ELTE | FACULTY OF INFORMATICS

ETHOROBOTICS

Dr. Balázs Nagy

ELTE | IK
DEPARTMENT OF ARTIFICIAL INTELLIGENCE

Motivation

- Building a Transformer is the ultimate goal
- Anki’s Vector
  - Behaviour as a tool in communication
  - Robots can be treated as a new spices
  - Social robots becoming widespread

Vector

- Background
  - 2018 - Developed by Anki
  - 2019 - Anki is no longer in business
  - 2019 - Digital Dream Labs purchased
- AI related skills
  - Navigation
    - Path planning
    - Object avoidance
  - Voice recognition (cloud based) - NLP
  - Realtime CNN architecture
    - Person detection
    - Novelty detection
    - Object classification
  - Emotion engine
    - Cat like ’personality’

Emotions of Vector

What are the Goals?

- Integrate robots into the everyday life
- Overcome the communication gap
- Interact with humans
- Help with simple task
  - Weather forecast
  - News
  - Entertainment
- Give the technology a body to connect with people more easily

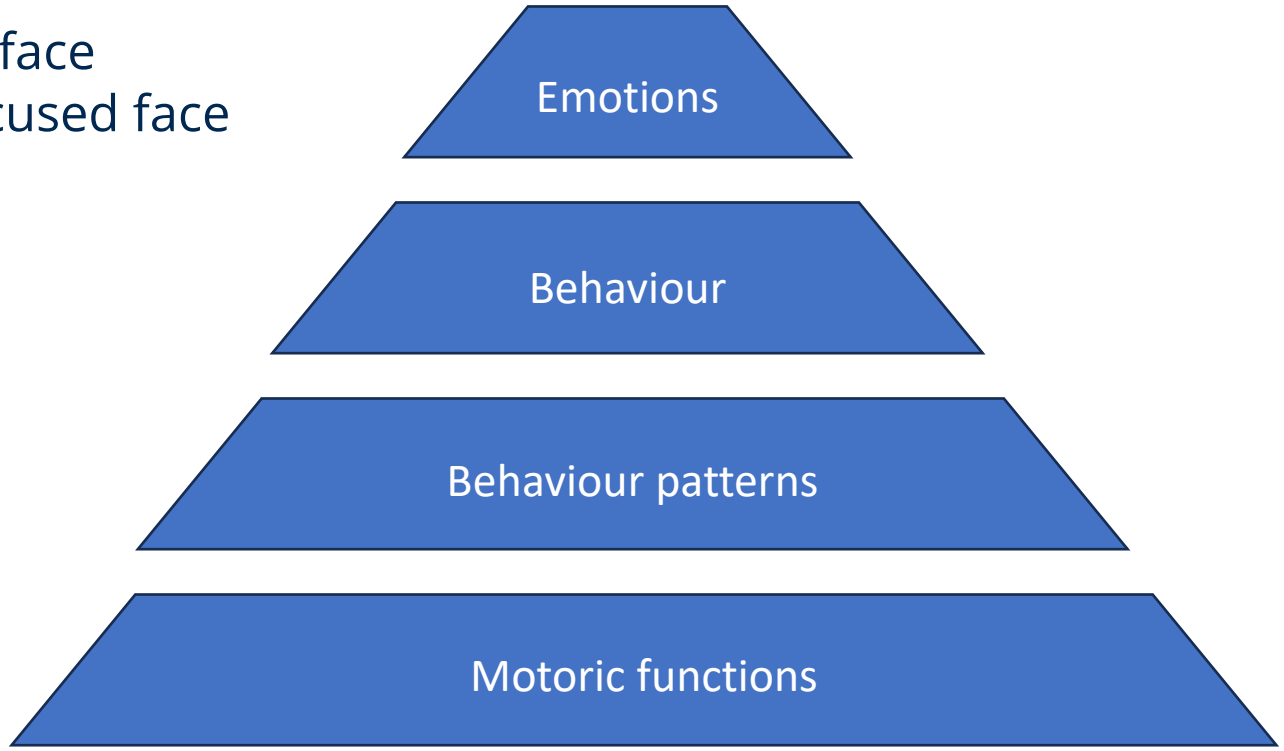
How?

- Behaviour model
- Social robotics
  - A social robot is an artificial intelligence (AI) system that is designed to interact with humans and other robots.

- Ethology + Robotics = Ethorobotics
  - Ethology = is the scientific study of animal behaviour
  - Robotics = design, construction, and use of machines (robots) to perform tasks

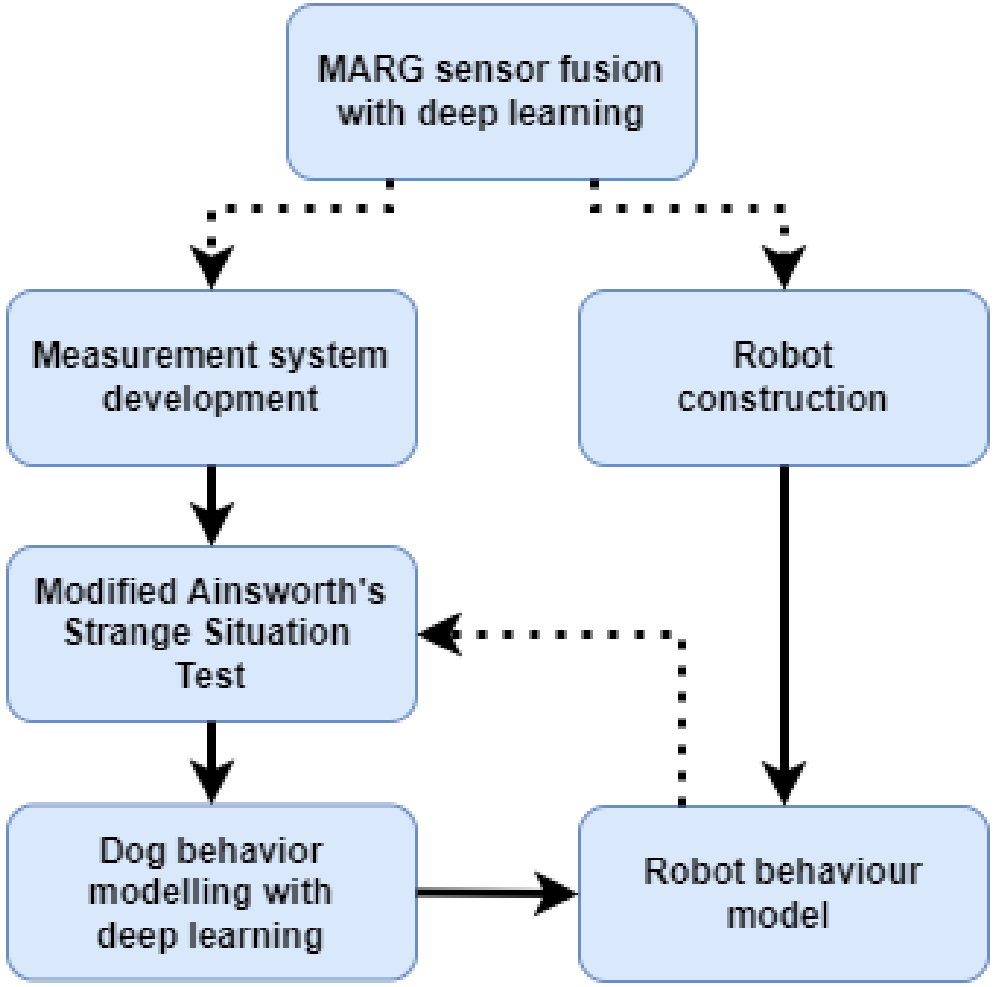
How?

