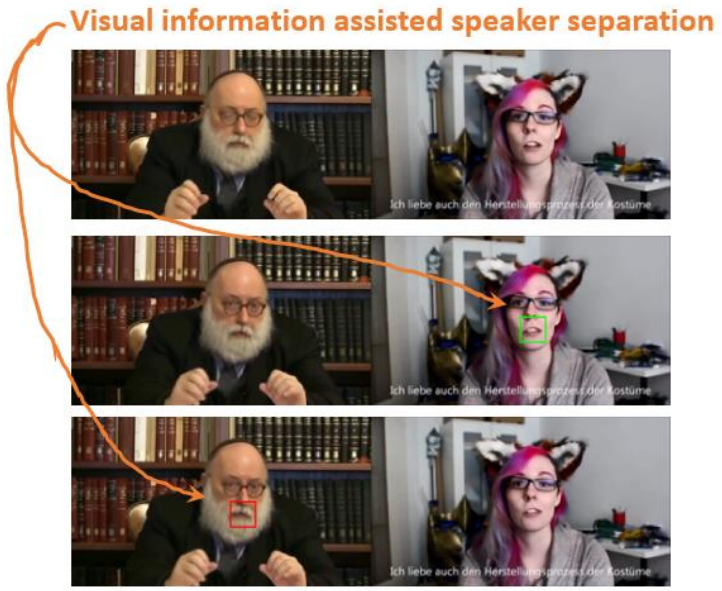
- Goal
  - Human-centered AI
  - Turstworthy, explainable
- Approach
  - Composite Artificial Intelligence
  - Computational Intelligence
  - Neural Information Processing
- A diverse set of technologies
  - Deep Learning
  - Collective Intelligence
  - Evolutionary Technologies
  - Embodied Systems

Human centered AI

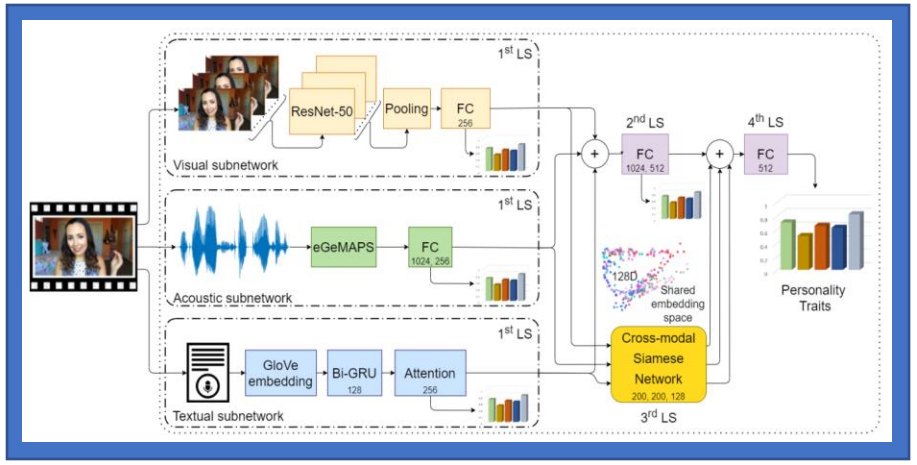
- During an interaction it can be estimated what AI can do
- There are many possible applications, such as:
  - Home companion - for elderly people
  - Helping, encouraging companion - for obesity, depression, rehabilitation
  - Warehouse robot
  - Business service robot
  - Learning companion
  - Interesting: teaching autistic children is easier when the teacher is a robot
  - Lots of AI is needed → a few examples

Elements of effective interaction:
Speech recognition; understanding of behavior; intent estimation

