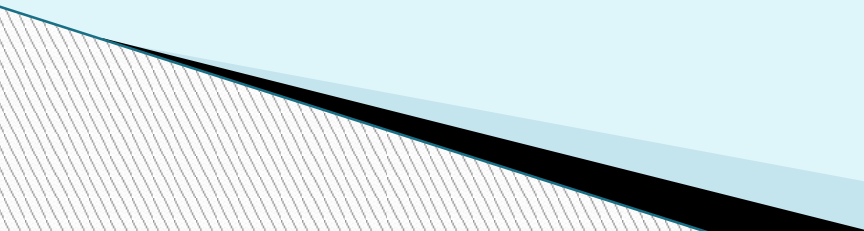# Toward design of a robotic companion

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Wroclaw University of Technology (WRUT)
Poland

Plan of the talk

- Robot and robotics
- Social robot
- Robotic companion
- Robot FLASH
- Design
- Control
- Performance

What is a robot?

- Robot is an artificial human.
- Robot is a machine performing some physical and intellectual activities of a living being.
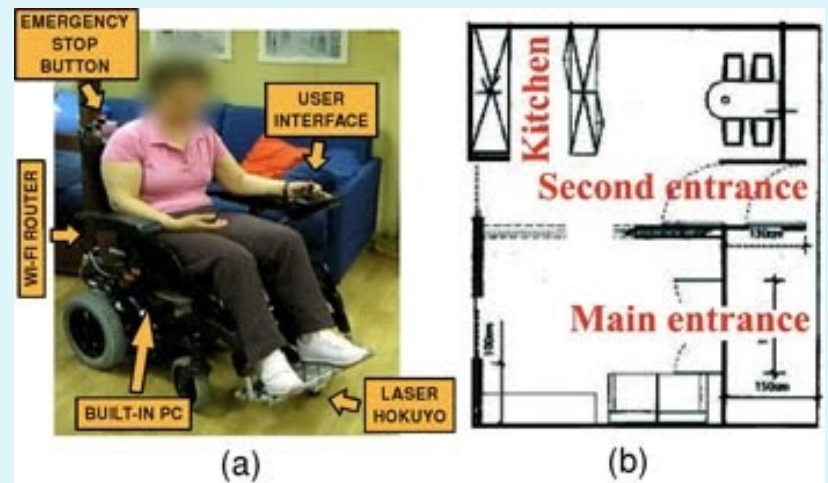
What is robotics?

984

Robotics is the intelligent connection of perception to action.
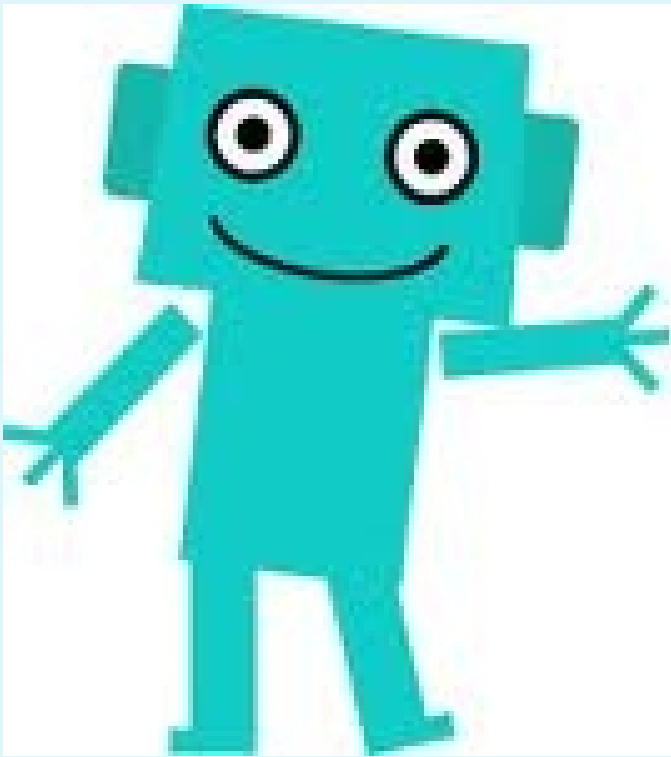
Usually this connection is done by a computer.

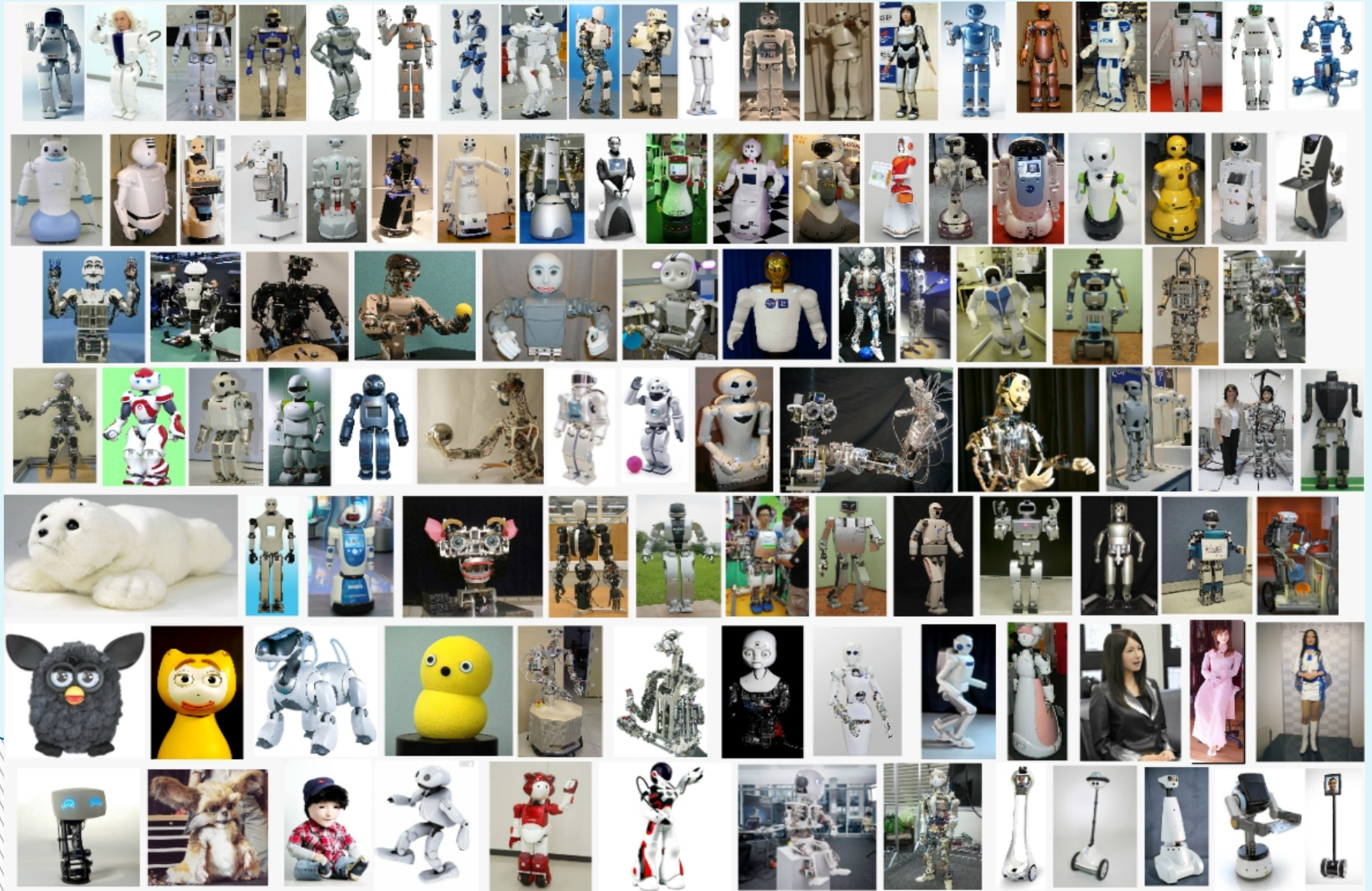# Separation

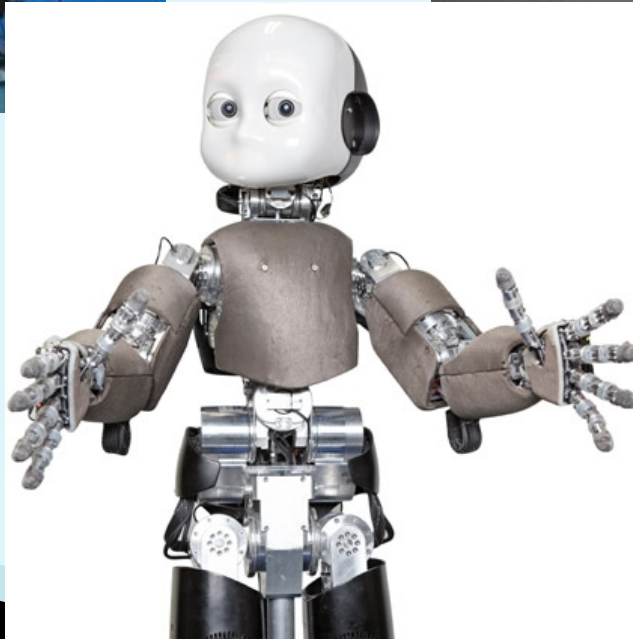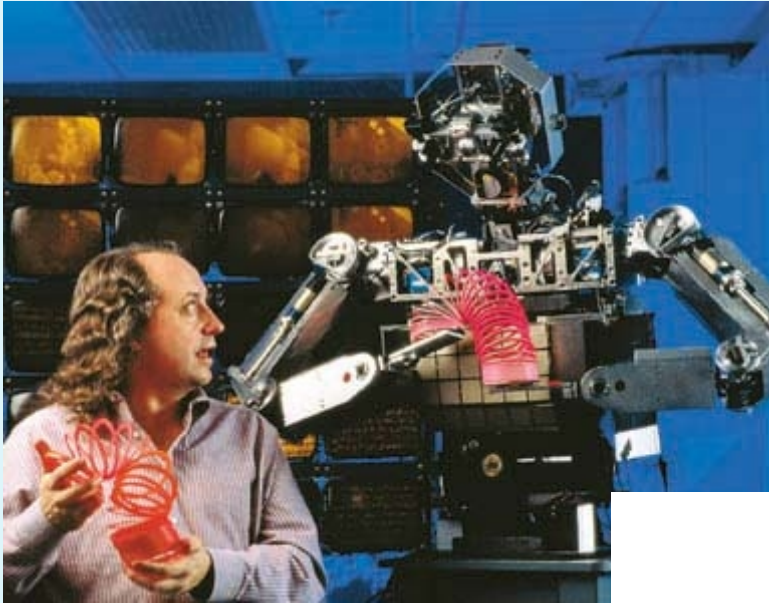# Closer to humans

Social robot

A social robot is an autonomous robot able to interact and communicate with humans in a socially accepted way.
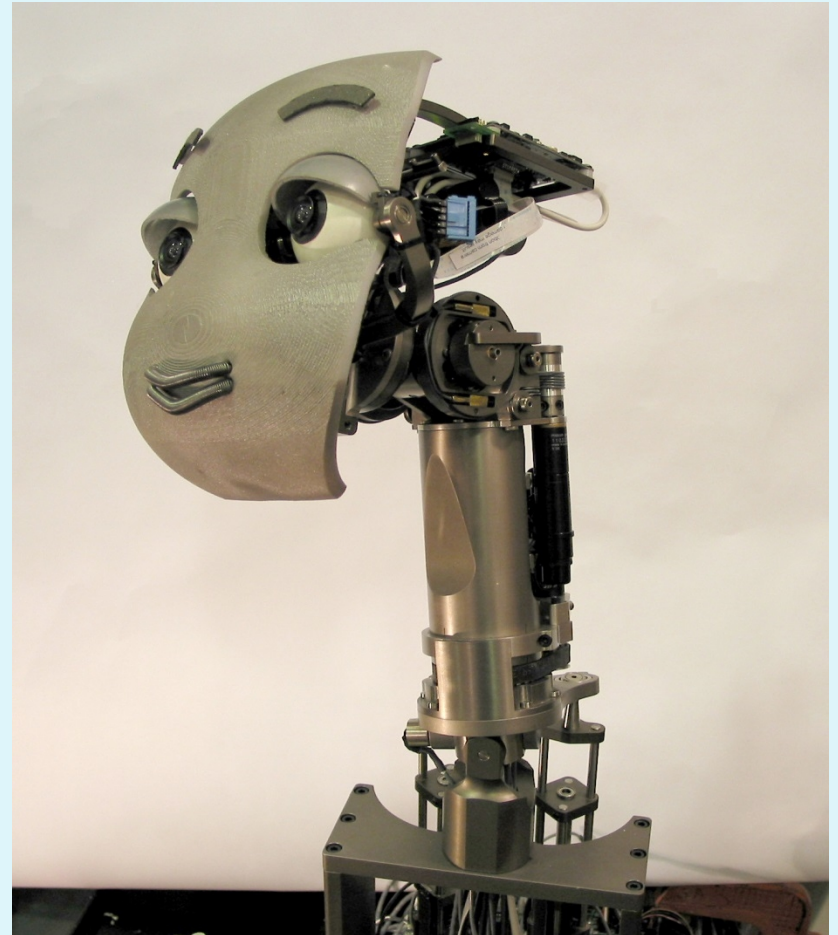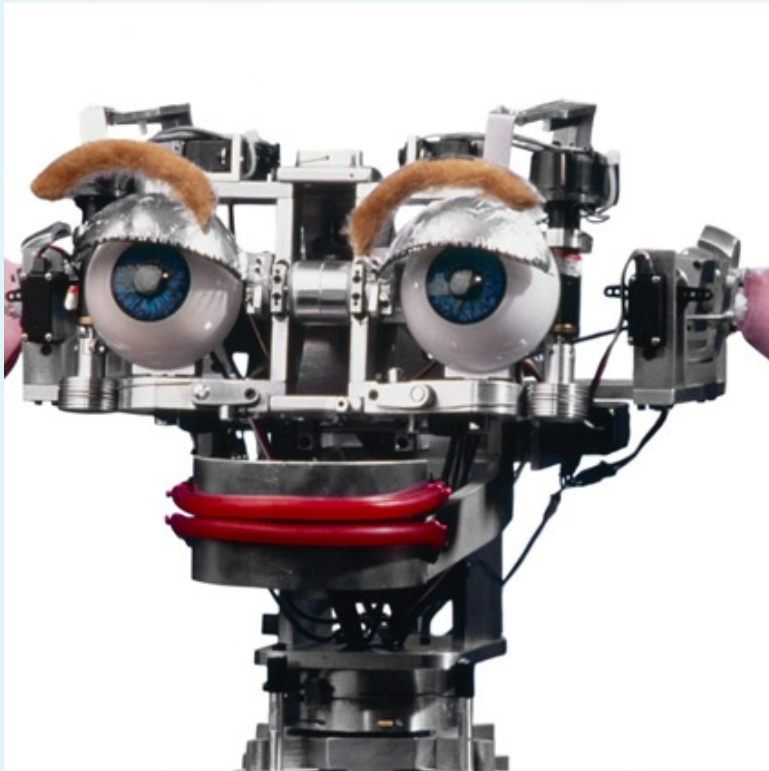
Social robots: gallery 1