- Emotion
  - Tune the behaviour
    - Do it fast = Angry + Display Angry face
    - Do it slow = Focused + Display Focused face
- Behaviour
  - Sequence of behaviour patterns
    - Lift up actuator
    - Put down actuator
    - Display face
    - Play sound
- Behaviour pattern
  - Lift up and put down actuator
- Motoric functions
  - Lift up actuator



Overview

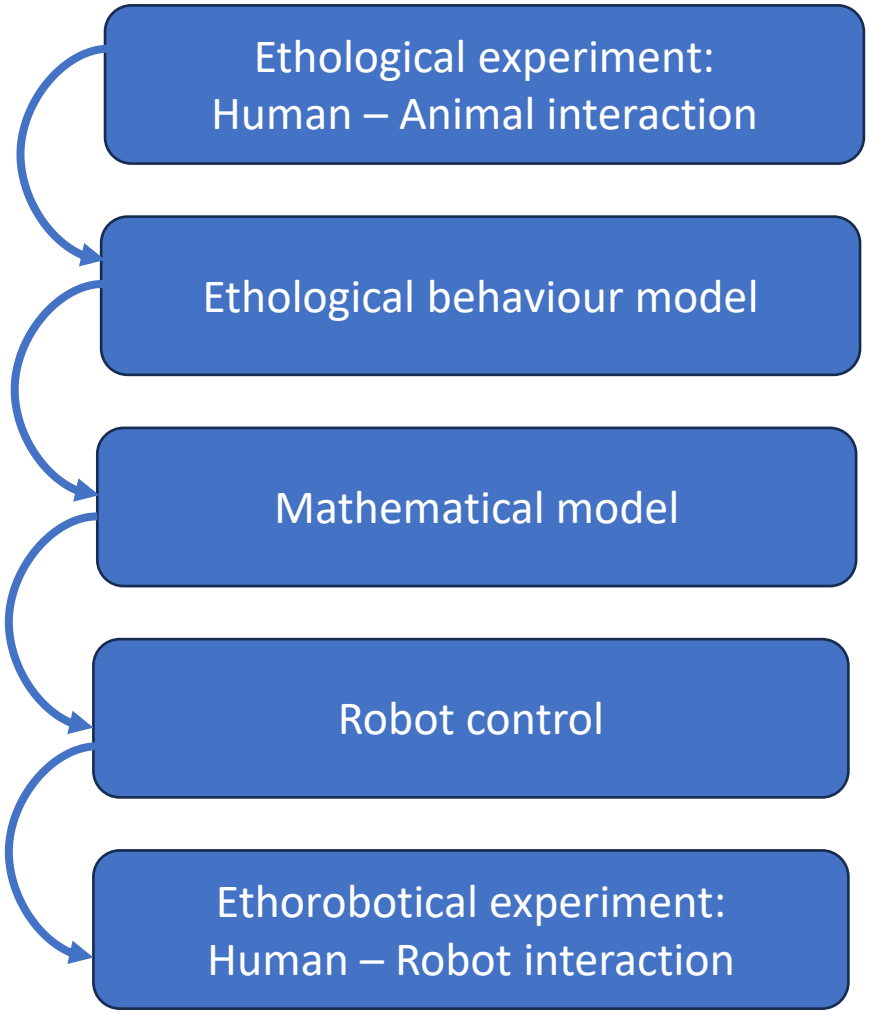
- Ethologically inspired robot behaviour
- Leading questions:
  - How can we measure animals quantitatively?
  - How can we use deep learning to learn animal behaviour pattern?
  - How can we implement animal like behaviour on an autonomous robot?