- Visual information-assisted speaker separation
- Speech recognition afterwards

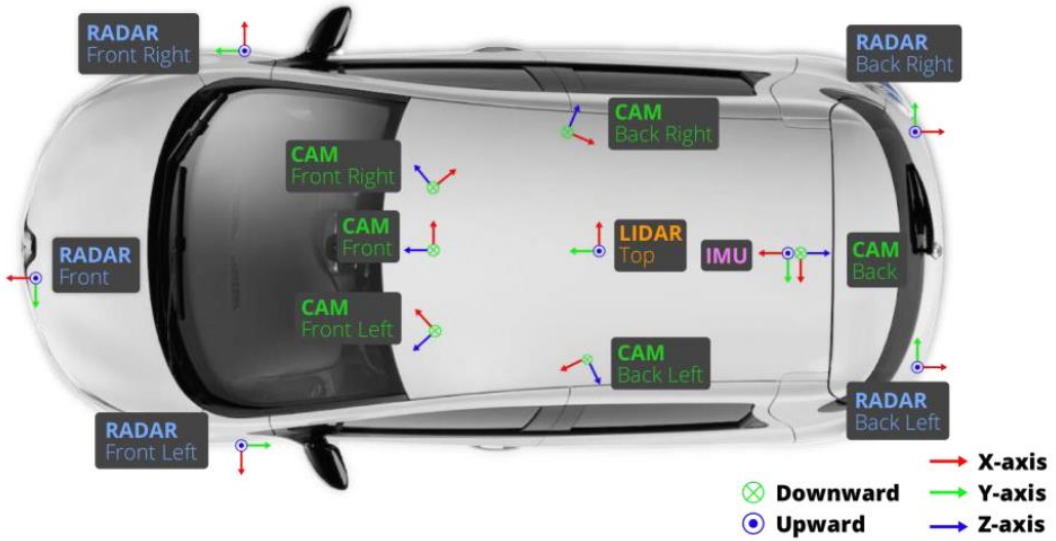


- Estimating emotion (from text, from speech patterns, facial expression)
- Detecting changes in partner's mood (from text, speech patterns, facial expression)
- Fusion of information chunks to characterize behavior

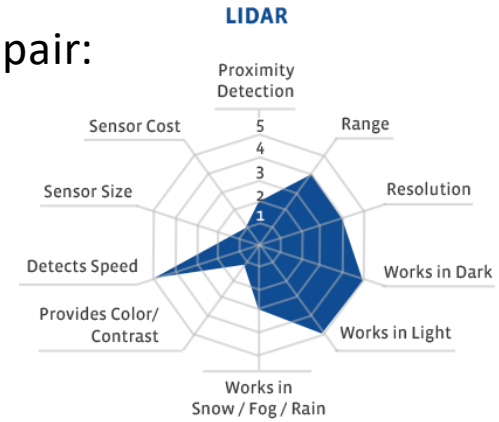


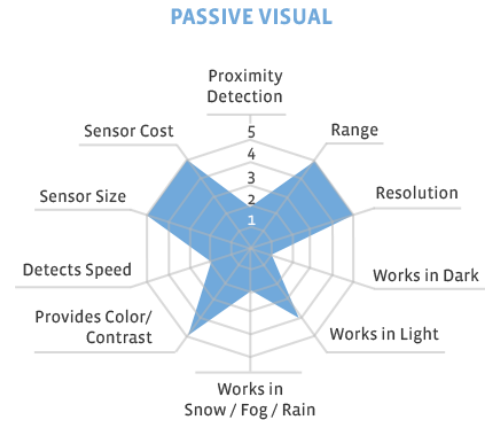
- Estimating intent and mental state, e.g.
  - from blinking, gaze direction, and prosody
- Estimation of activity, e.g.
  - object manipulation,
  - estimation of hand pose, body pose, head pose