Social robots: gallery 2

Social robots: gallery 3

Robotic companion 1

Companion = someone to share bread with during a journey

panis, -is (in Latin) = bread

Robotic companion 2

A social robotic helper:
- caregiver
- therapist
- escort
- coach
- tutor
- teacher
- entertainer …

Challenges

- Believability (appearance, emotions, perception, communication, interaction)
- Long term companionship (rapport, theory of mind)
- Social usability (assisting, caregiving, teaching)
- Ethics (roboethics, ethics of robots)

Companionship
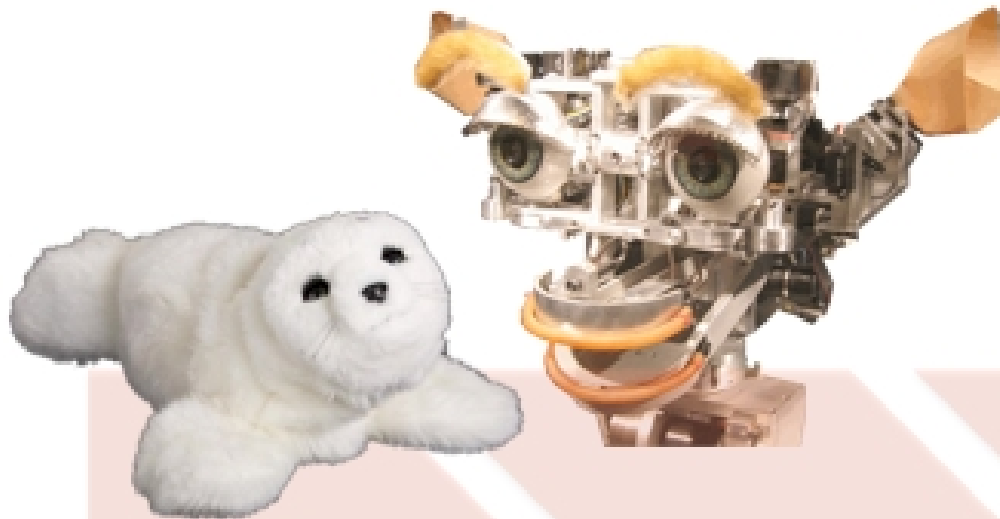
passive   reactive   relational

LIREC IP (2008-2012)

LIREC=LIving with Robots and intEractive Companions

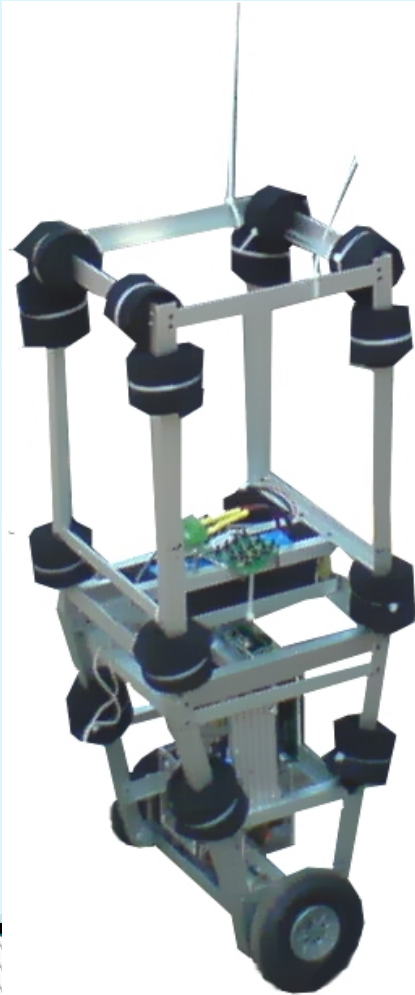Task: Build a robotic companion using available technology

Design: focus

- Appearance (mechanoid, humanoid)
- Emotions (facial expressions, gestures)
- Perception (video, audio)
- Social cues (eye contact, gaze direction, utterances)
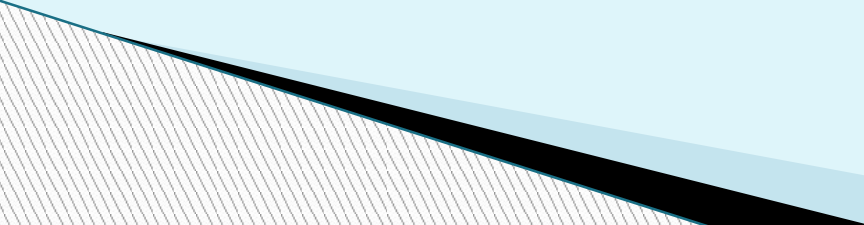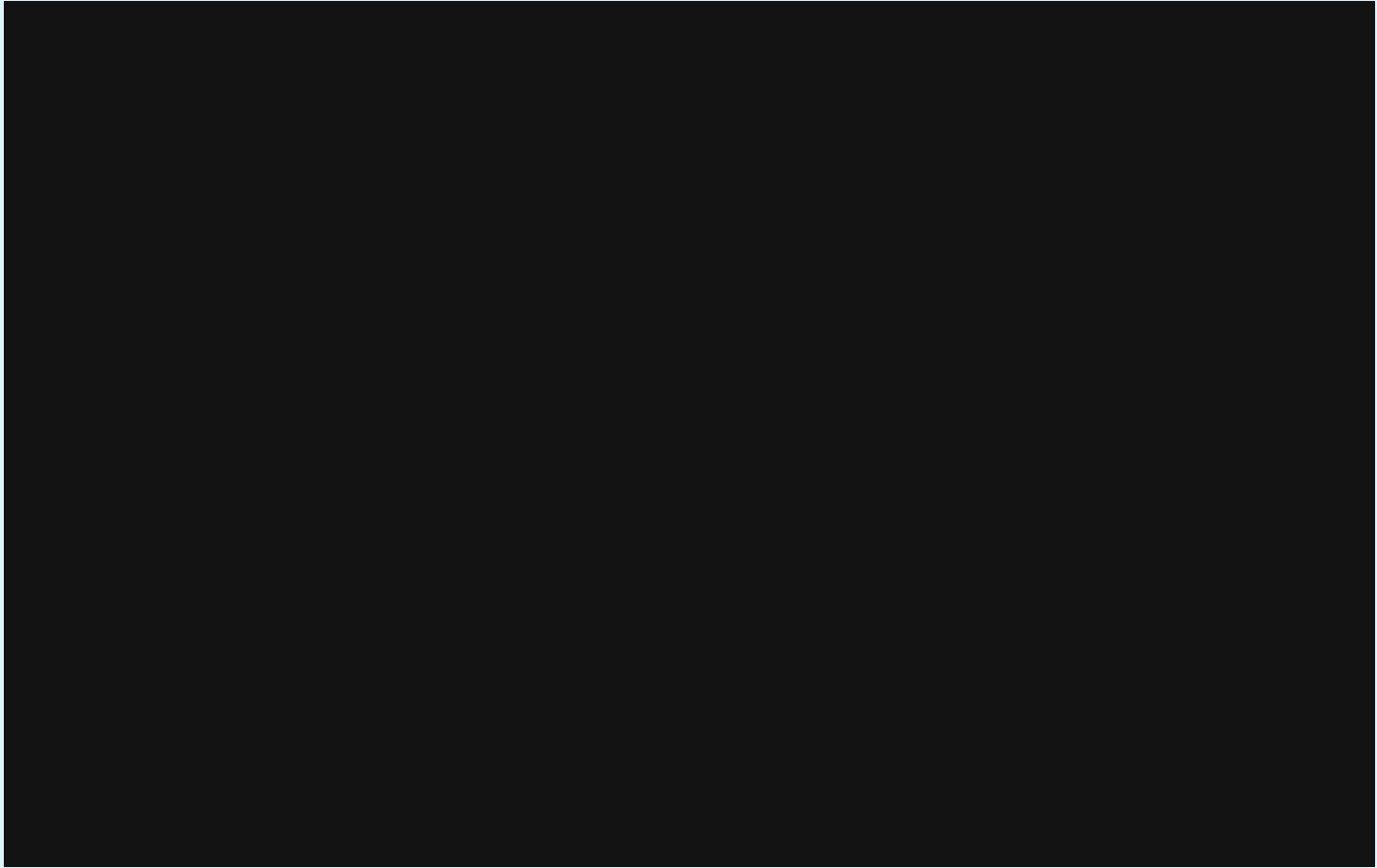- Interaction (establishing, maintaining)
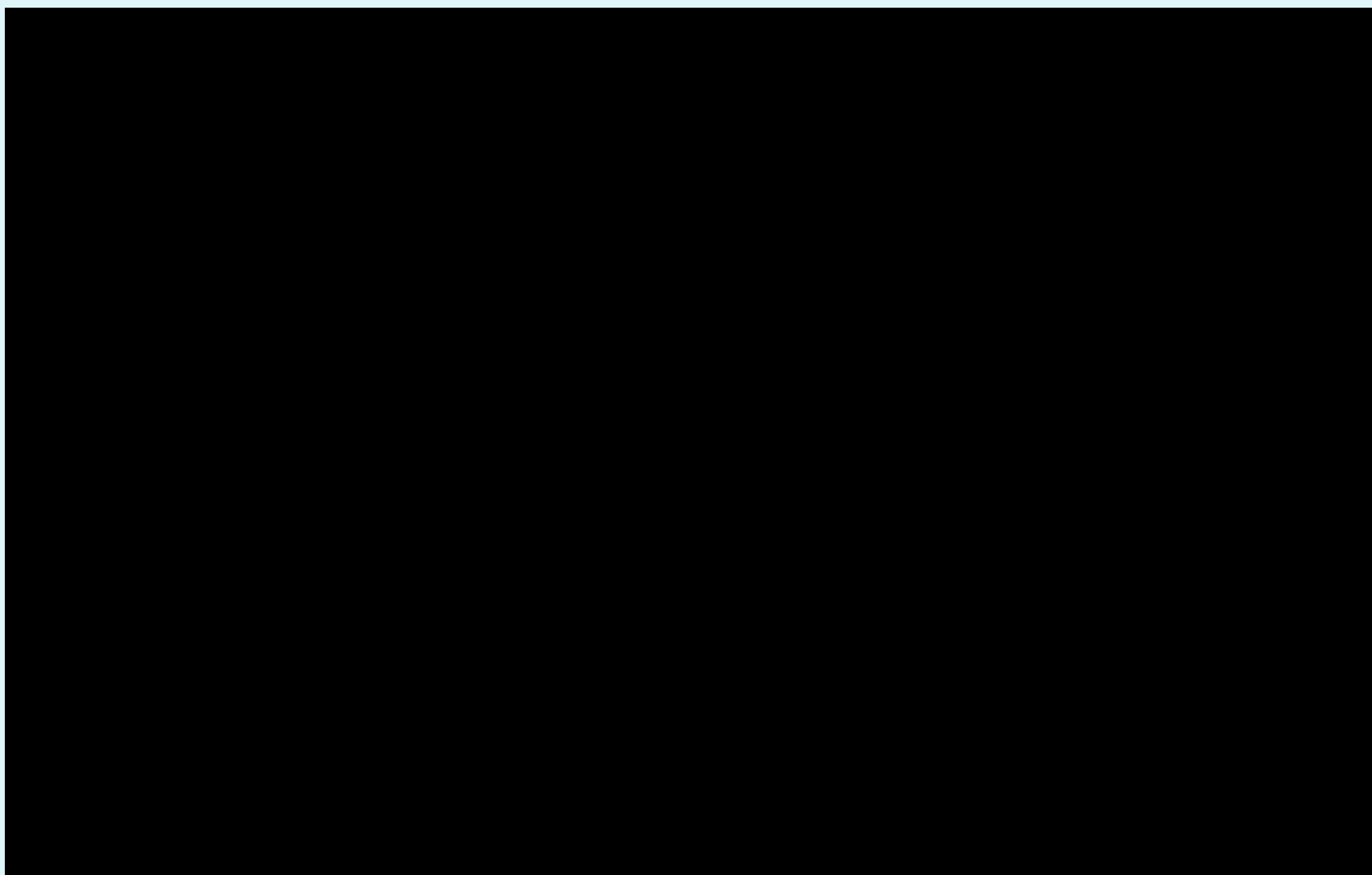- Learning

