ELTE | FACULTY OF INFORMATICS

ETHOLOGICALLY INSPIRED ROBOT BEHAVIOUR

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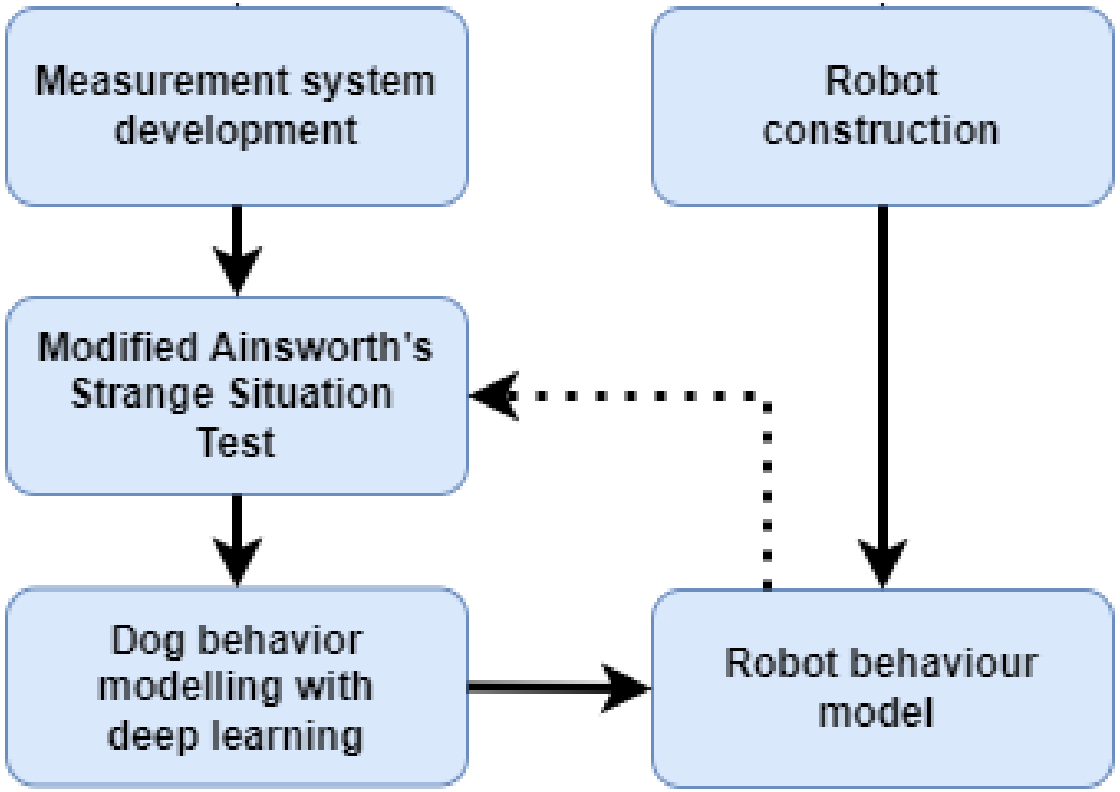
BOSCH

Motivation

- Robots outside the industrial sector
- Social robotics
- Human-Robot interactions
- Behaviour as a way of communication
- Robots can be treated as a new spices
- Ethorobotics as a new field of science