Autonomous Perception



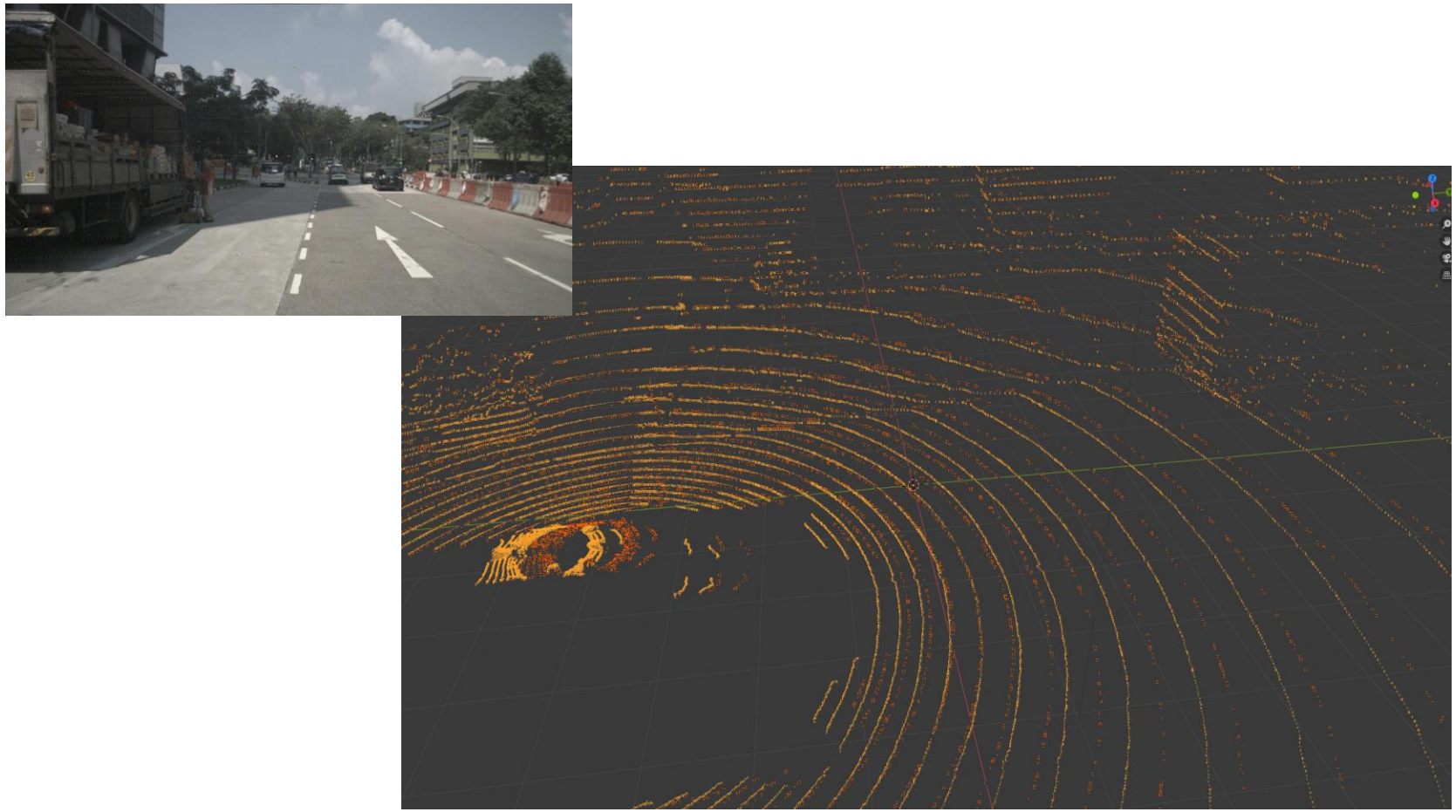
Selected sensor pair:





Perception → **Tracking** → Abstract Environment → Behavior Prediction → High level functions

Multimodal Sensor Fusion



Primary goal:

- Trainable representation that can store information from consecutive samples of different sensor types to perform stabilized object detection