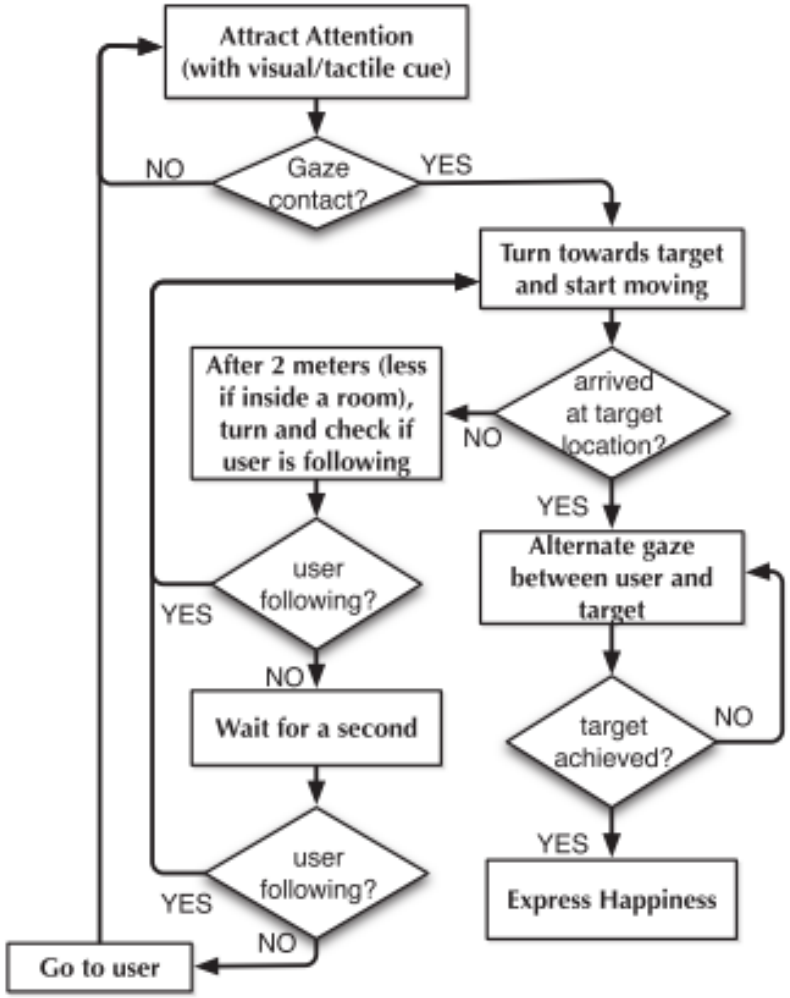
Base behaviour model

- Behaviour models based on social animals: dogs
- During domestication, dogs acquired social skills that helped them to integrate into the human environment
  - Communication
  - Cooperation
  - Attachment
- Help dogs
  - Guide dogs for the blind
  - Search and rescue dogs
  - Guarding dogs