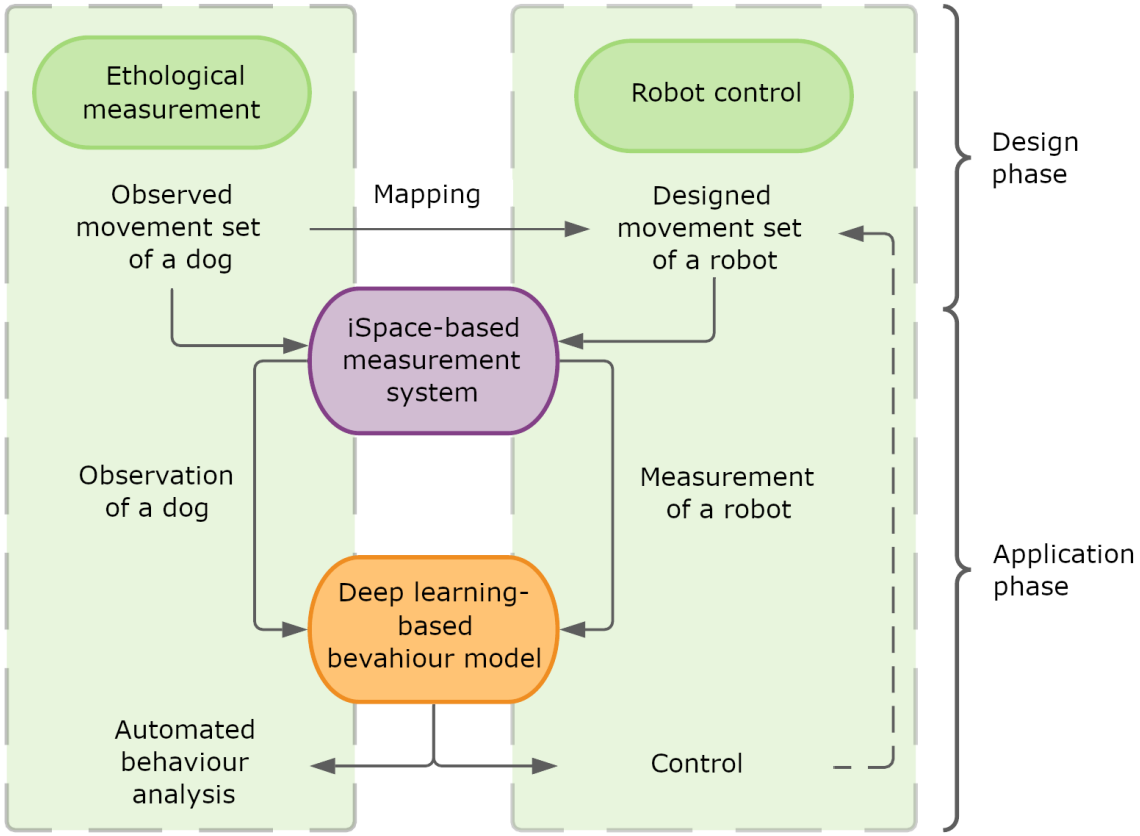
Ethorobotics

- Leading questions:
  - How can we measure animals quantitatively?
  - How can we use deep learning to learn animal behaviour pattern?
  - How can we implement animal like behaviour on an autonomous robot?



Behaviour Transfer System

- Define an ethological measurement
  - Ainsworth's strange situation test
- Develop a measurement system
  - MoCap (iSpace)
  - Collect data (quality and quantity)
- Design and build a robot
  - Mecanumbot
- Use deep learning to process the data and learn behaviour patterns
- Implement the learned behaviour patterns on the robot



Ainsworth test

- Ainswort's strange situation test (Human – Human)
  - The strange situation is a standardized procedure devised by Mary Ainsworth in the 1970s to observe attachment security in children within the context of caregiver relationships.
- Modified Ainsworth test (Human – Dog)
  - The ethologists of ELTE redefined the procedure to observe attachment between a dog and its owner.
- Projected Ainsworth test (Human – Robot)
  - My goal was to extend the procedure to examine behaviour between a robot and a human

Ainsworth's test with a dog

- #1: Acclimatisation
- #2: Introduction to STR
- #3: OWN leaves, first separation
- #4: First reunion with OWN
- #5: Dog alone, second separation
- #6: Separation continuation with STR
- #7: 2nd reunion with OWN
- *Instructions:*
  - *First half of every scenario is passive, the second is active*
  - *Use the dominant hand with the marker set*

Episode	Subject	Duration
1	DOG, OWN, TOY	2 min
2	DOG, OWN, STR, TOY	2 min
3	DOG, STR, TOY	2 min
4	DOG, OWN, TOY	2 min
5	DOG, TOY	2 min
6	DOG, STR, TOY	2 min
7	DOG, OWN, TOY	2 min

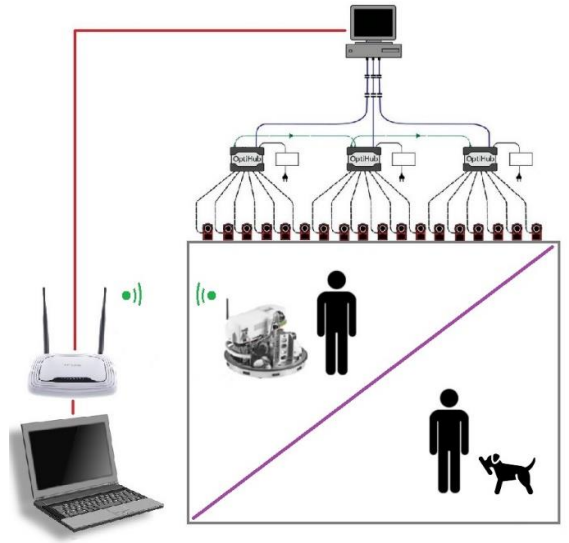
DOG – dog
OWN – owner of the dog
STR – stranger to the dog
TOY – toy