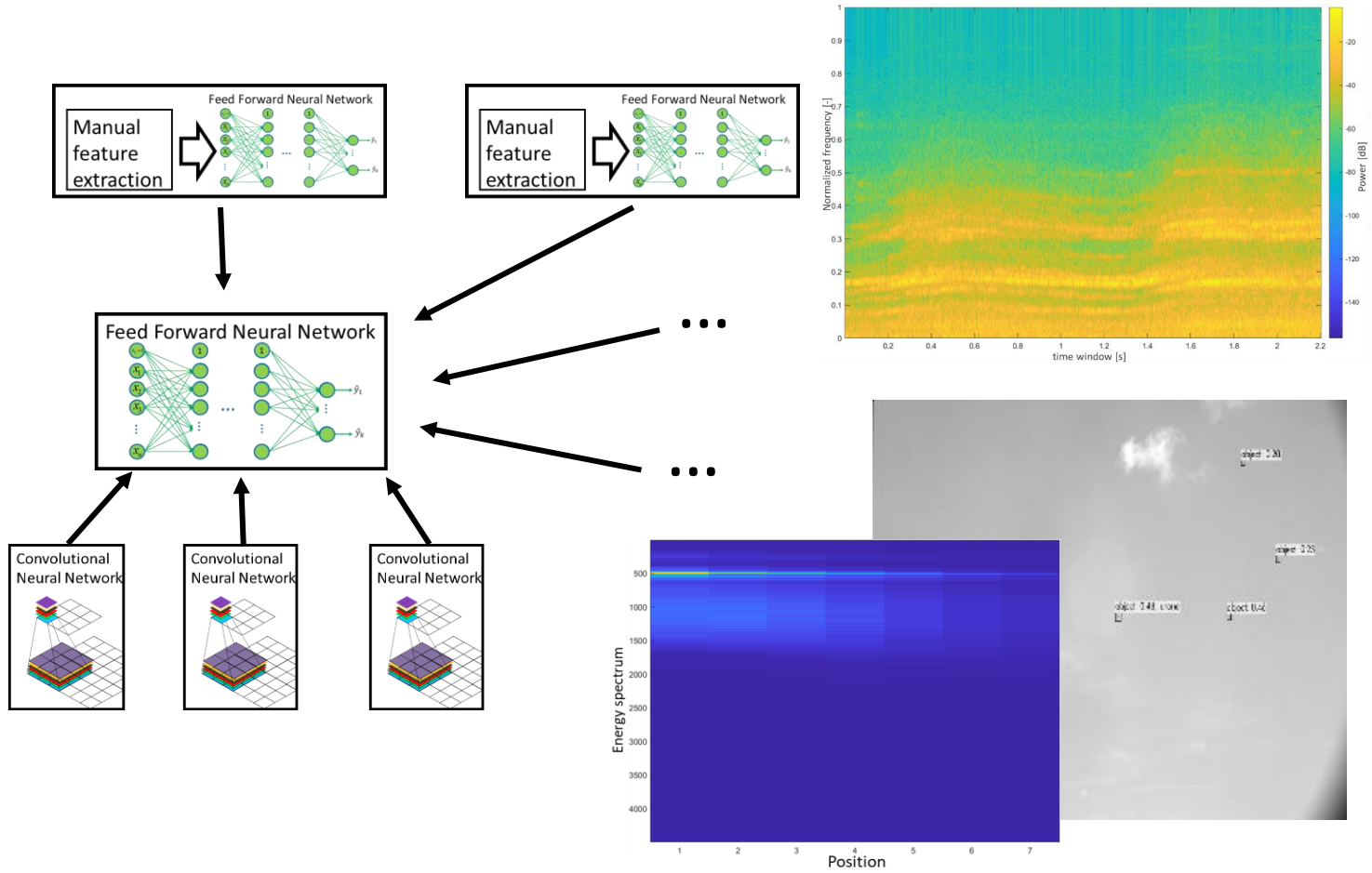
Worth investigation:

- Association between modalities should be in latent space
- From safety aspects, spatial-temporal reasoning through feature explanation

Multisensor data fusion

Main Topics:

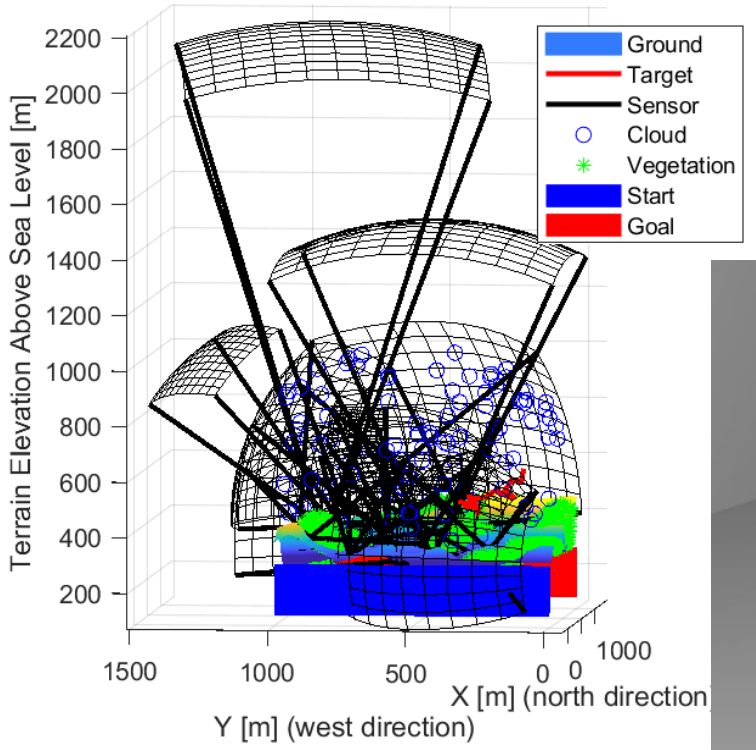
- Radio, acoustic, image data
- Decision reliability
- Flexibility of the system
- System evolvability
- Reducing the required samples