Design: Unacanny valley
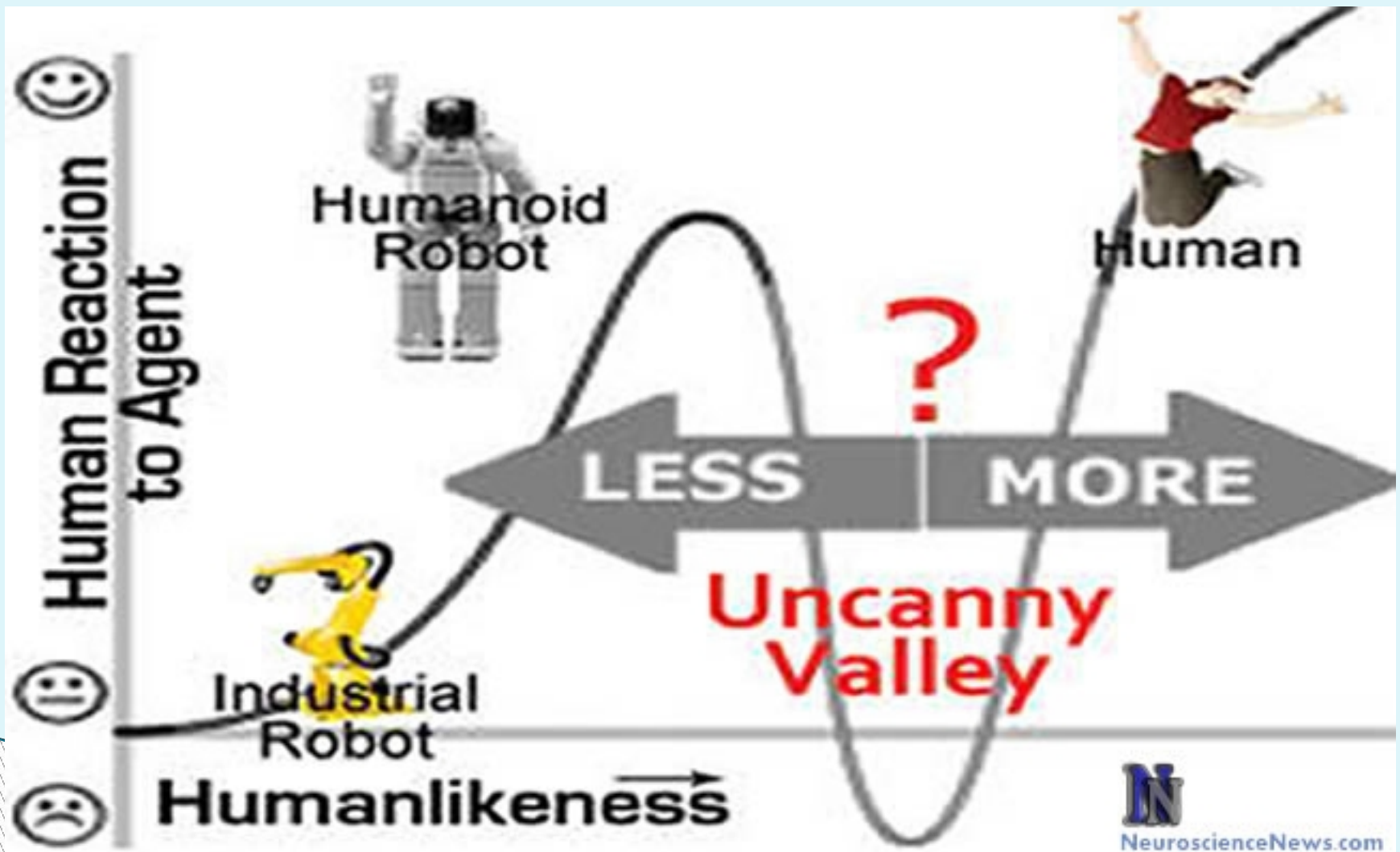
Design: mobility + hand

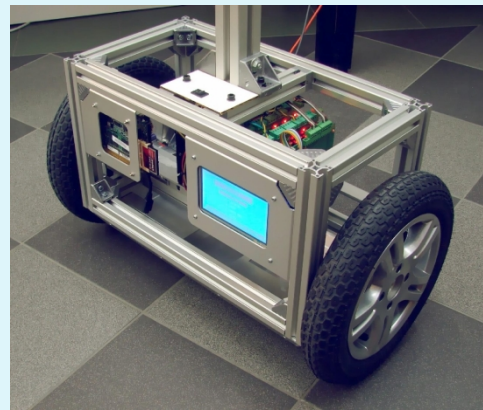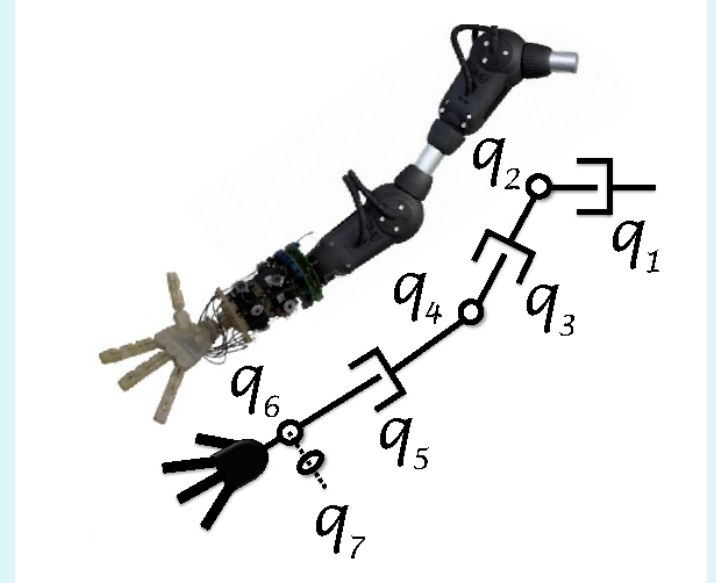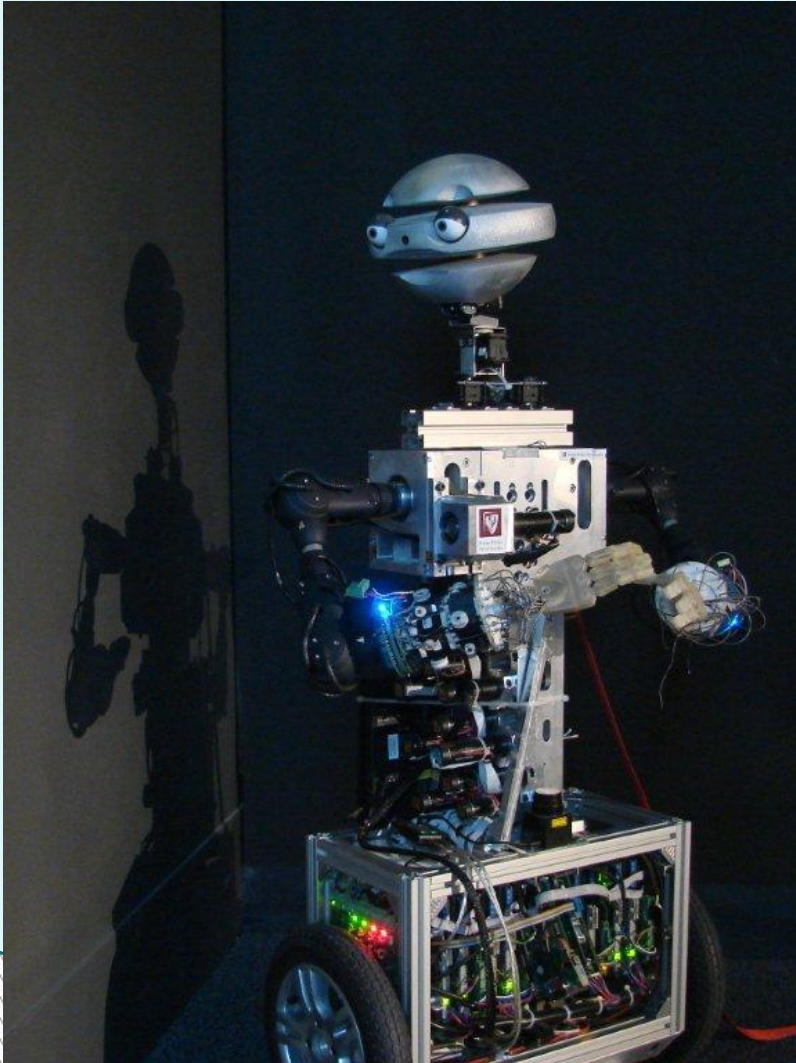# COSMOS platform

Design: head

Romek

FLASH (FLexible Autonomous Social Helper)

- Balancing platform

- Hands able to gesticulate
WANDA: Wrut hAND for gesticulAtion

- Head able to express emotions
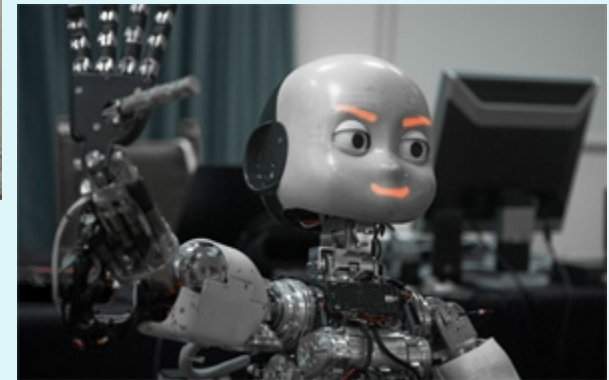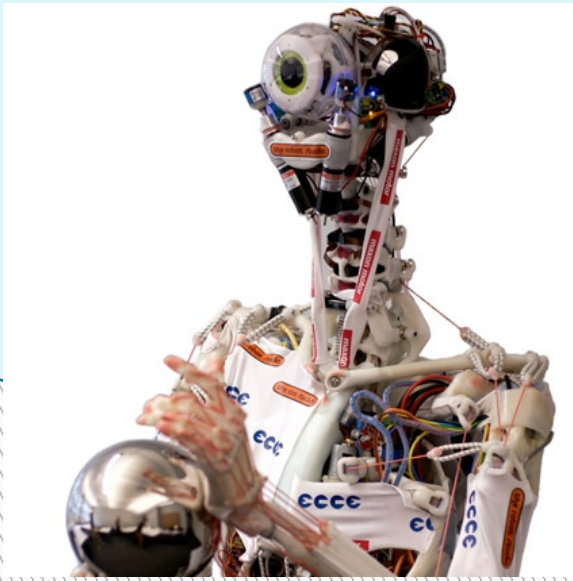EMYS: EMotive headY System
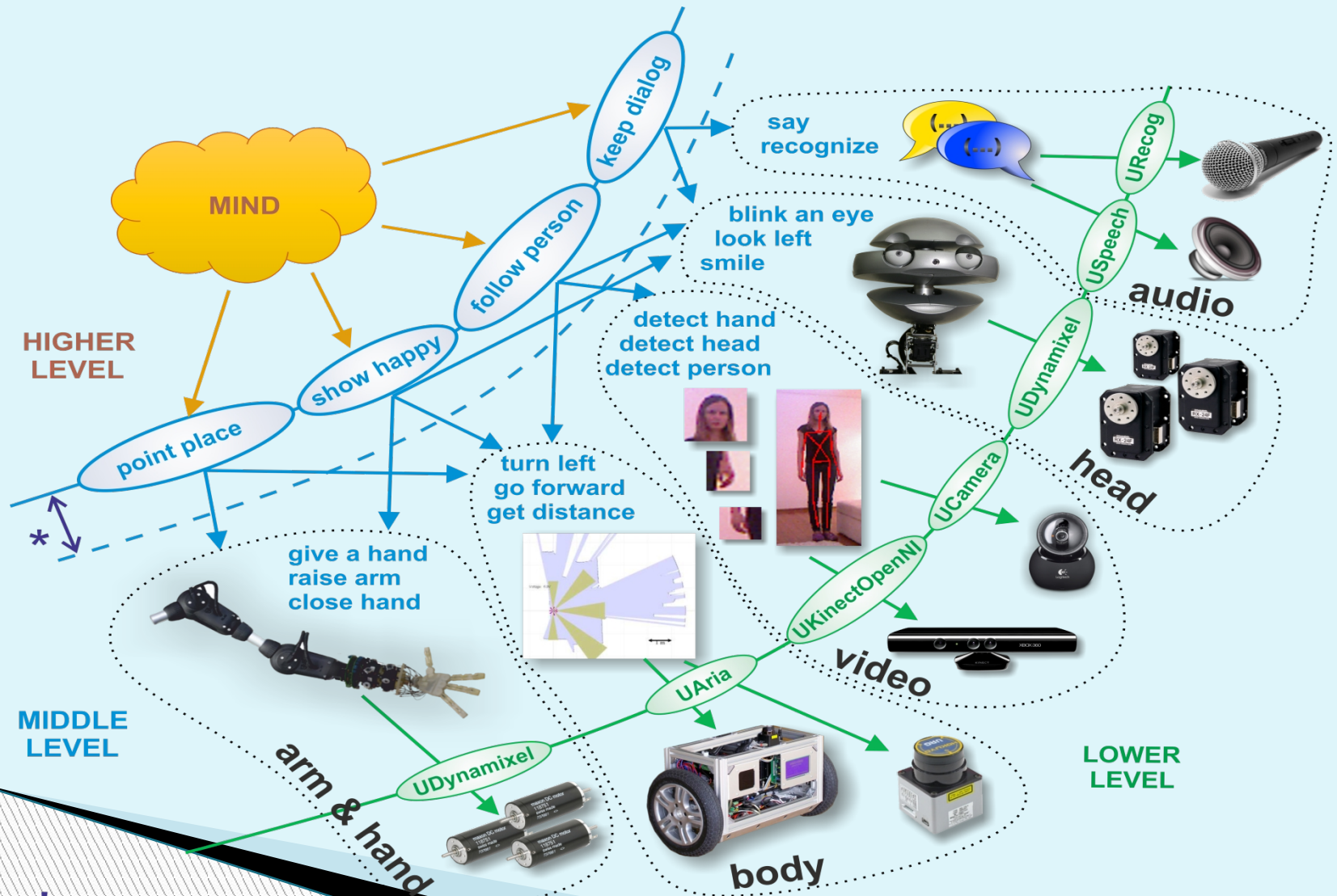
FLASH: Appearance