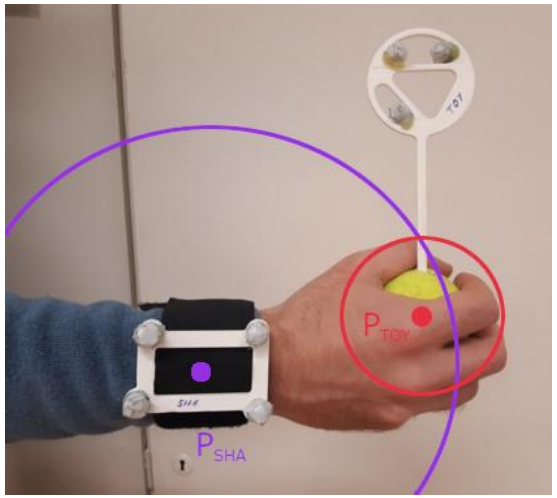
Dog playing with Owner (#2)

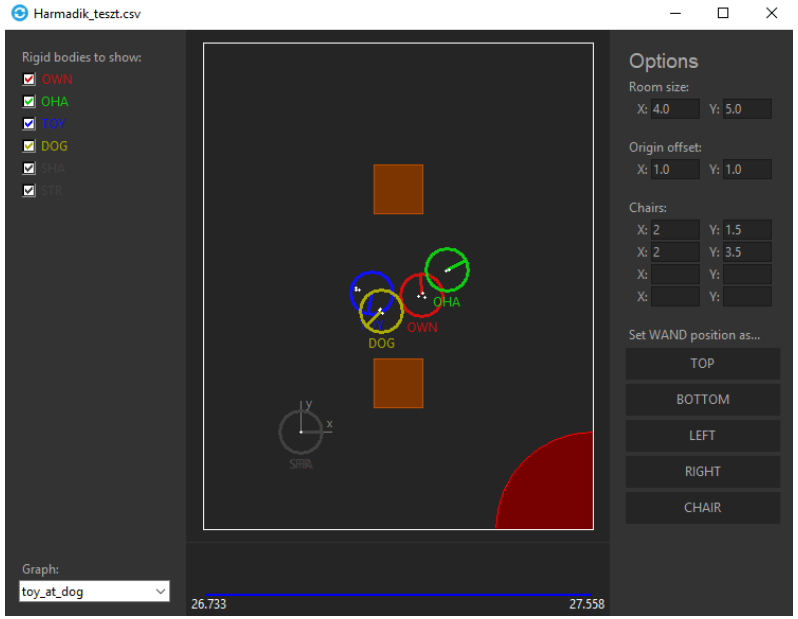
Dog with Stranger (#3)

MoCap

- Measurement system
  - Contains 18 infra cameras
  - Capable of tracking the position and orientation of marker sets made from infra reflective markers
- Intelligent space
  - Automated measurement
  - Sound controlling the participants