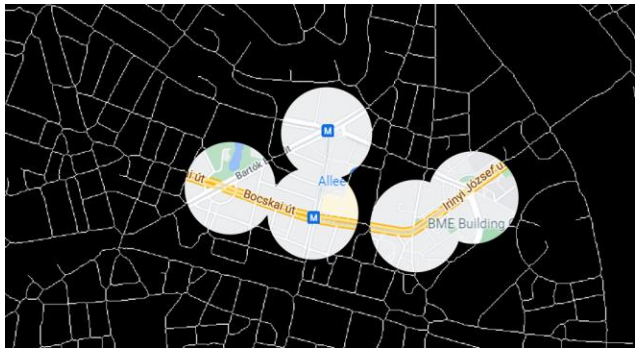


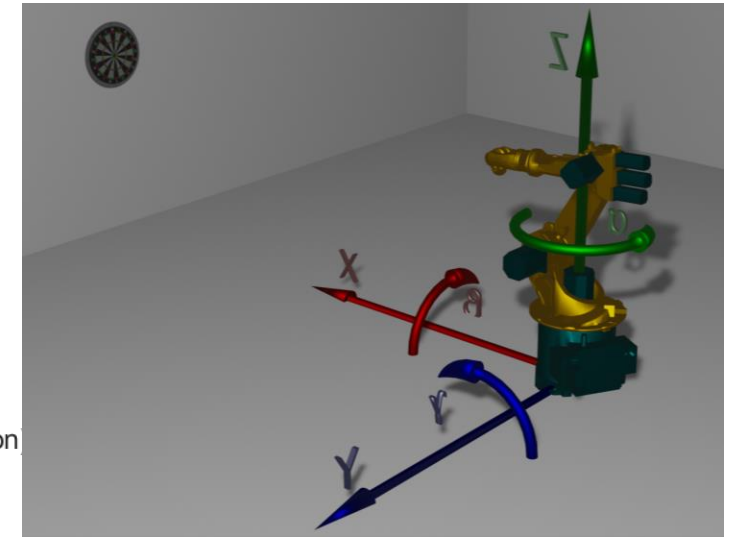
Model based optimization

Main Topics:

- Memetic algorithms
- Multi-objective optimization
- Hierarchical population structure
- Coevolution of the model and optimization





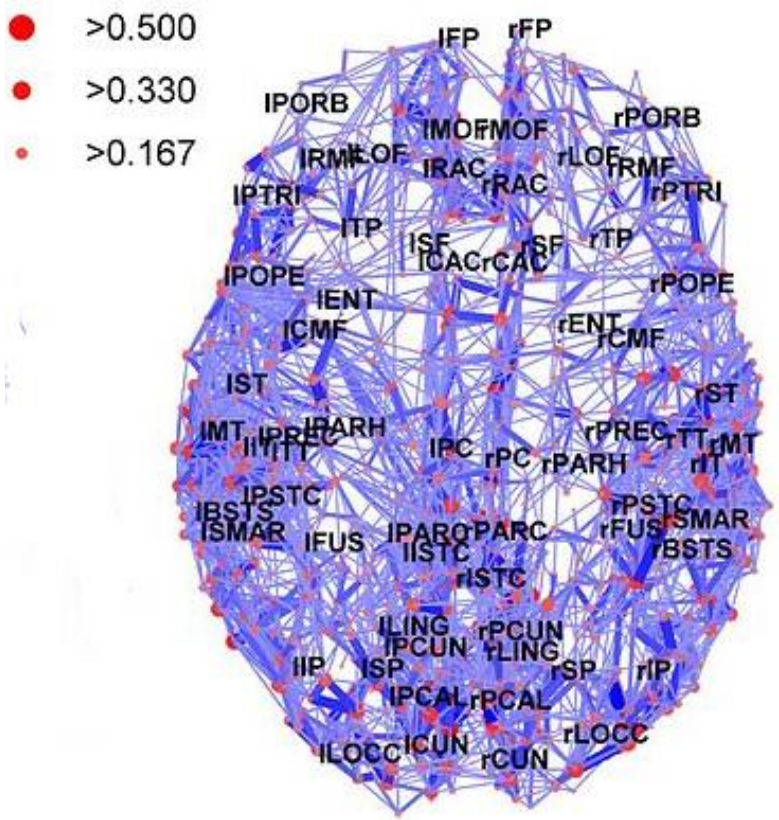


Multi-agent systems

- Intelligent systems are no longer stand-alone entities
  - The traditional view no longer holds
    - NOT: A single entity making complex decisions
- AI systems interact ‚on the field'
  - Safe and controlled co-existence of intelligent agents, or
  - The combined actions of several actors lead to a solution
- Methods
  - Multi-agent reinforcement learning (MARL)
  - Mean-field game theory (MFG)
  - Etc.