FLASH+WANDA+EMYS

FLASH: In the family
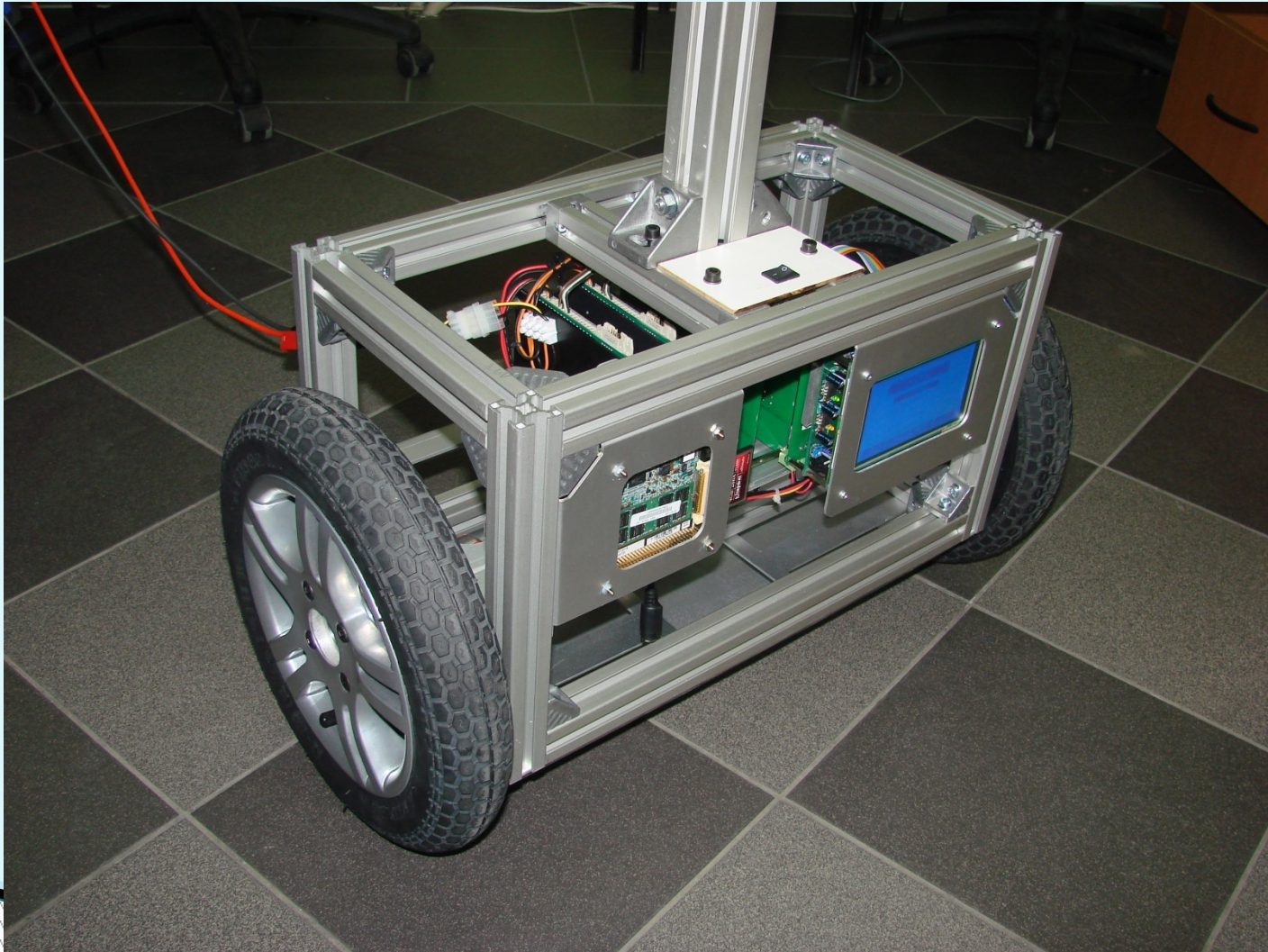
FLASH: Competencies

- Balancing and navigation
- Maintaining robot-human distance
- World perception (video, audio)
- Detecting humans
- Maintaining eye contact
- Communication (verbal, non-verbal)
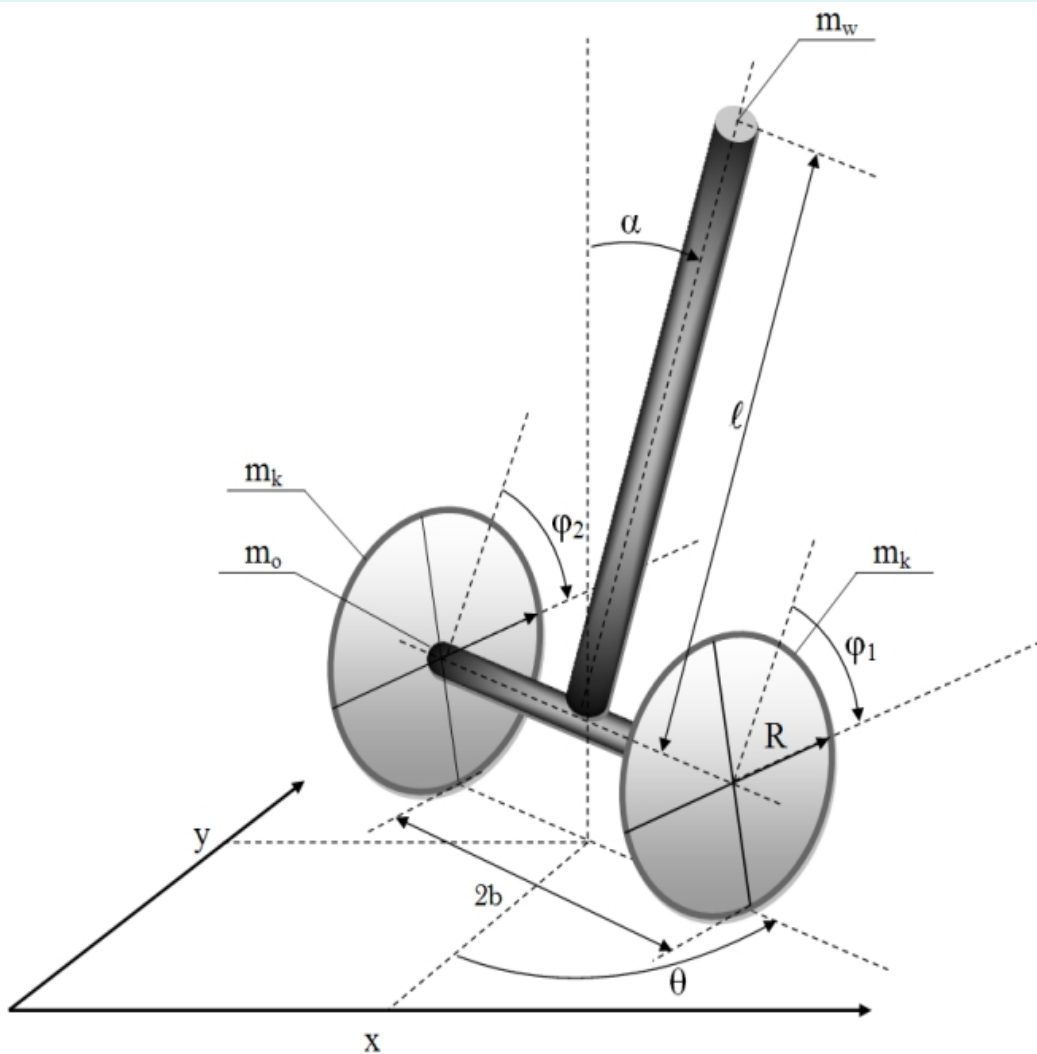- Displaying emotions
- Learning

FLASH: Architecture

MIND

keep dialog

follow person

show happy

point place

HIGHER LEVEL

*

say recognize

blink an eye look left smile

detect hand detect head detect person

turn left go forward get distance

give a hand raise arm close hand

MIDDLE LEVEL

URecog

USpeech

UDynamixel

UCamera

UKinectOpenNI

UAria

UDynamixel

audio

head

video

body

arm & hand

LOWER LEVEL

* Manager competency layer dedicated for every embodiment

FLASH: Platform

FLASH: Dynamics

$$q = (x, y, \theta, \varphi_1, \varphi_2, \alpha),$$
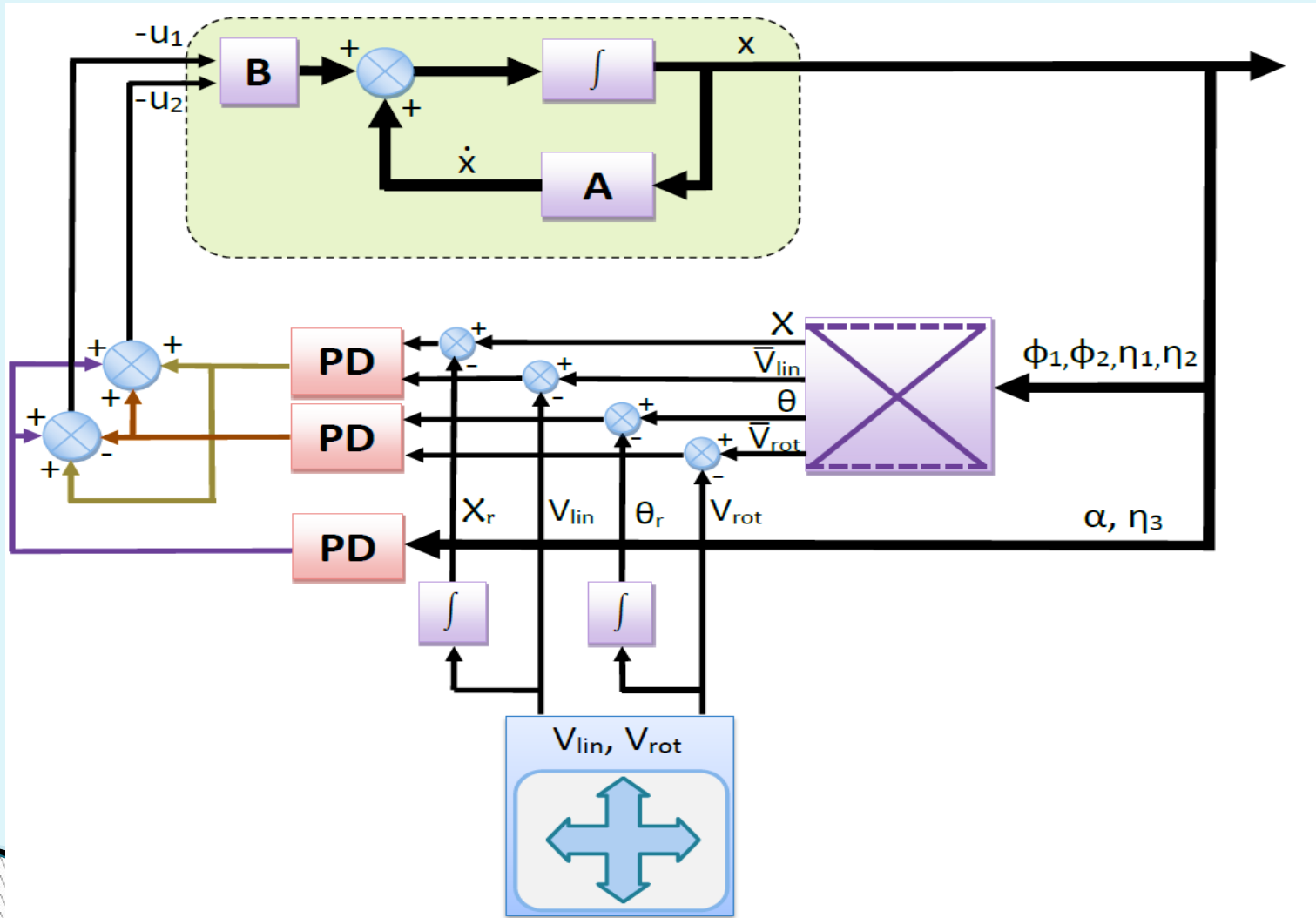$$\eta = (\eta_1 \, \eta_2 \, \eta_3)$$