Research and Development flow

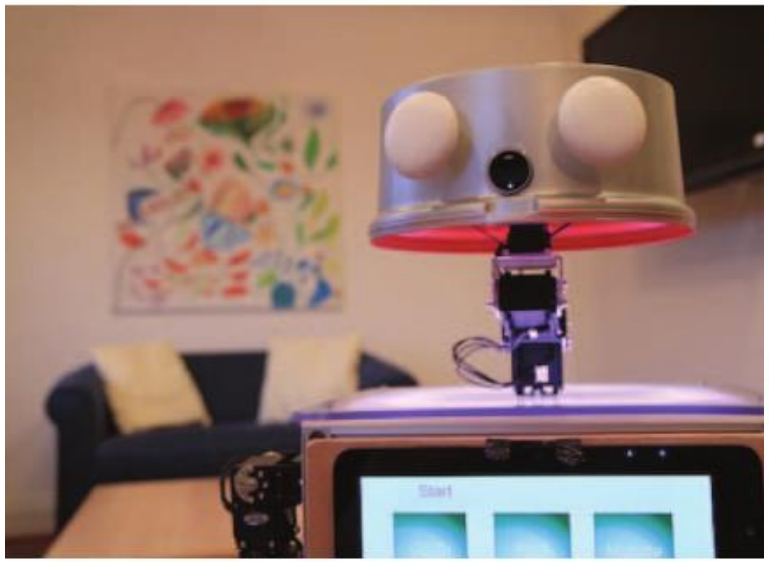


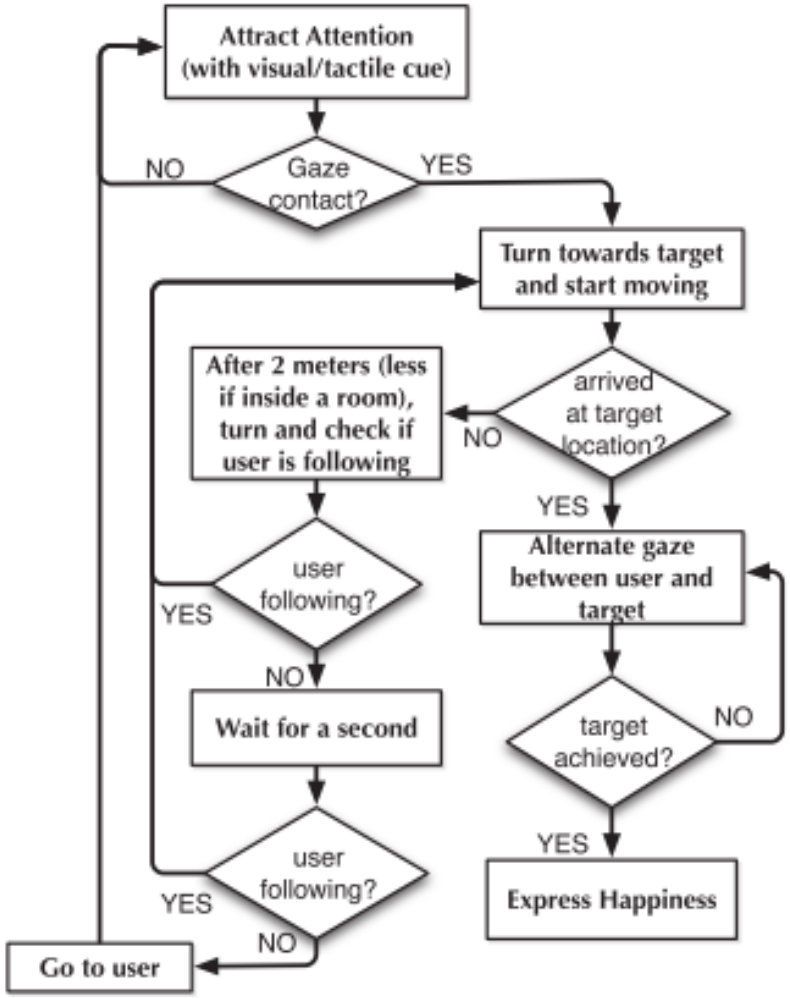
Leading to sound source



Leading to sound source

Sunflower robot

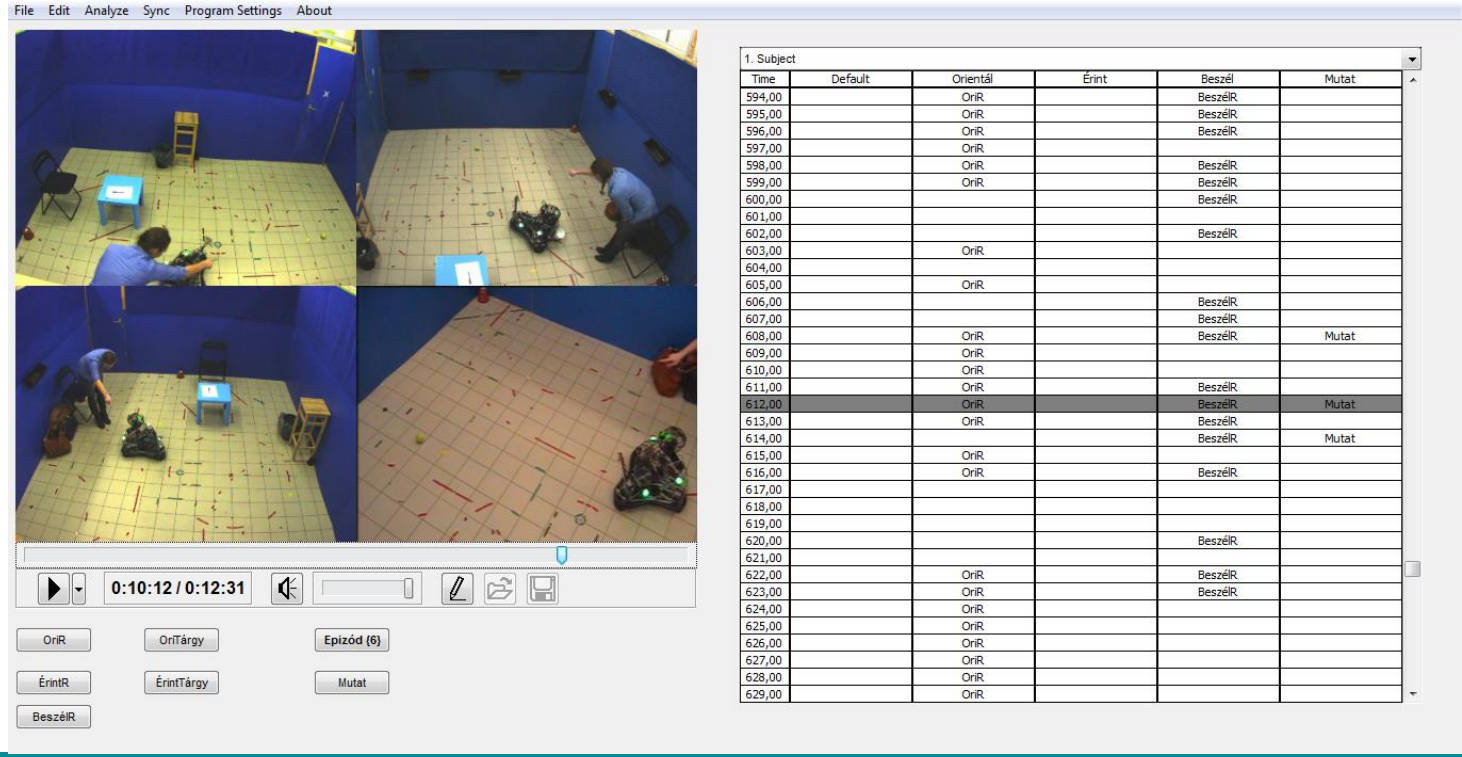




Ethology research process

- Experiment/observation
- Recording measurements (usually video recordings)
- Behaviour coding
- Data
- Statistics
- Behavioural model

Ethograms



1. Subject

Time	Default	Orientál	Érint	Beszél	Mutat
594,00		OriR		BeszélR	
595,00		OriR		BeszélR	
596,00		OriR		BeszélR	
597,00		OriR			
598,00		OriR		BeszélR	
599,00		OriR		BeszélR	
600,00				BeszélR	
601,00					
602,00				BeszélR	
603,00		OriR			
604,00					
605,00		OriR			
606,00				BeszélR	
607,00				BeszélR	
608,00		OriR		BeszélR	Mutat
609,00		OriR			
610,00		OriR			
611,00		OriR		BeszélR	
612,00		OriR		BeszélR	Mutat
613,00		OriR		BeszélR	
614,00				BeszélR	Mutat
615,00		OriR			
616,00		OriR		BeszélR	
617,00					
618,00					
619,00					
620,00				BeszélR	
621,00					
622,00		OriR		BeszélR	
623,00		OriR		BeszélR	
624,00		OriR			
625,00		OriR			
626,00		OriR			
627,00		OriR			
628,00		OriR			
629,00		OriR			

Observed behaviour

- How long does the dog:
  - Play
  - Wait
    - beside the owner
    - beside the door
  - Explore
- How many times does the dog:
  - Initiate contact
    - With owner
    - With stranger

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)
  - Extend the procedure to examine behaviour between a robot and a human

Ainsworth's test with a dog

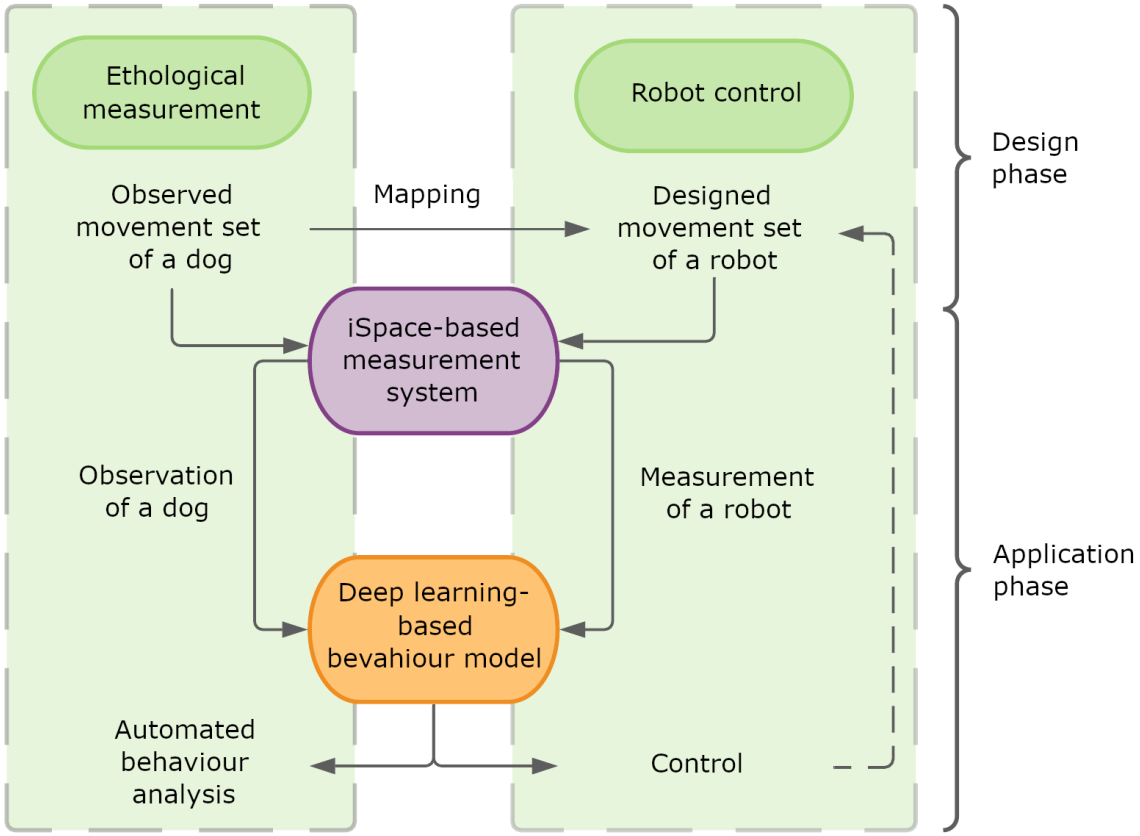
- #1: Acclimatisation
- #2: Introduction to STR
- #3: OWN leaves, first separation
- #4: First reunion with OWN
- #5: Dog alone, second separation
- #6: Separation continuation with STR
- #7: 2nd reunion with OWN
- *Instructions:*
  - *First half of every scenario is passive, the second is active*
 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