Structural Analysis of Sparse Neural Networks

- Sparse Artificial Neural Networks
  - Can help increasing the performance of ANNs
  - The human brain is sparse
- The structure of best performing SANNs is not understood
  - A new research direction
- Application of the toolset of Network Science to SANNs
  - An ongoing research project

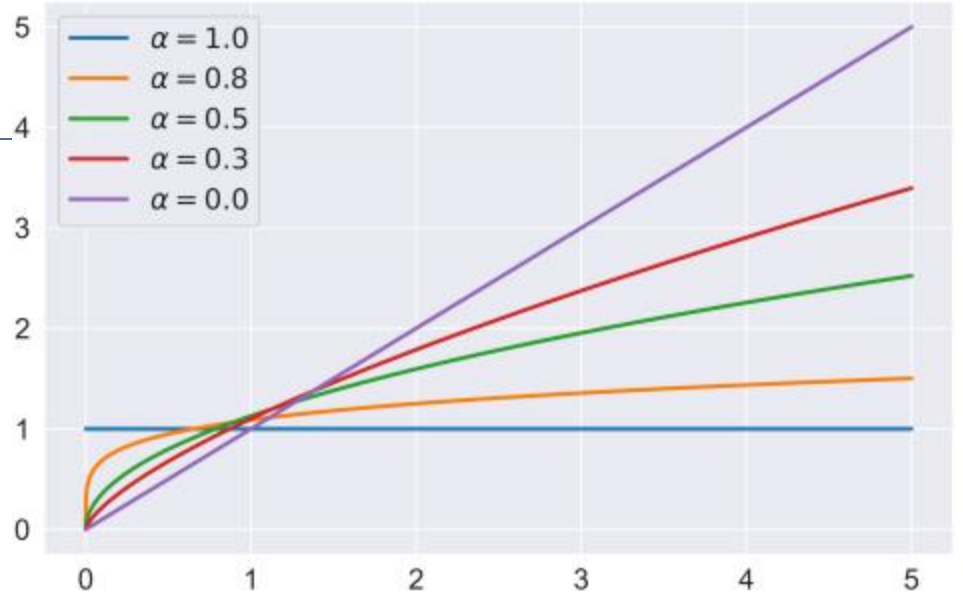


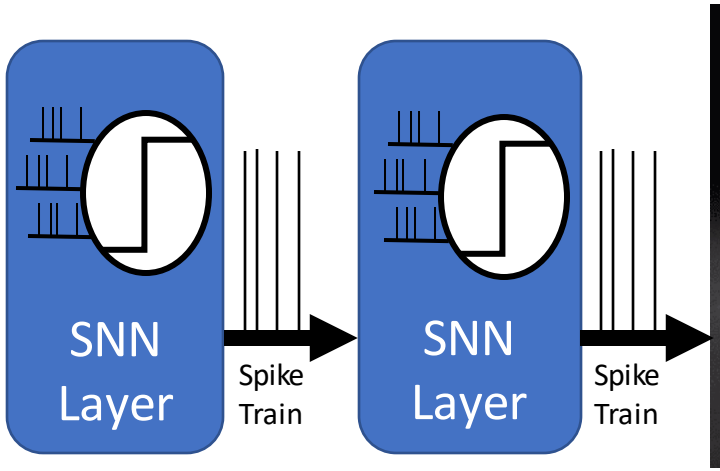
Hagmann et al. (2008) Mapping the structural core of human cerebral cortex. PLoS Biology Vol. 6, No. 7, e159

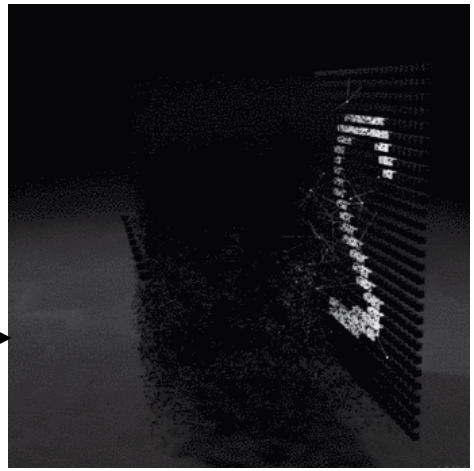
Neuromorphic Computing

- Spiking Neural Networks (SNN)
  - Event-based information handling
  - Energy efficient
- Dynamic Biological Neuron Simulation
- Temporal coding
- Local learning
- Caputo derivative-based training