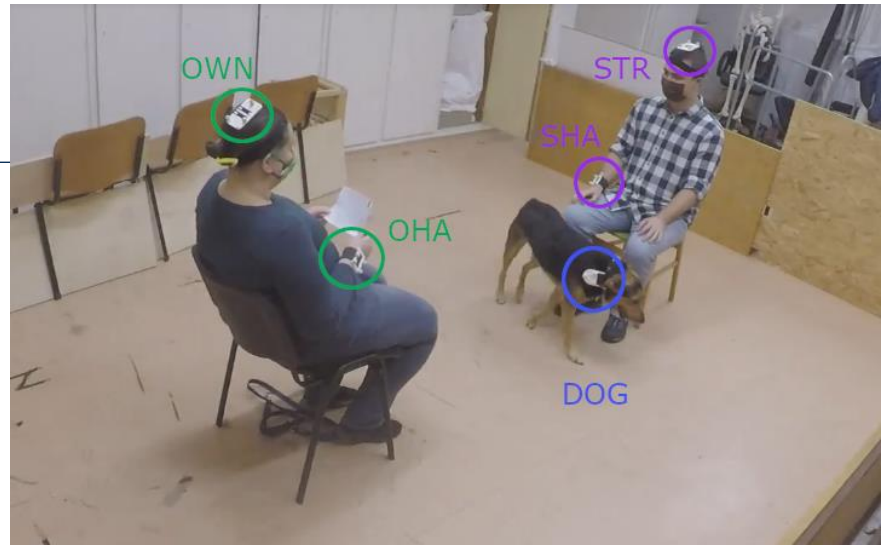


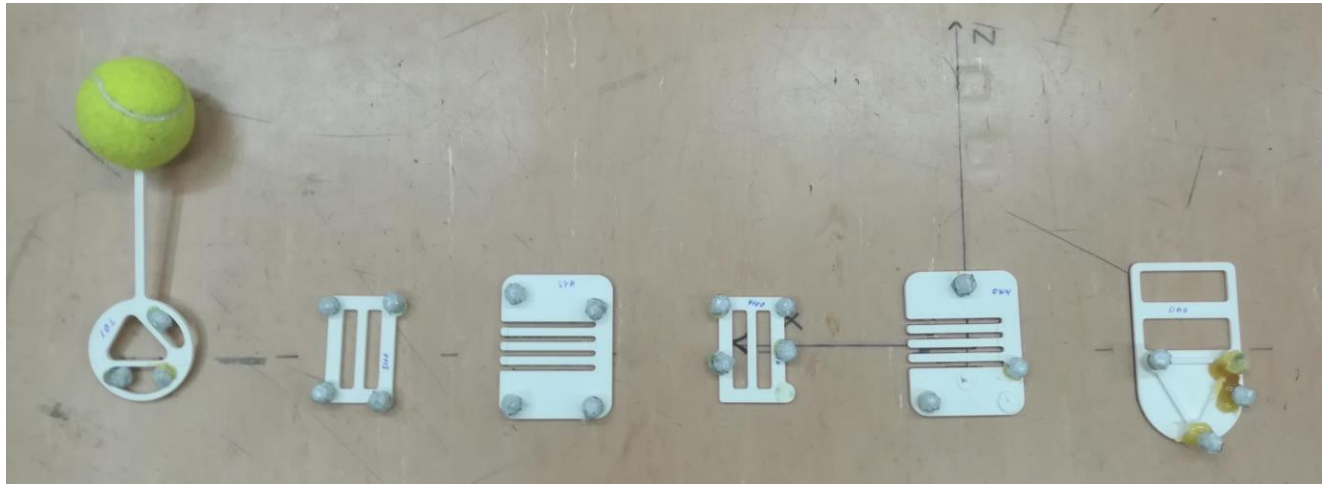




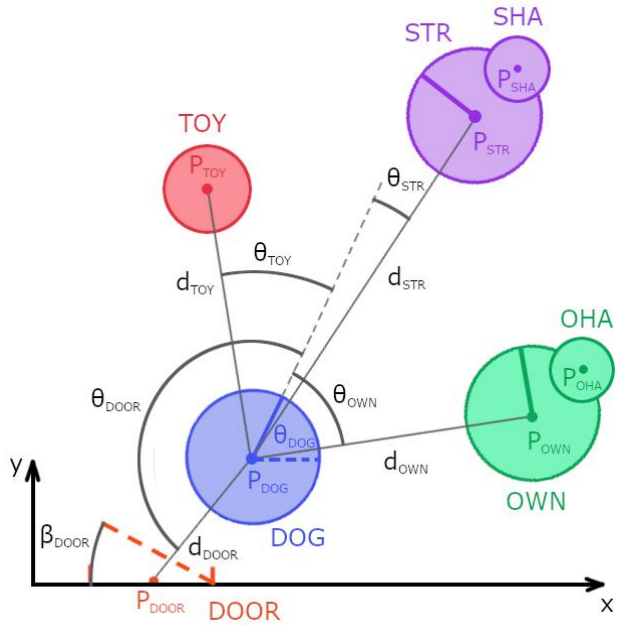
Modell and Tracking

- 3D printed marker sets
- Infra reflective markers
- At least 3 markers for a set
  - Position tracking
  - Orientation tracking