$$\dot{q} = F(\eta),$$
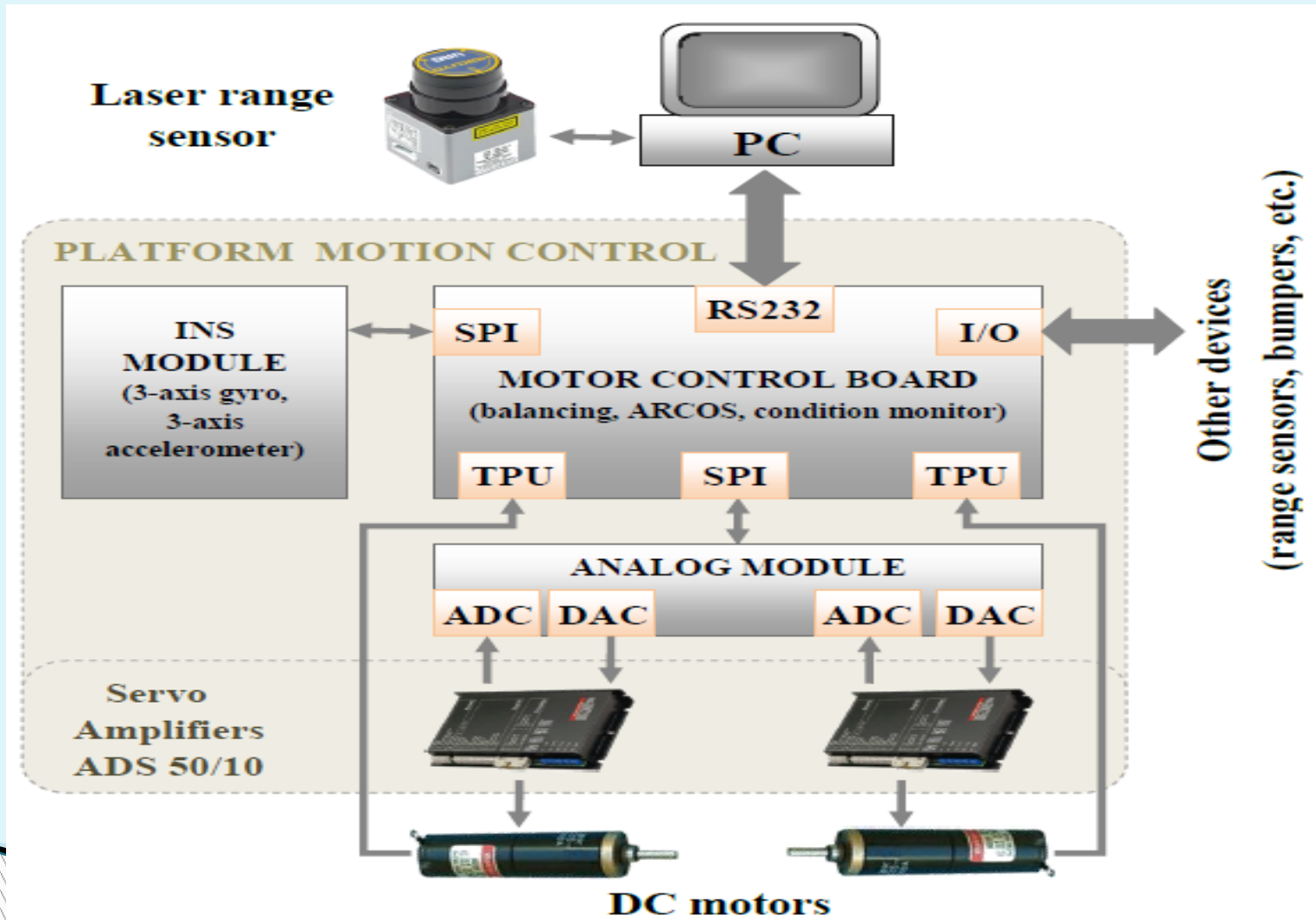$$M(q)\dot{\eta} + N(q, \eta) = B\tau$$