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

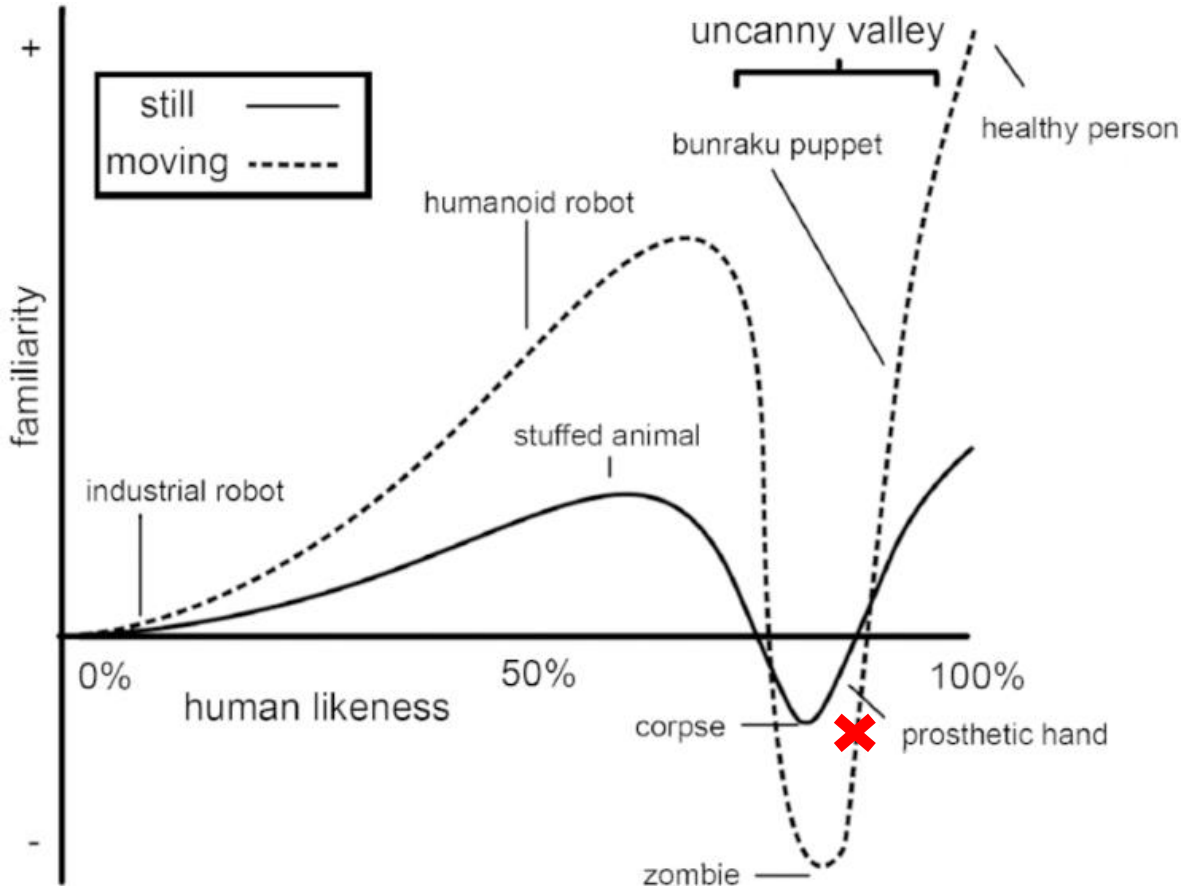


Robot design approaches

- **Top-down:** breaking down of a system to gain insight into its compositional subsystems in a reverse-engineering fashion. In a top–down approach an overview of the system is formulated, specifying, but not detailing, any first-level subsystems.
- **Bottom-up:** piecing together of systems to give rise to more complex systems, thus making the original systems subsystems of the emergent system.
- Be aware of the „Uncanny Valley” effect
  - Form from function

Uncanny Valley (Masahiro Mori, 1970)

Hiroshi Ishiguro with Geminoid HI-4
2013, Osaka University



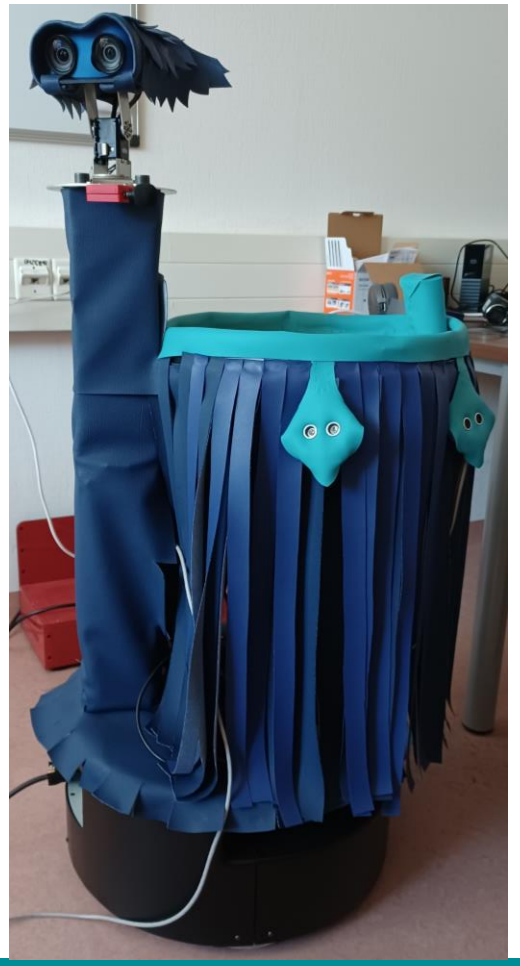
Feature matching

Get his cube, Blackjack	**Play**	Fetch a ball
Using worm wheels	**Move**	Using legs
Eyes on LCD screen, movements	**Emotion expression**	Complex mimic, tail movement, body language