TOY SHA STR OHA OWN DOG



Results

- Examined behaviours of dog:
  - Tail wagging
  - Contact seeking
  - Attention
- Neural networks
  - 8-10 hidden layers
  - 10-100 neurons in each layer

Pattern	Train	Valid	Test
Contact	99%	92%	88%
Tail wag	94%	88%	82%
Attention	96%	74%	88%

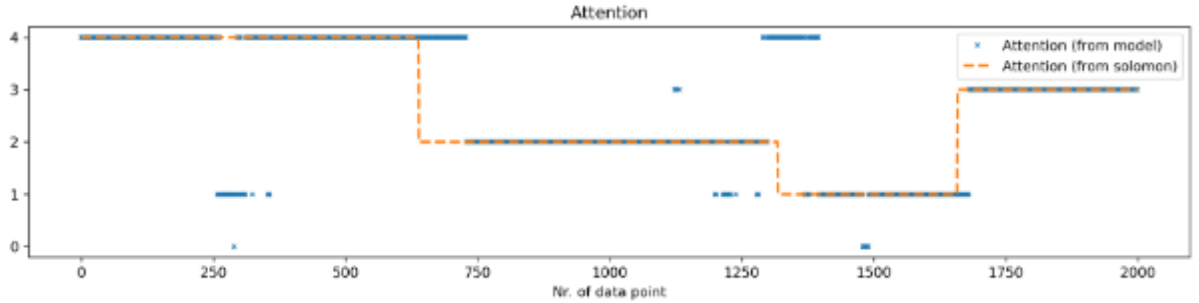


FIGURE 6. Result of attention prediction. (Dog looking at 0: non specified location, 1: owner, 2: stranger, 3: door, 4: toy)

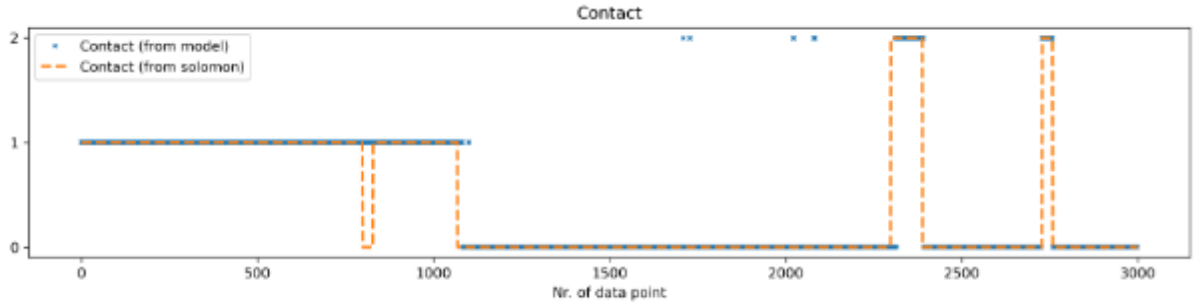


FIGURE 7. Result of contact prediction. (0: No contact, 1: Contact with owner, 2: Contact with stranger)

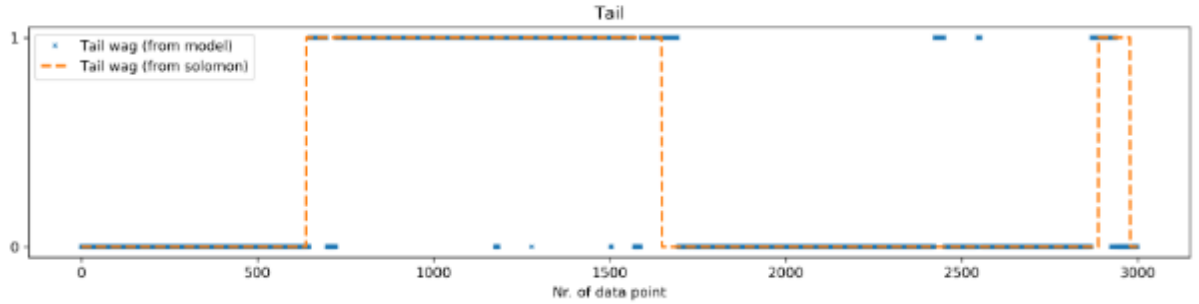
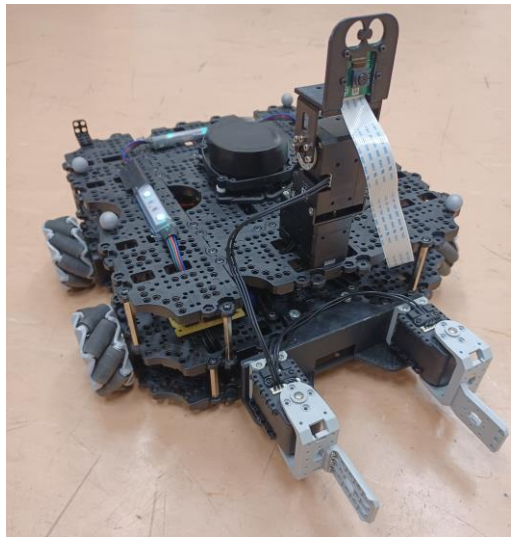