FLASH: Control

- Linear control: LQR, PP, PD
- Differential flatness
- Endogenous configuration space approach (imbalanced Jacobian, prioritarian approach)
- Optimal control approach (ACADO)
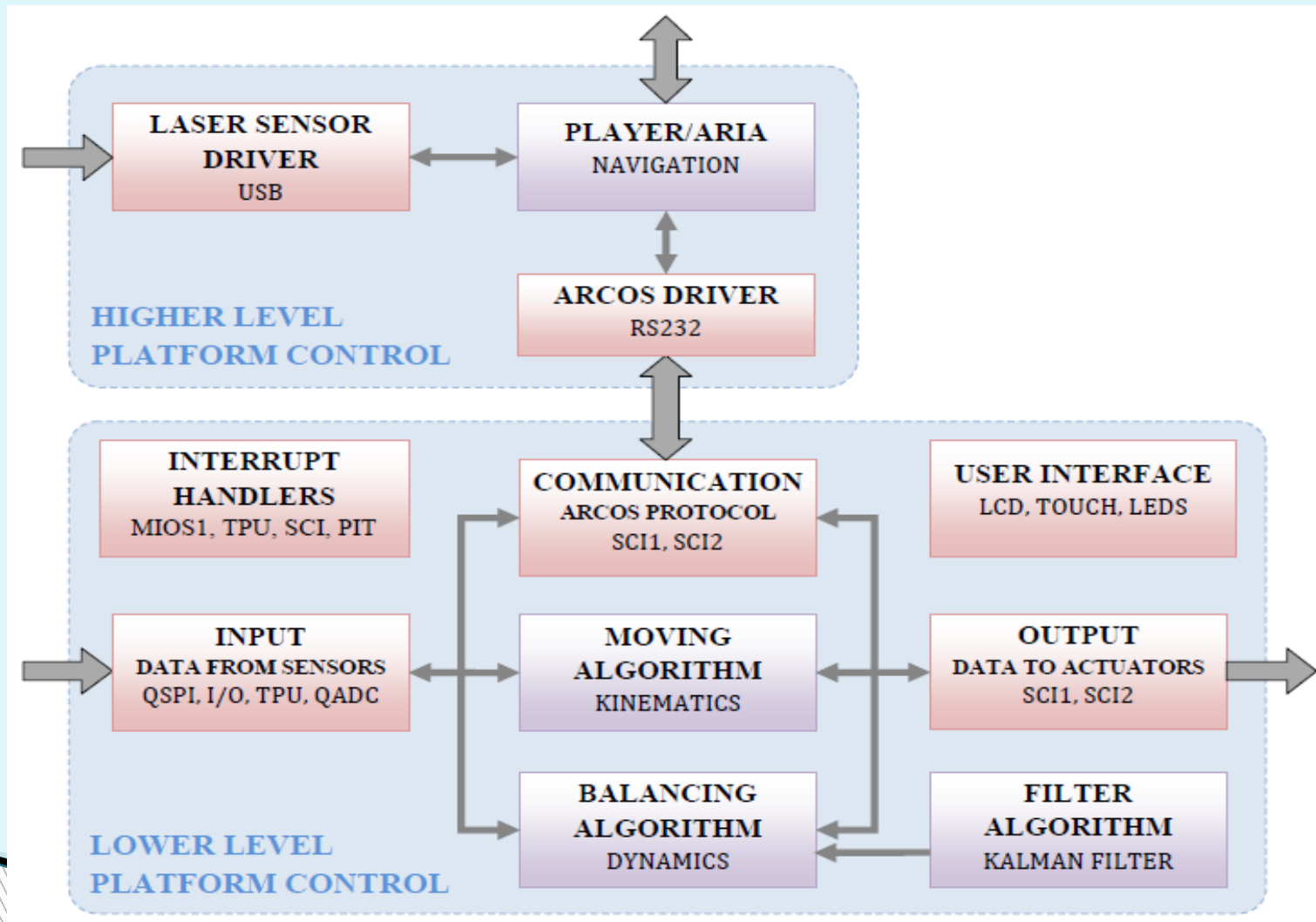- Nonlinear model predictive control (ACADO)
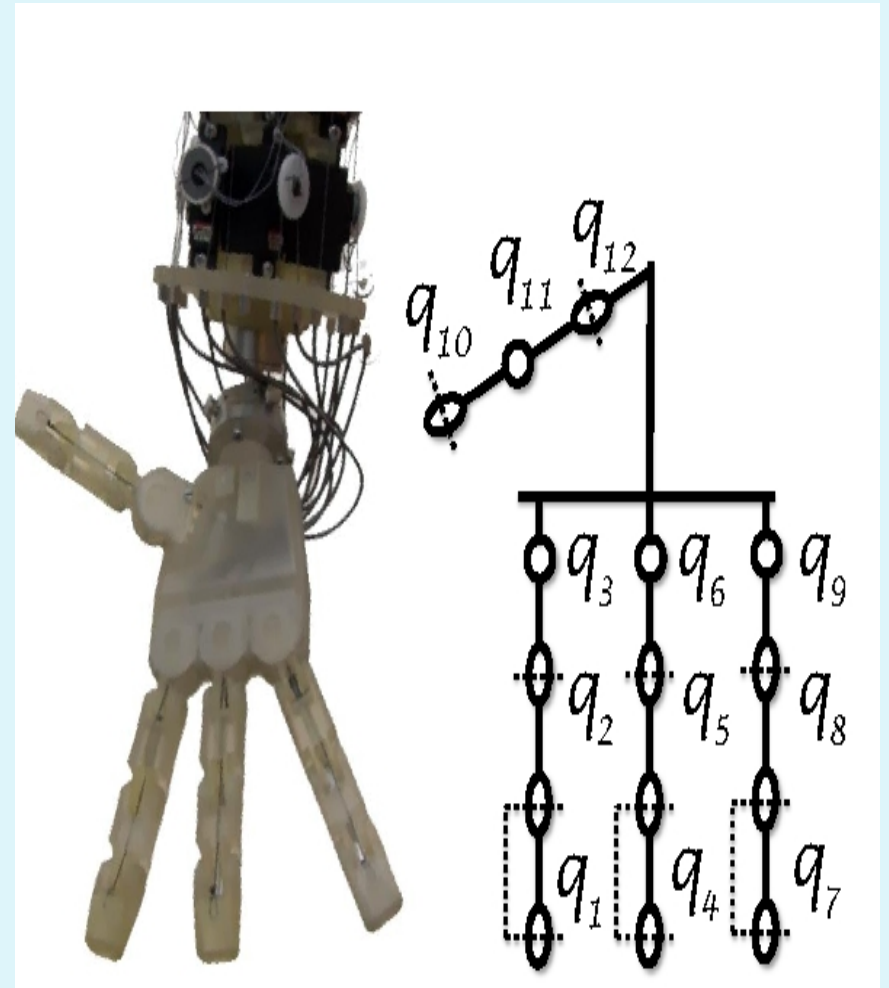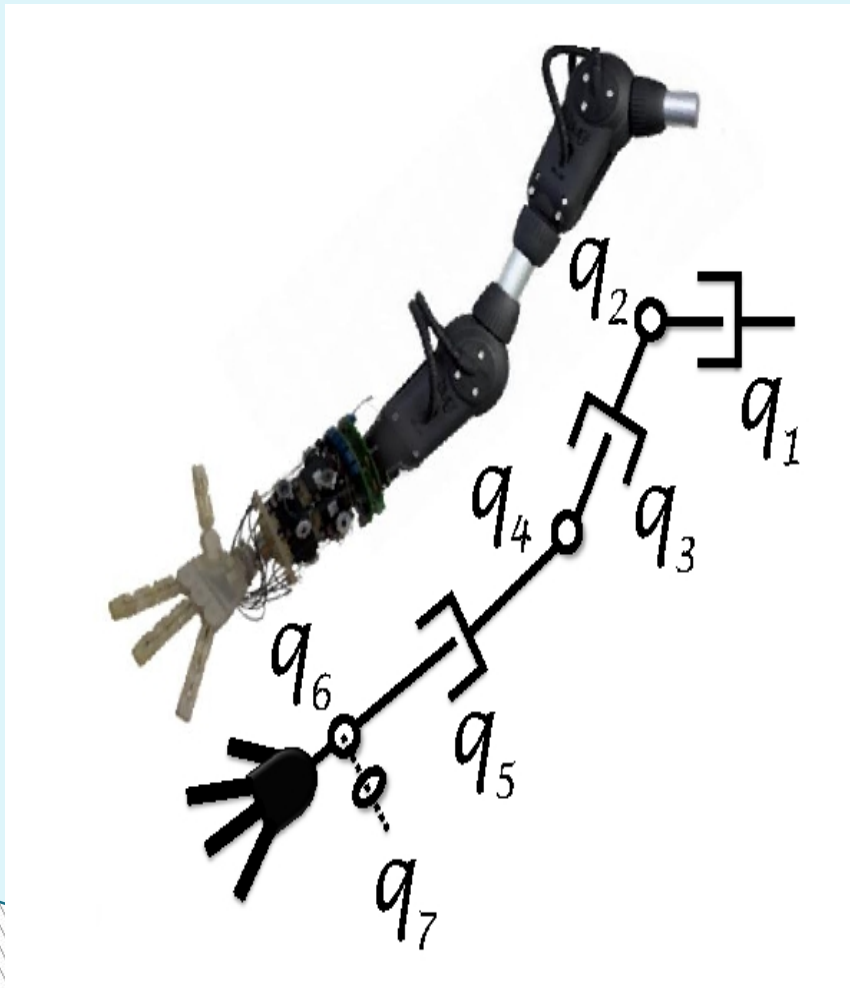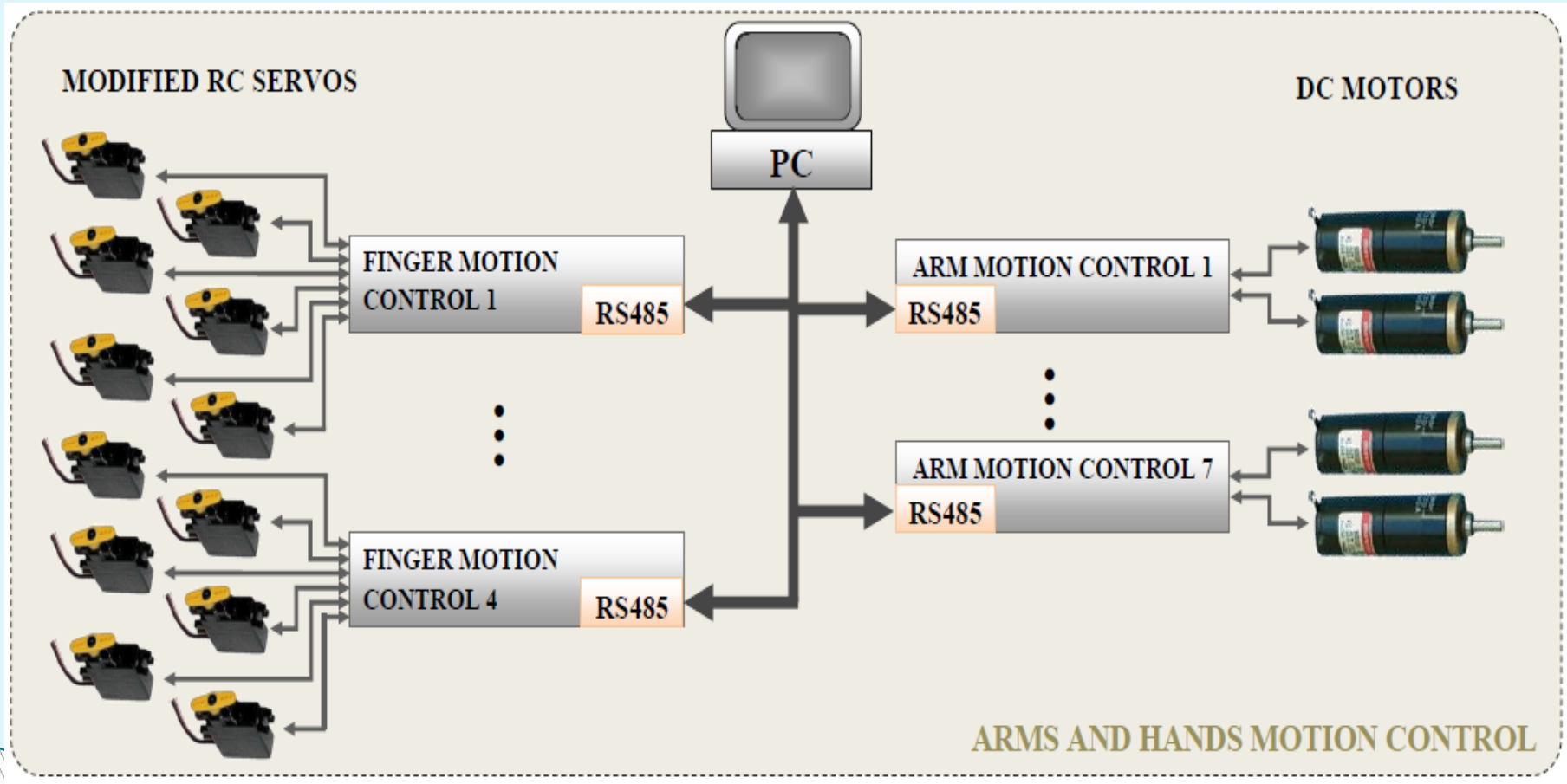
FLASH: PD Control
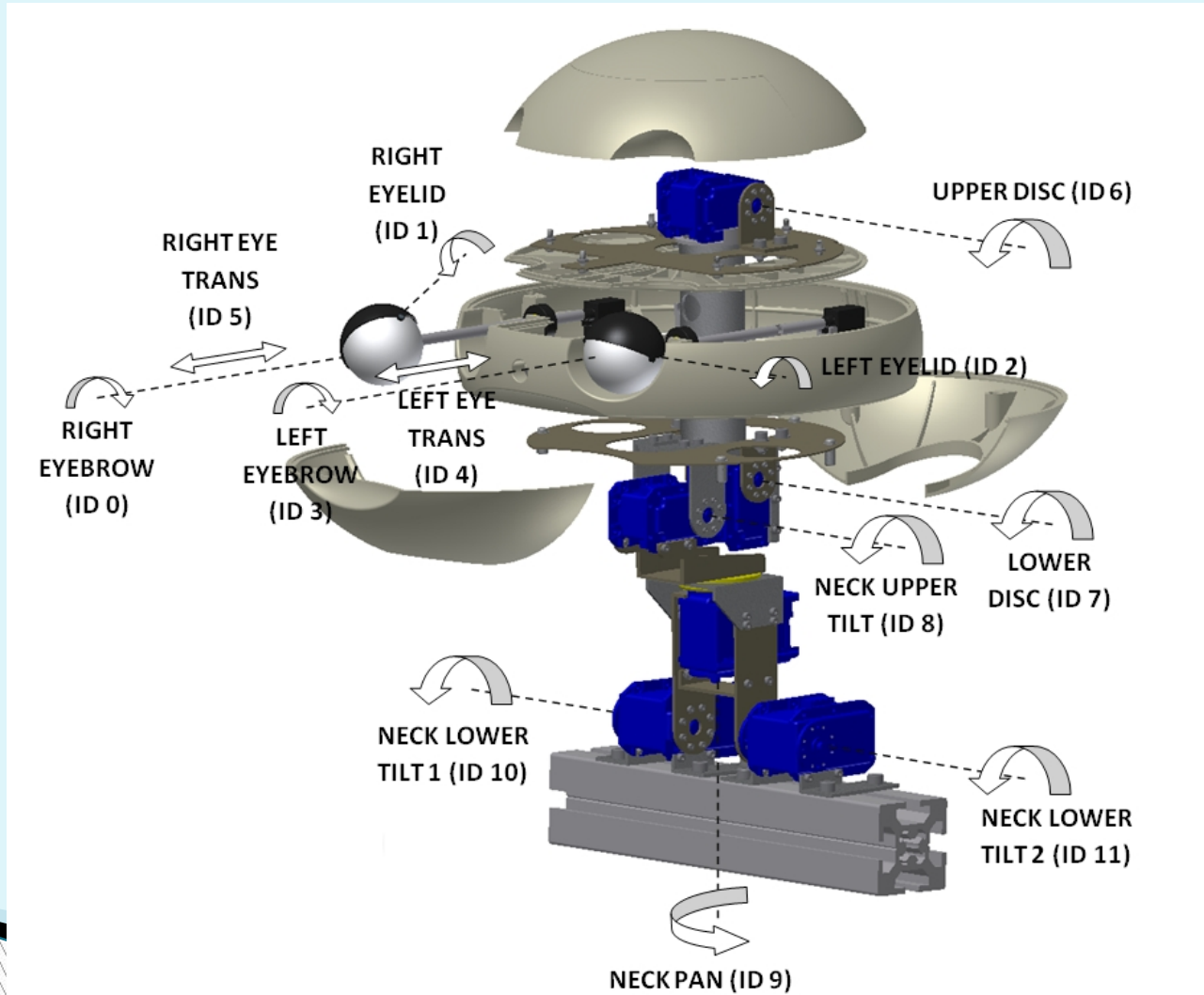
FLASH: Platform 1
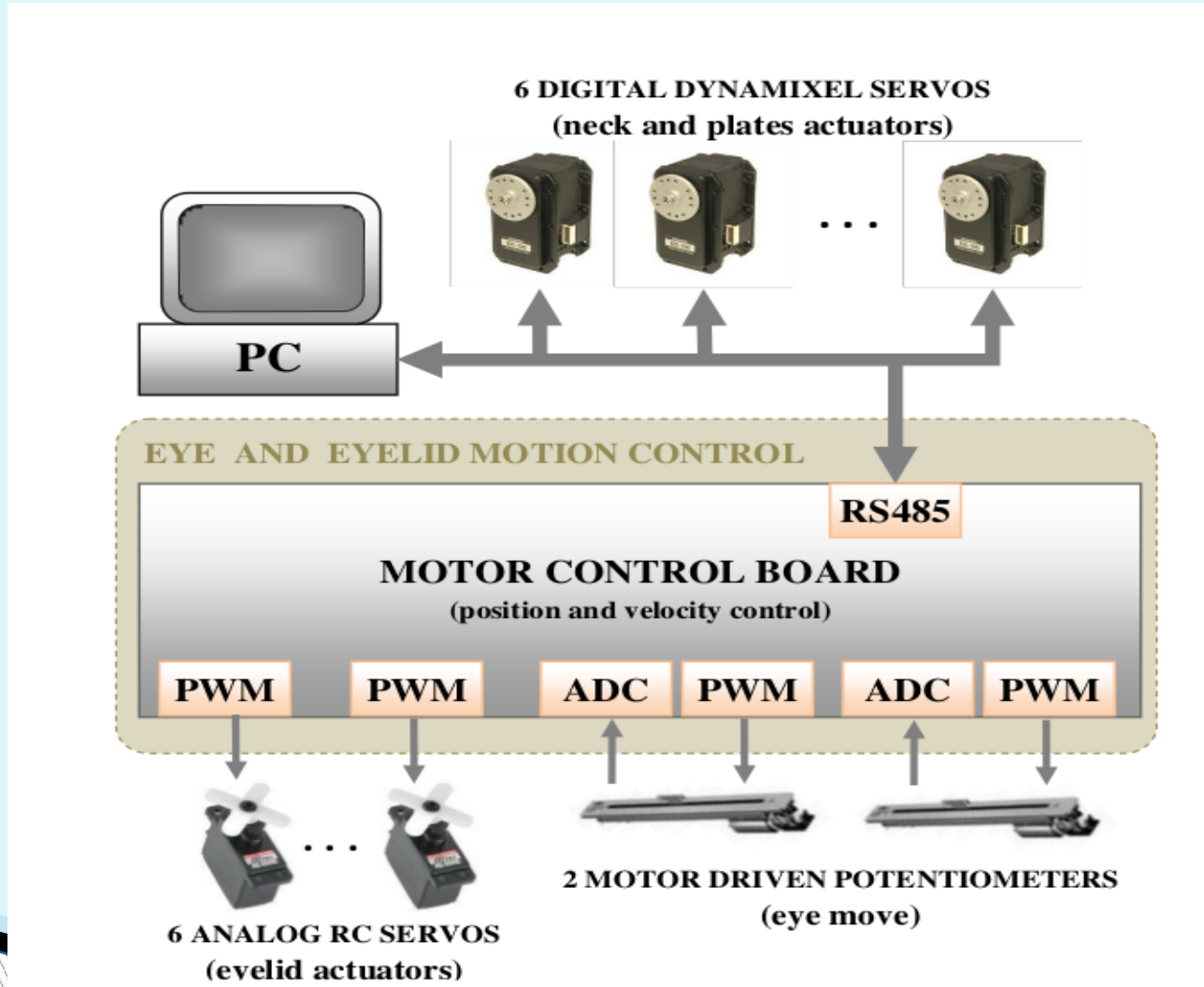
FLASH: Platform 2