Behavior elements
social skills

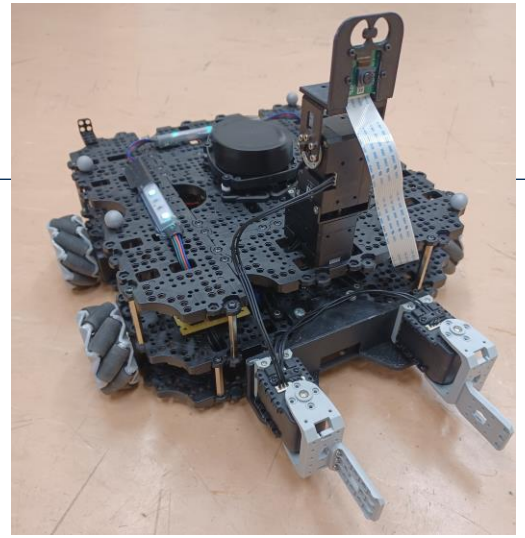
Biscee

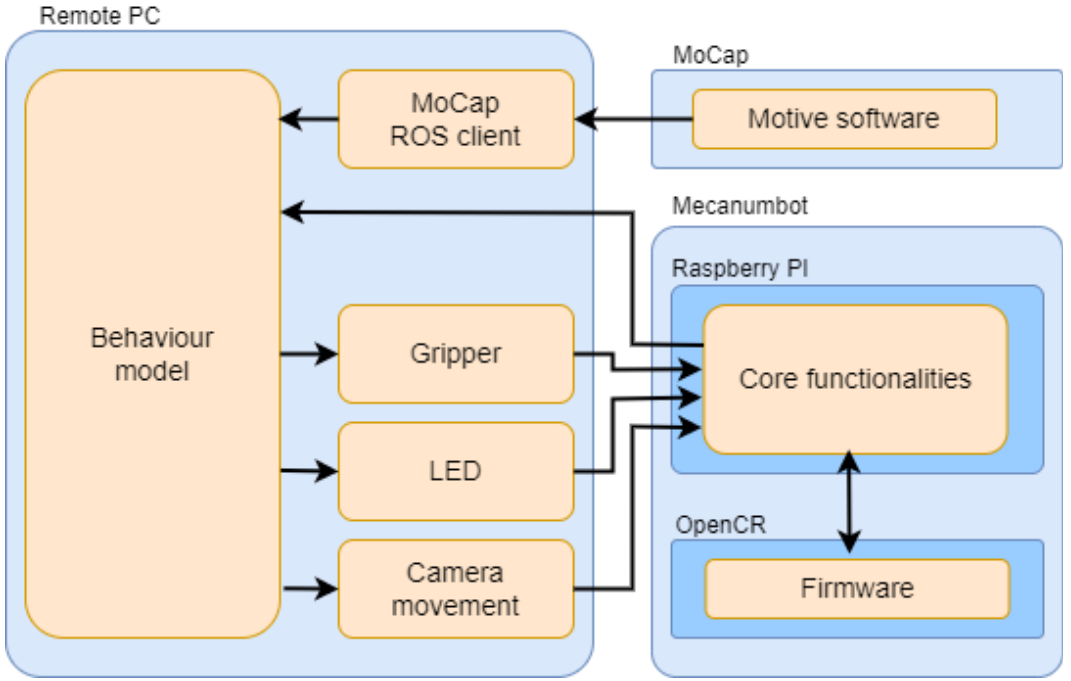
- First version of the ethorobot project
  - Ethon
  - Biscee
- Moduls
  - SLAM
  - Camera
  - MARG sensor
  - Microphone



Mecanumbot

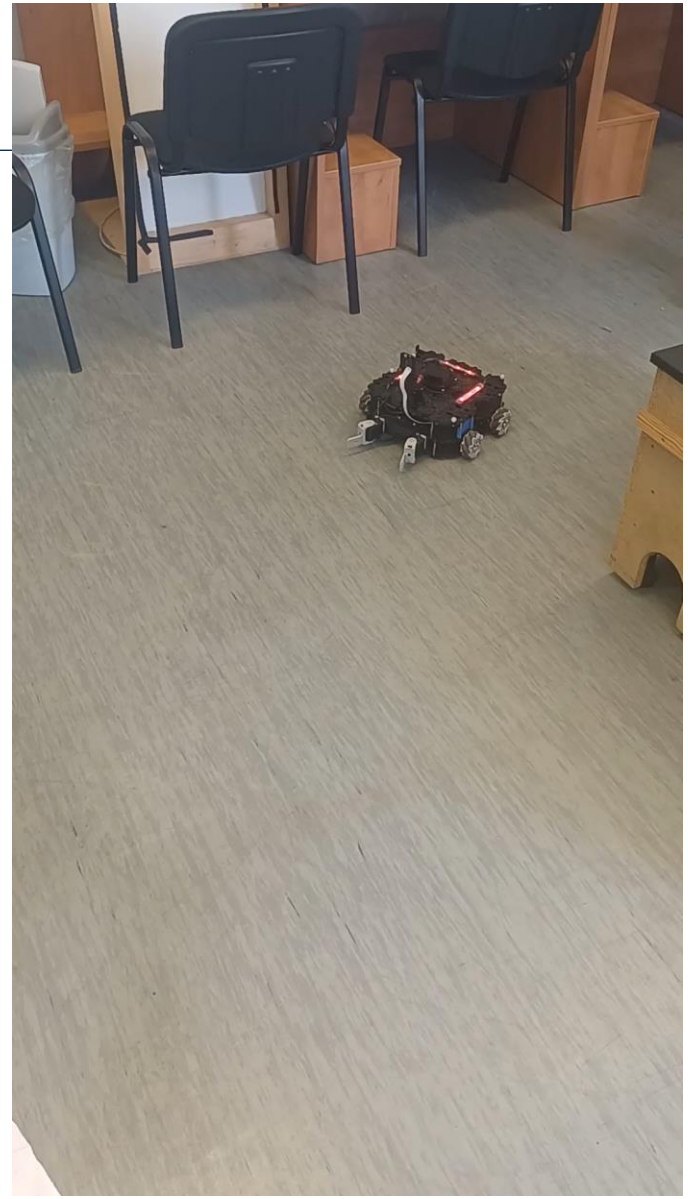
- External intelligence - Remote PC
  - Deep learning-based behaviour model
  - High level robot control
  - Data collection from observer
- Robot – Mecanumbot
  - Motor control – OpenCR
  - Core functionalities – Raspberry PI
  - Dog like features
- External observer – MoCap
  - Marker based position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