FIGURE 8. Result of tail wag prediction. (0: No tail wag, 1: Tail wag)

Ethorobots

- Developments
  - SLAM
  - Camera moving mechanism
  - MARG sensor mounting and sensor fusion
  - Microphone mounting

Mecanumbot



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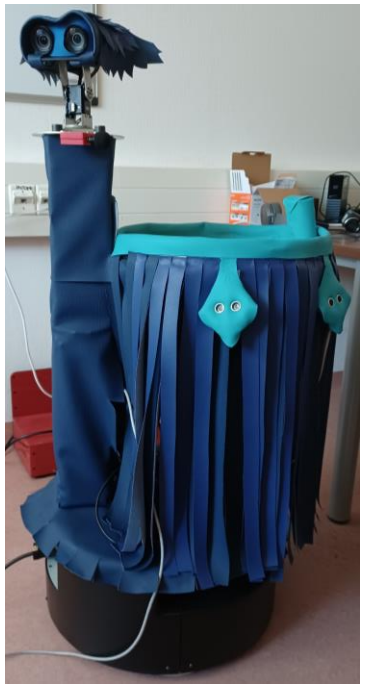
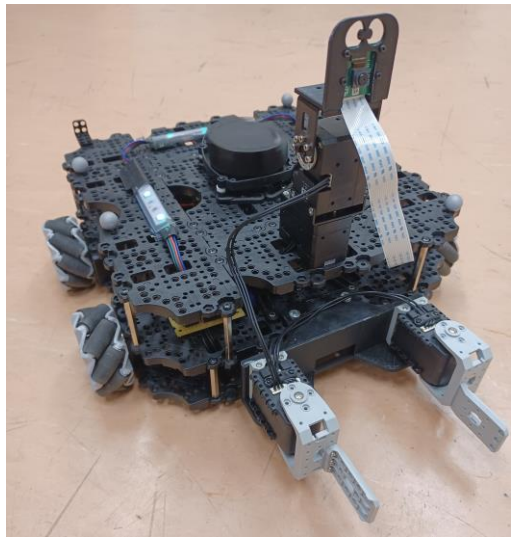