FLASH: Arms and hands 1

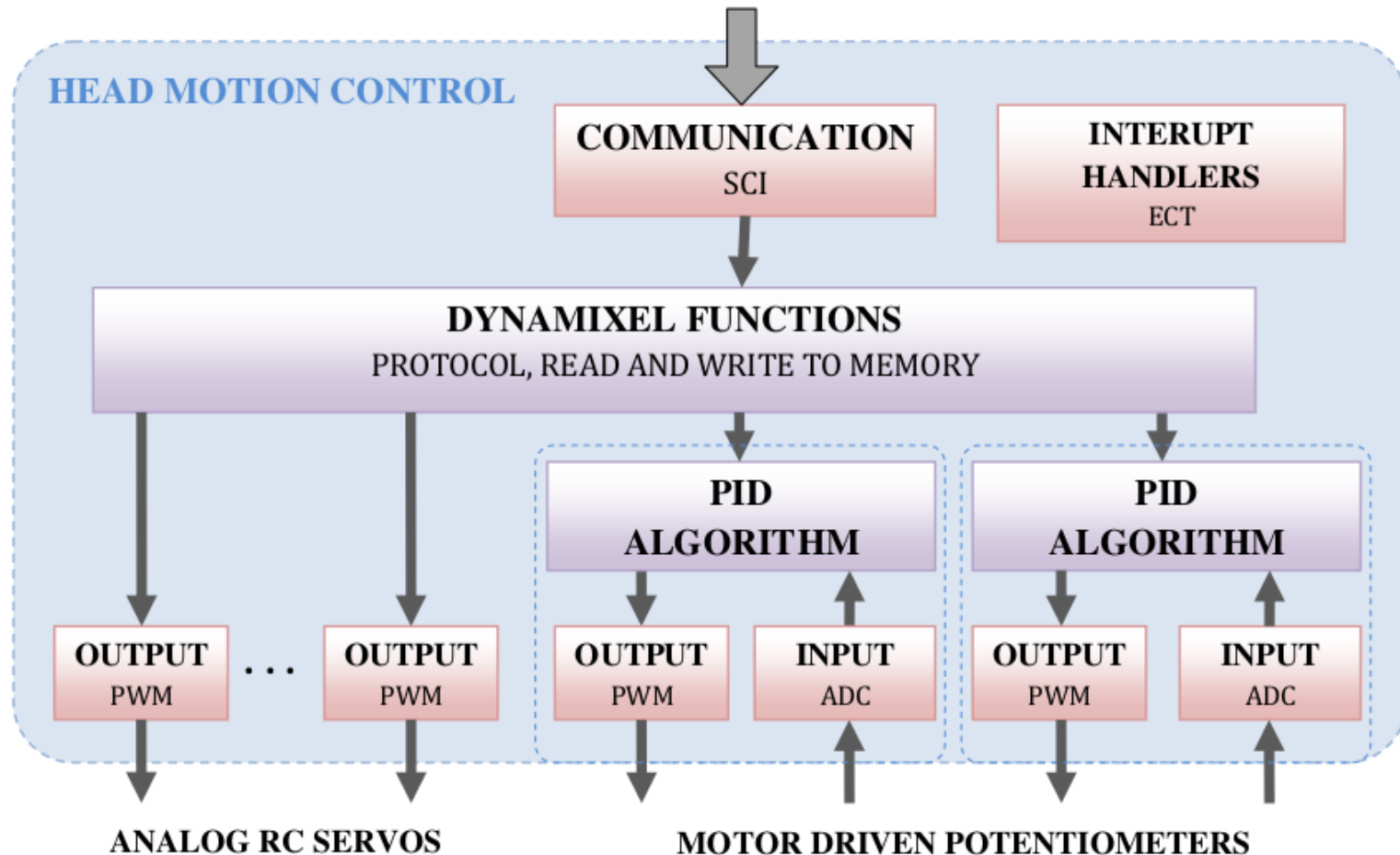# FLASH: Arms and hands 2

FLASH: Head (EMYS) 1

FLASH: Head 2
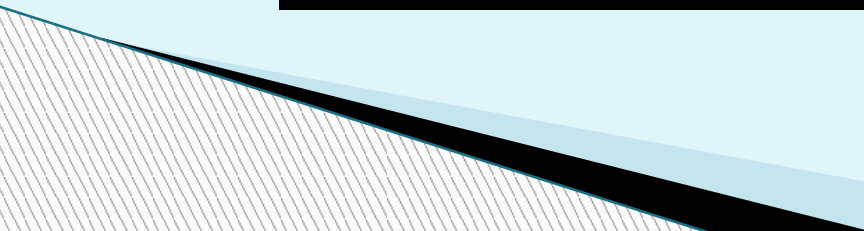
FLASH: Head 3
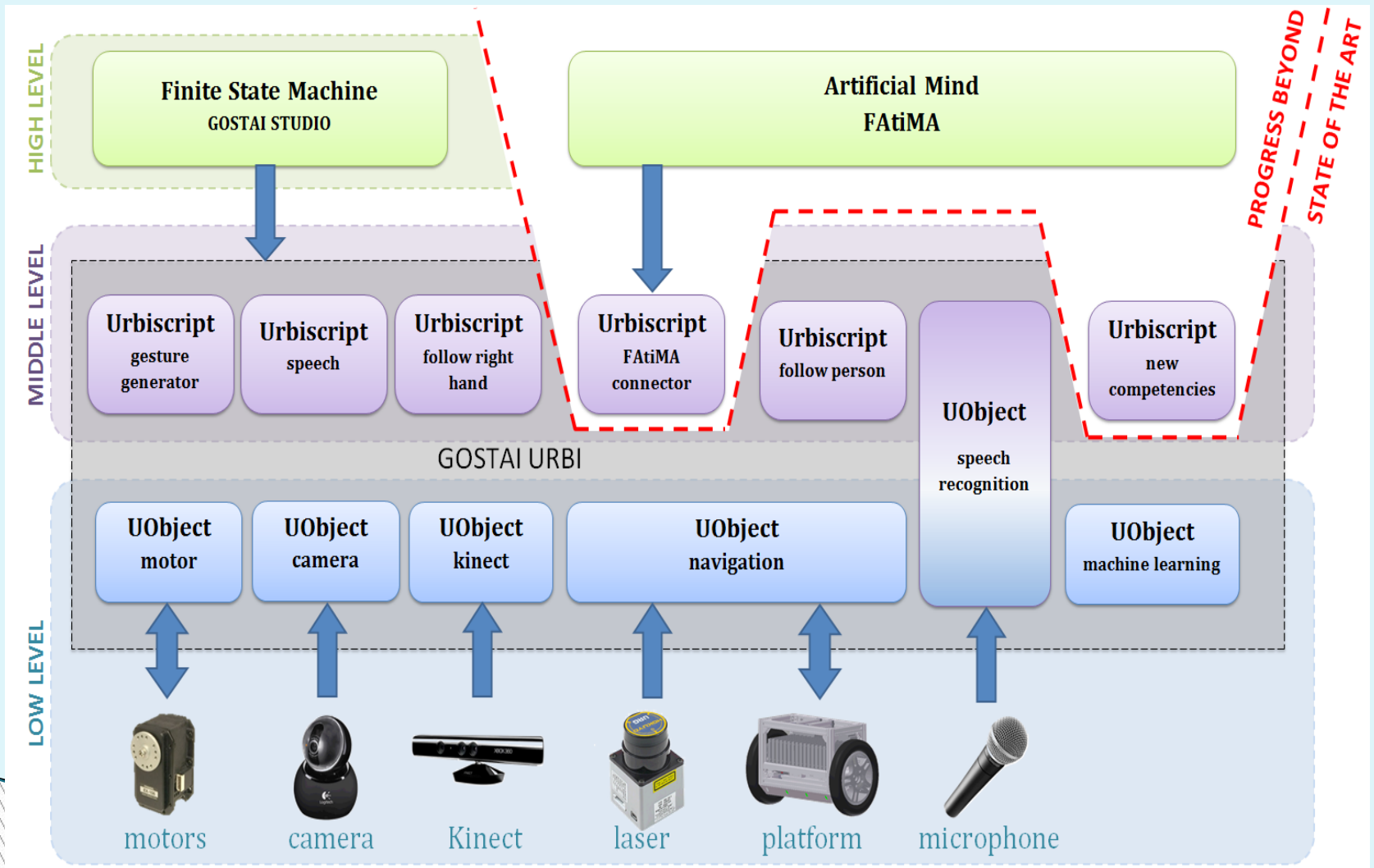
EMYS: Emotions

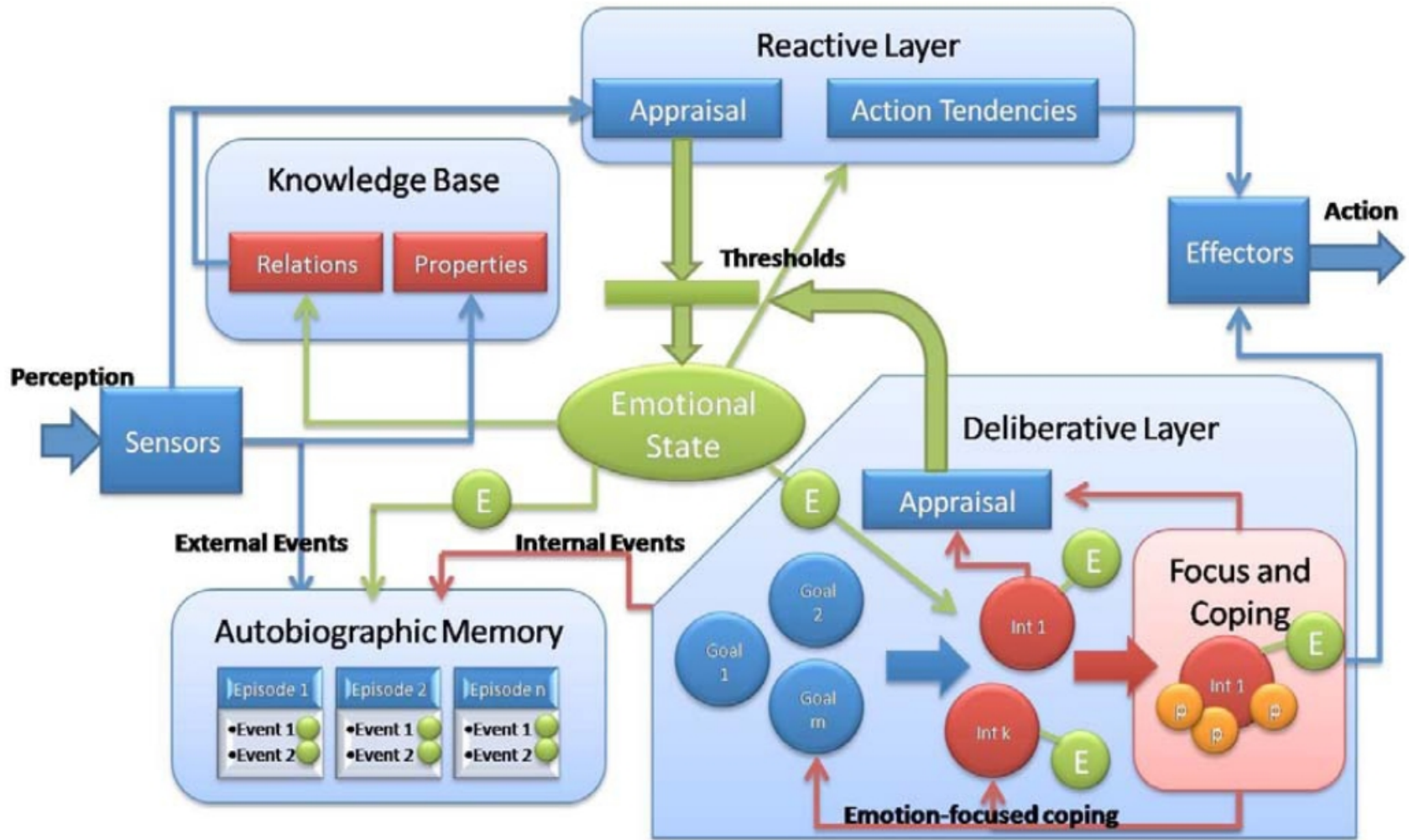joy, fear, disgust, surprise, anger, sadness

FLASH: EMYS band

FLASH: 3 layer control

Higher level: FAtiMA

FLASH + children
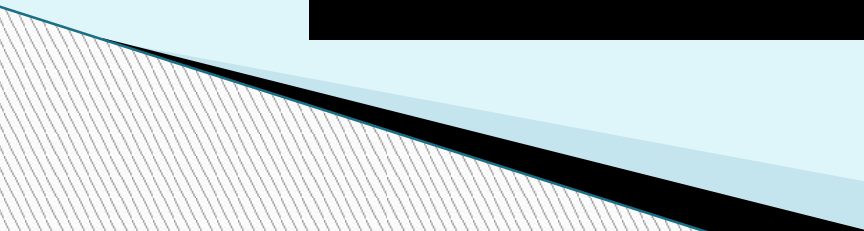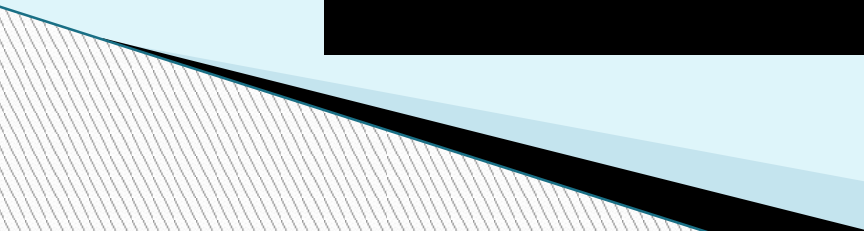
FLASH: just married