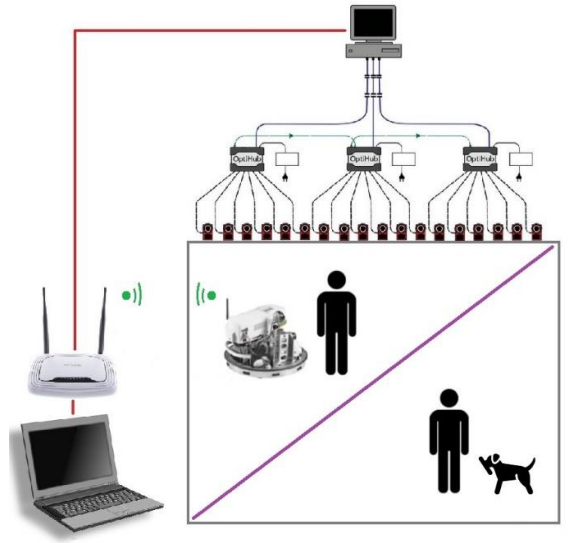
Mecanumbot – Play

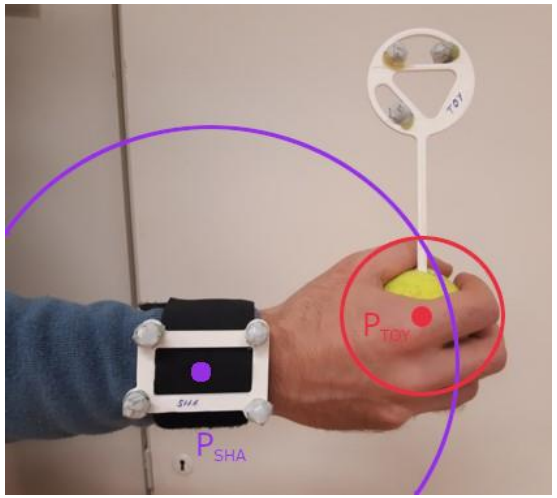
- Search the toy
  - Based on colour discrimination
  - Red light
- Find human
  - Using Yolo neural network to identify humans
  - Blue light
- Bring the toy to the human
  - Green light