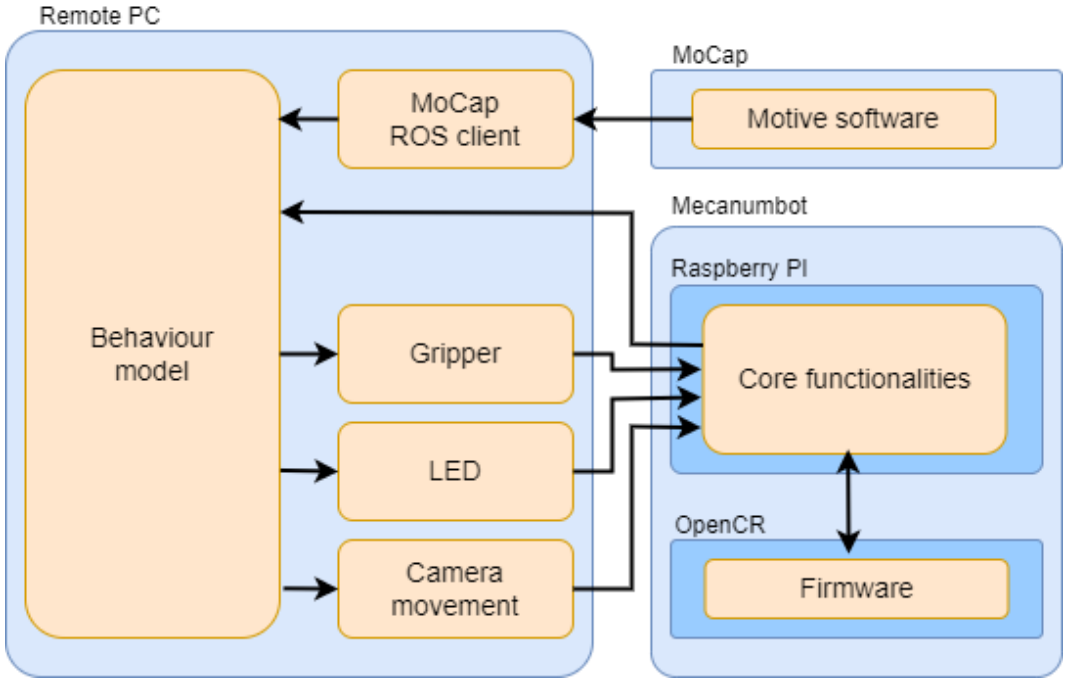
Robotino

MogiRobi

Mecanumbot

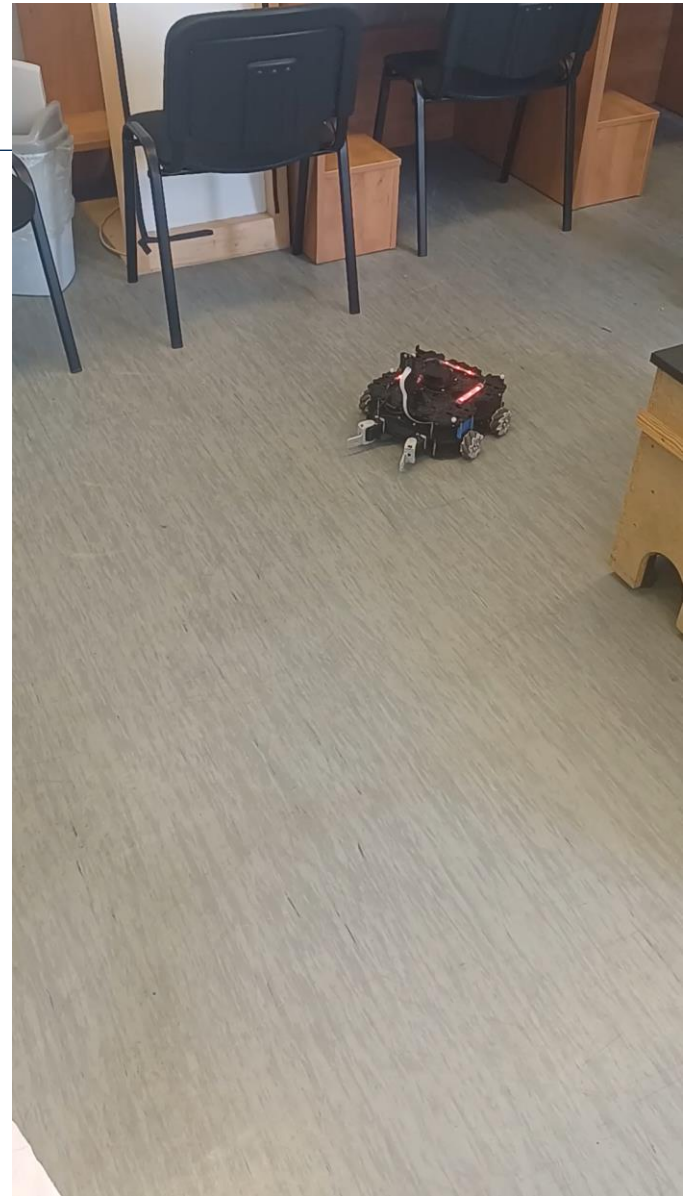
- External intelligence - Remote PC
  - Deep learning-based behaviour model
  - High level robot control
  - Data collection from observer
- Robot – Mecanumbot
  - Motor control – OpenCR
  - Core functionalities – Raspberry PI
  - Dog like features
- External observer – MoCap
  - Marker based position tracking
  - Environment monitoring





Mecanumbot – Playing fetch

- Search the toy
  - Based on colour discrimination
  - Red light
- Find human
  - Using Yolo neural network to identify humans
  - Blue light
- Bring the toy to the human
  - Green light



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Thank you for your attention!