Caputo derivative of f(x) = x

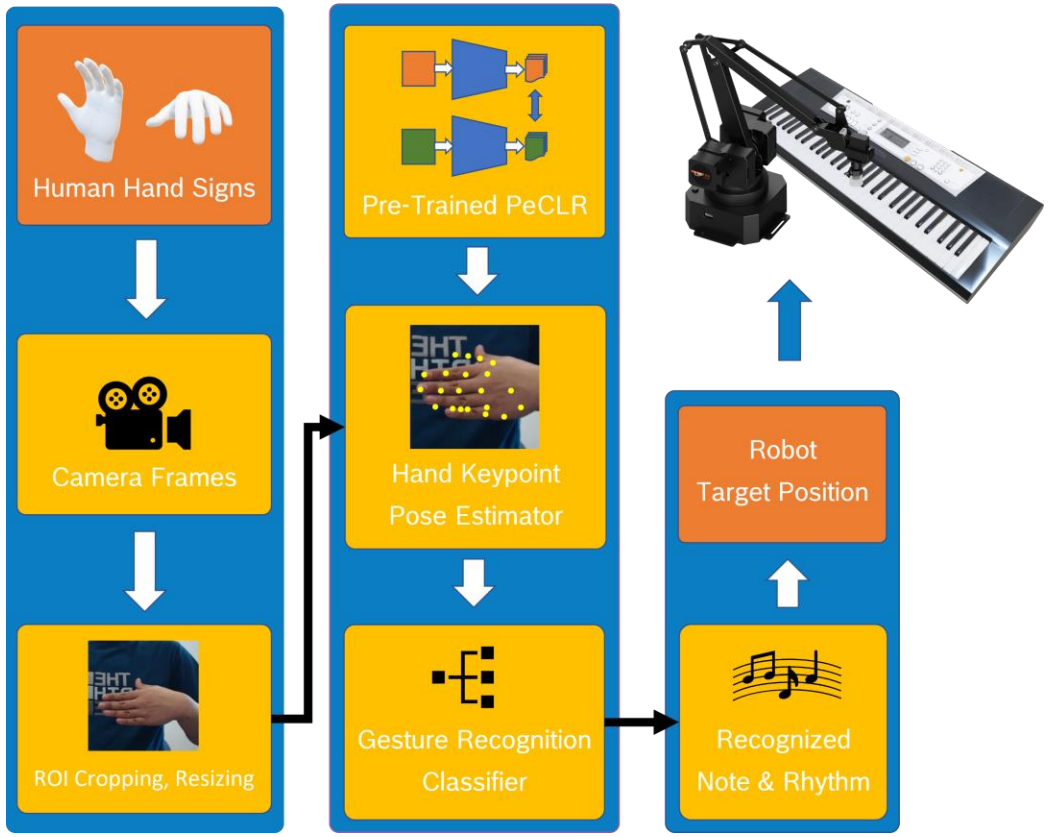






Cognitive Robotics: Hand Gesture Recognition

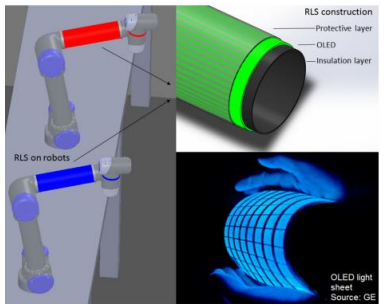
- Human-Robot Interaction (HRI) based on natural human signs
- Non-verbal signs
  - Sign languages (ASL, Tactical, Musical)
- A robot is instructed based on the Kodály hand signs
- Adaptation, learning together

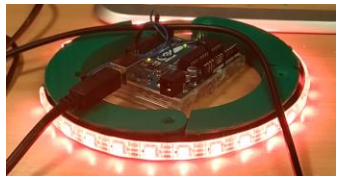


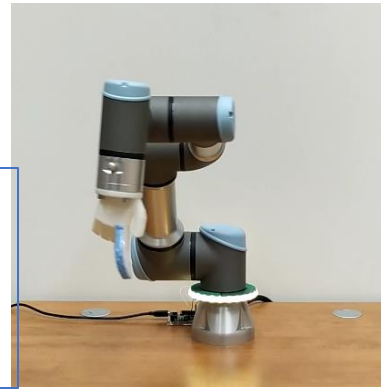
Human Robot Interactions: Communication and behavior optimization