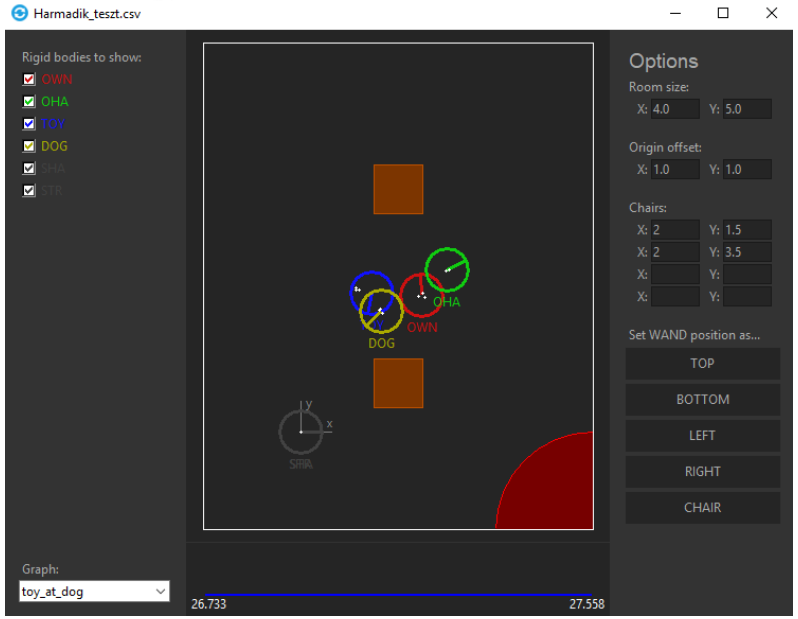


MoCap

- 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

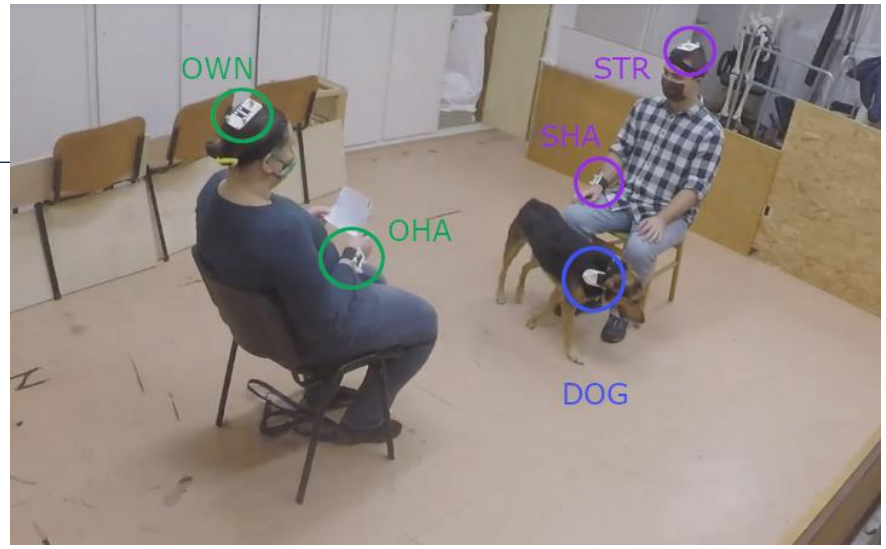


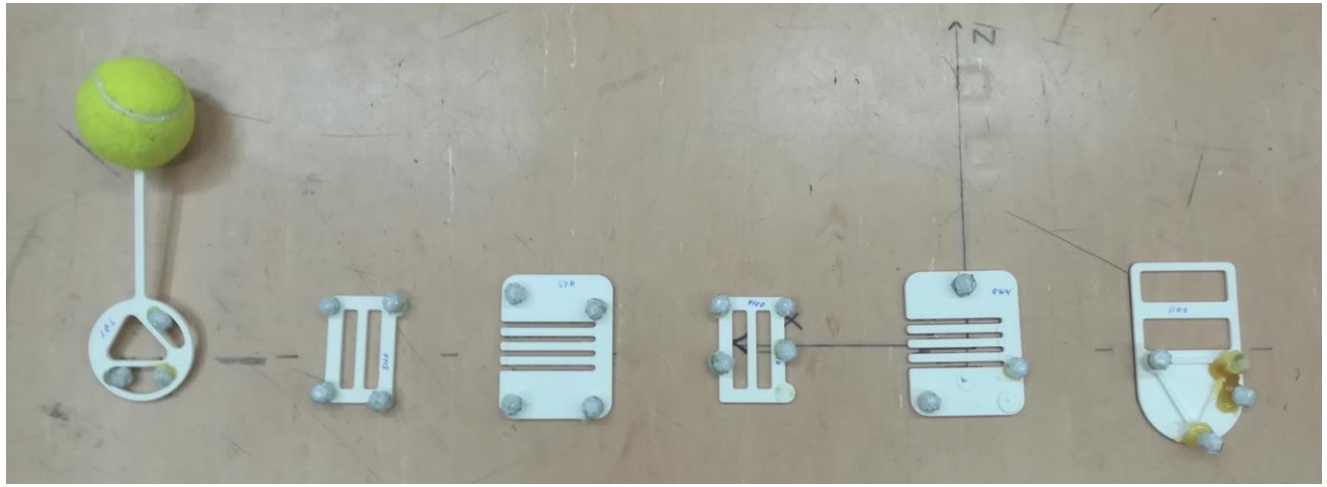




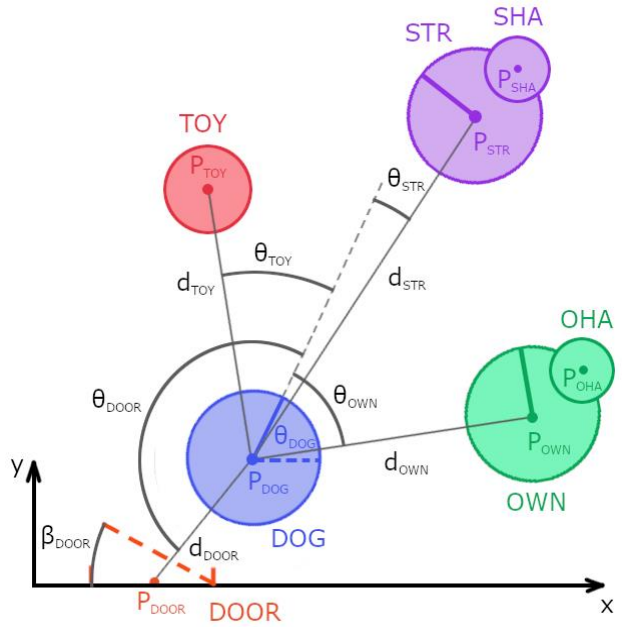
Modell and Tracking

- 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%

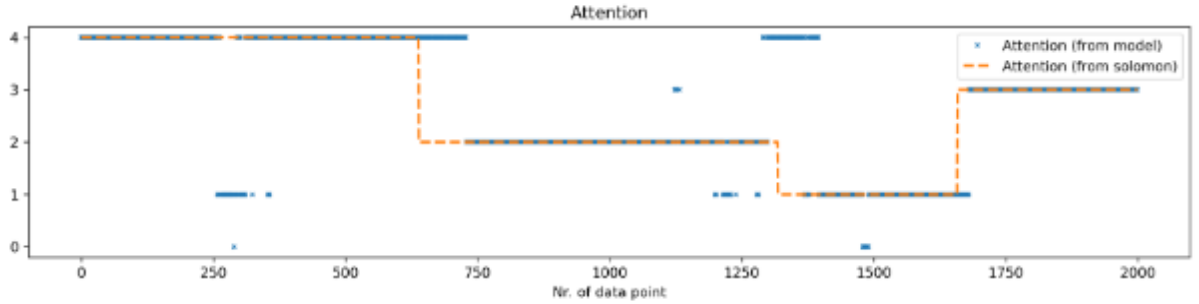


FIGURE 6. Result of attention prediction. (Dog looking at 0: non specified location, 1: owner, 2: stranger, 3: door, 4: toy)

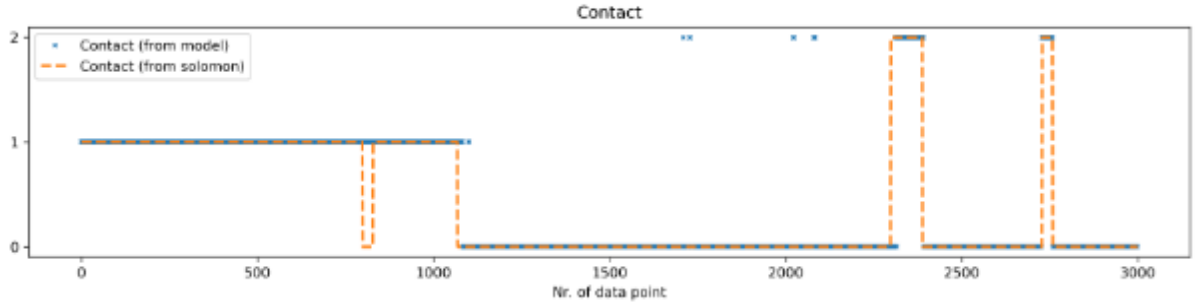


FIGURE 7. Result of contact prediction. (0: No contact, 1: Contact with owner, 2: Contact with stranger)

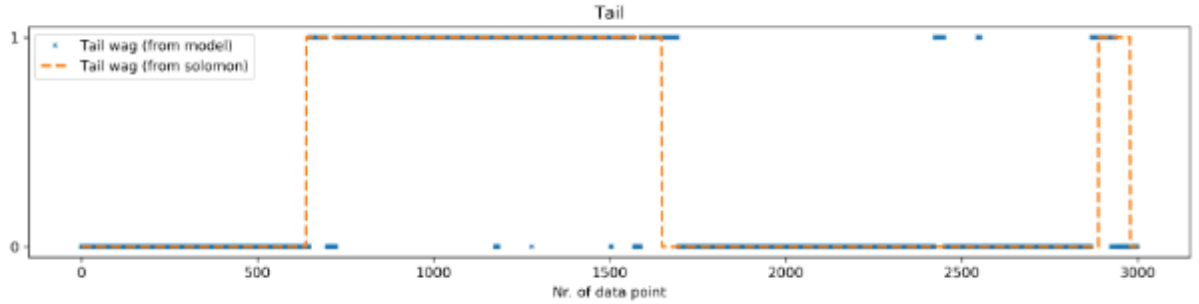


FIGURE 8. Result of tail wag prediction. (0: No tail wag, 1: Tail wag)

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Thank you for your attention!