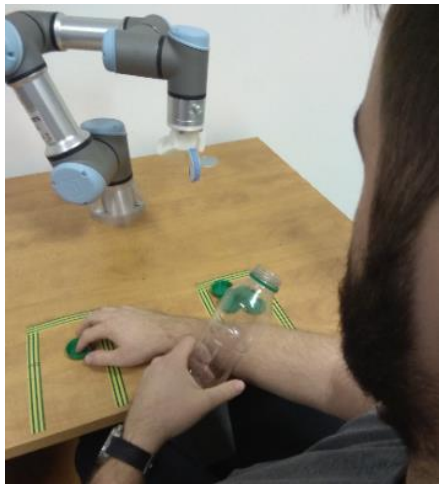
- Effective communication with simple methods
- Needed during a cooperation

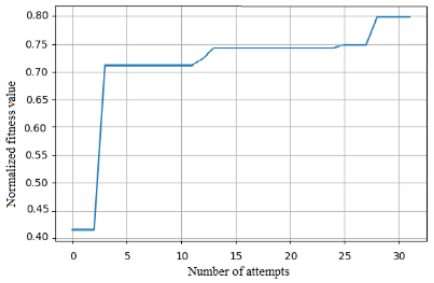
- Optimization of behavior according to the needs of the coworker and the process

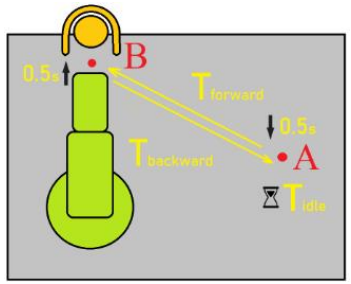










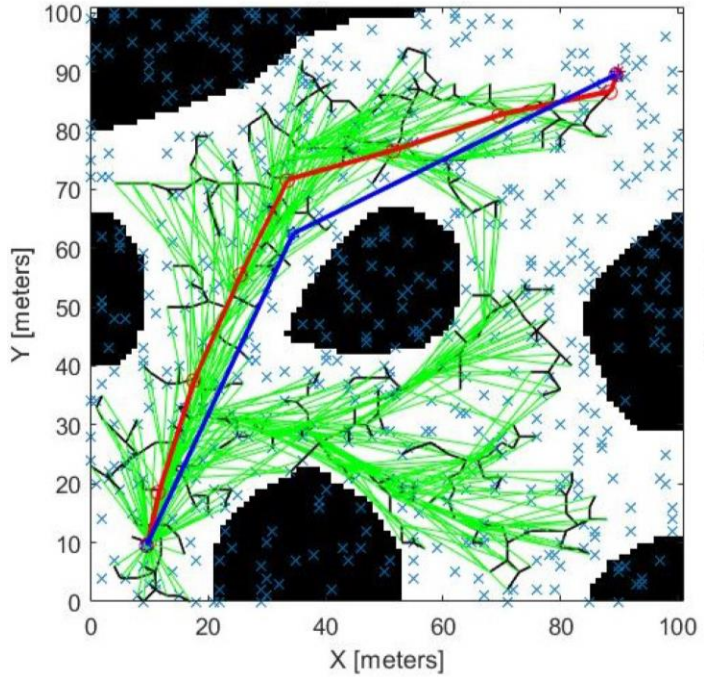


Evolutionary Computation

- Bacterial Memetic Algorithm
  - Applied for different type of optimization problem, e.g. combinatorial, integer, real
  - Applied for machine learning, e.g. building fuzzy rule bases from data, training neural network etc.
  - Fuzzy rule based system built by bacterial memetic algorithm is applied for outlier detection
- Bacterial Programming
  - Applied for structure optimization
  - Application in machine learning and robotics

An improved algorithm for path planning task of mobile robot

- We proposed an algorithm for improving the Rapidly Exploring Random Tree (RRT)
- We combined the Bacterial Mutation and Node Deletion Algorithms for post-processing the path result



Traditional RRT* (green)
Proposed RRT* (red);
Proposed RRT* with Bacterial Mutation and Node Deletion algorithm (blue).

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Thank you for your attention!