FLASH: HRI 1

HRI 1: OCEAN

Openness	87%
Conscientiousness	53%
Extroversion	96%
Agreeableness	51%
Neurocity	80%

HRI 1: emotions

Emotion	Affect description	Affect matching	Mean	Ekman emotion recognition questionnaire
Anger	97.8%	97.6%	97.7%	93.0%
Happiness	15.9%	22.5%	19.2%	91.9%
Sadness	91.1%	95.3%	93.2%	79.7%
Surprise	46.7%			92.1%
Disgust	13.6%			78.1%
Fear	68.9%			64.0%

FLASH: HRI 2
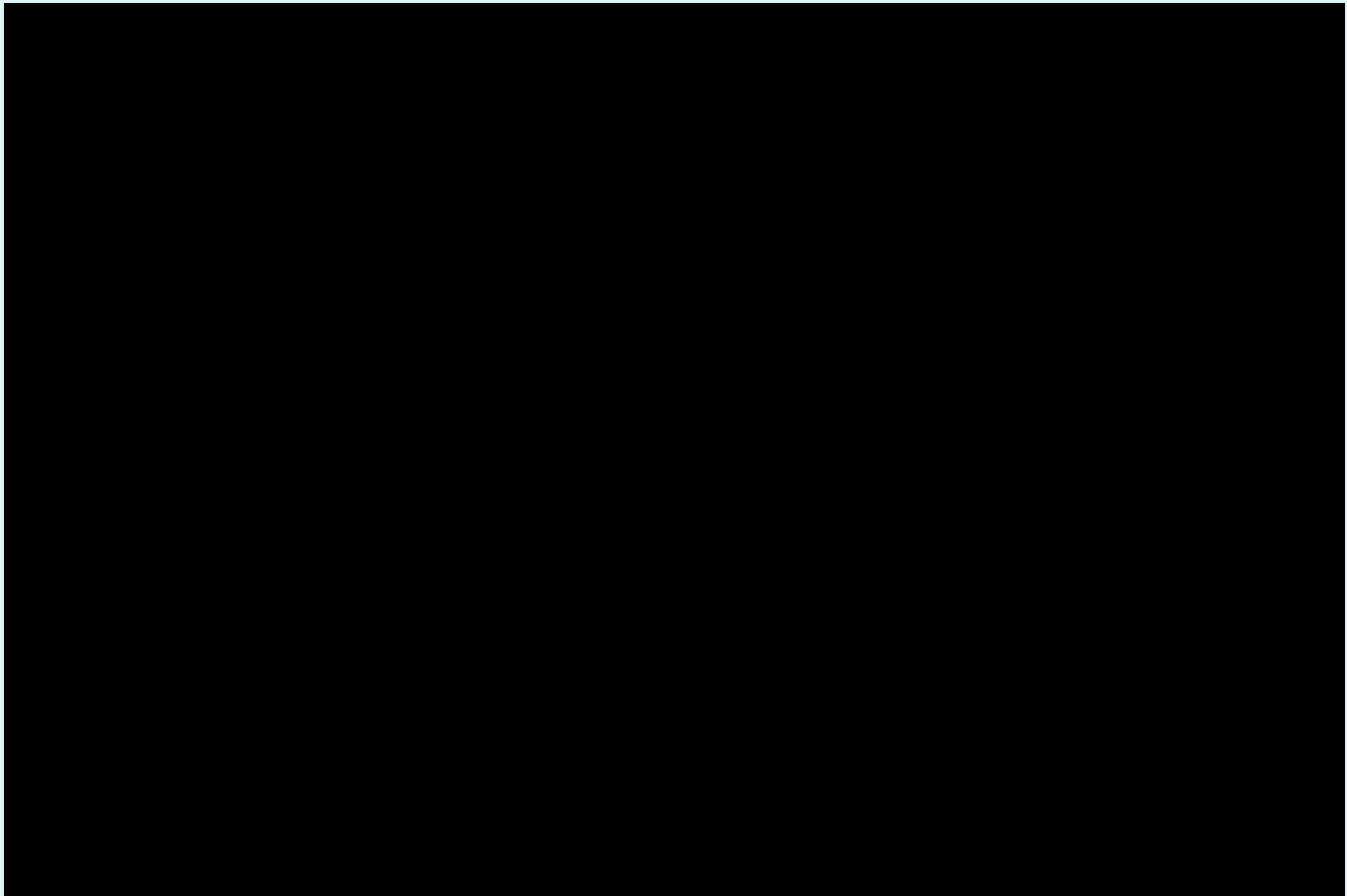
FLASH: eye fixations
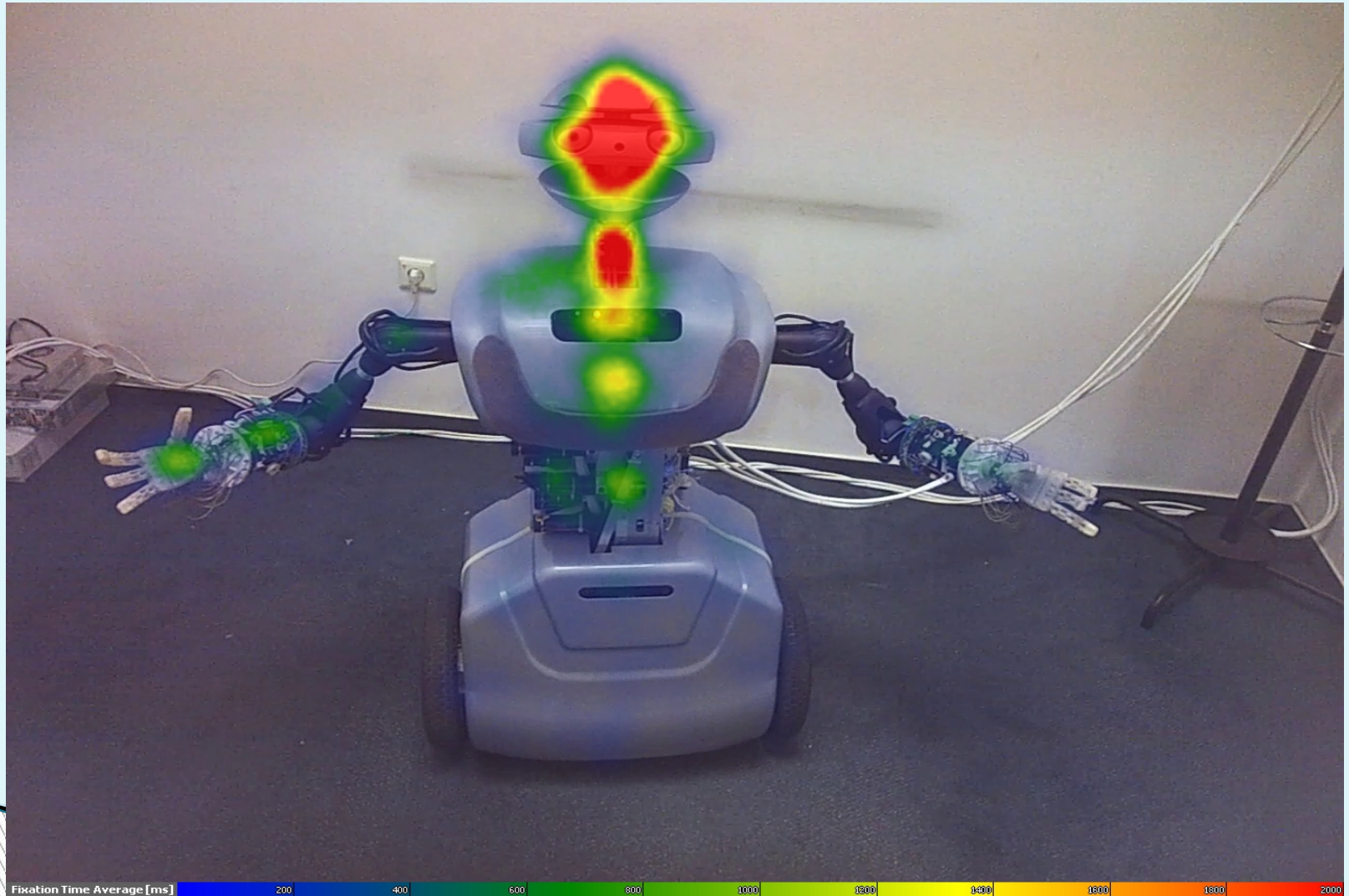
FLASH: ROI
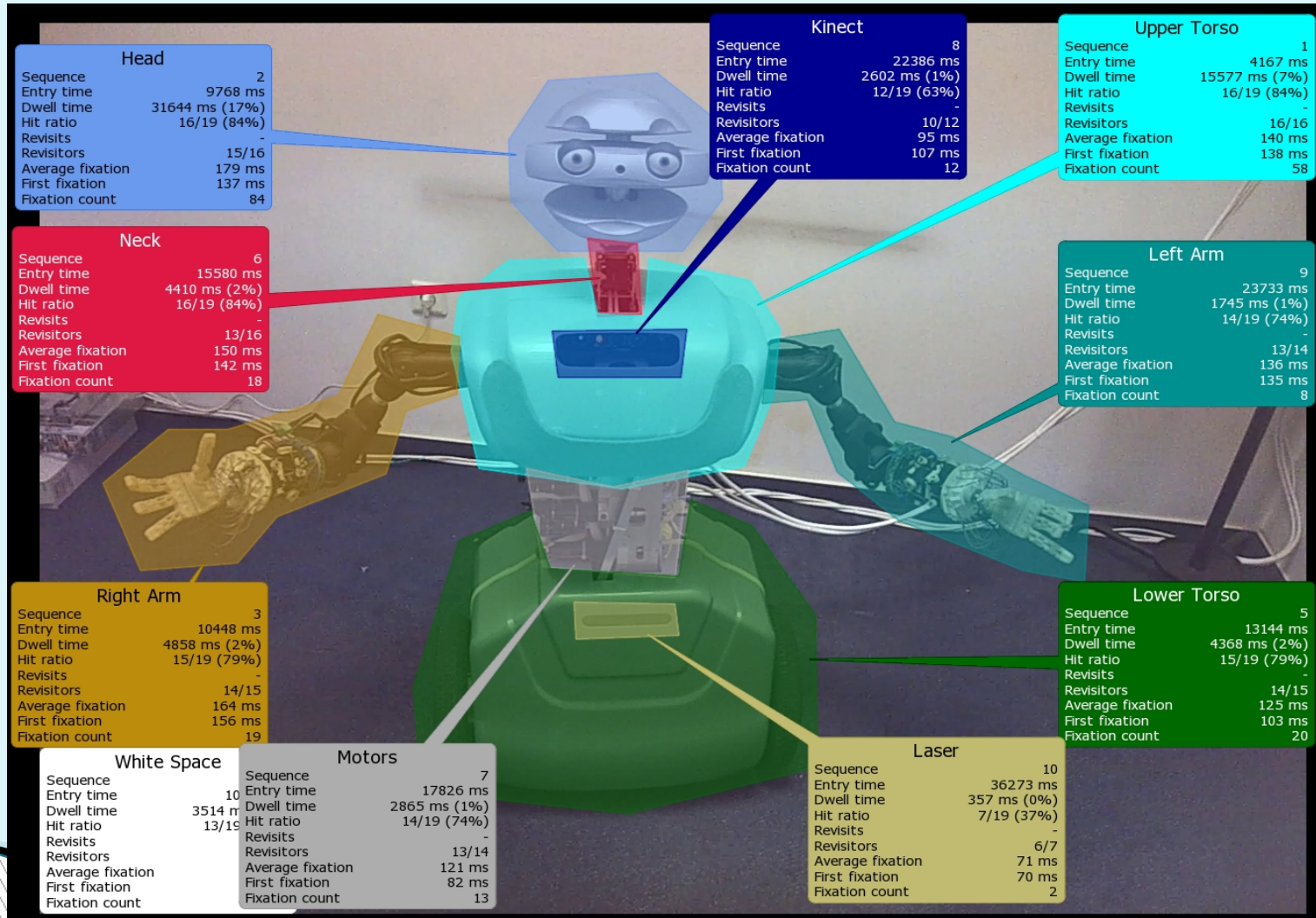
FLASH: questionnaires

|	
Robot FLASH certainly is a nice companion	78.9
Robot FLASH likes me	57.9
His emotional reactions are very natural	52.6
I'd like to spend more time with him	84.2
FLASH looks friendly	89.5
His emotional reactions are easily readable	84.2
His presence is embarassing to me	42.1
FLASH is interested in interaction with humans	89.5
FLASH behaves similarly to me	26.3
I feel secure in his company	78.9

FLASH: Totally unacceptable

FLASH's team
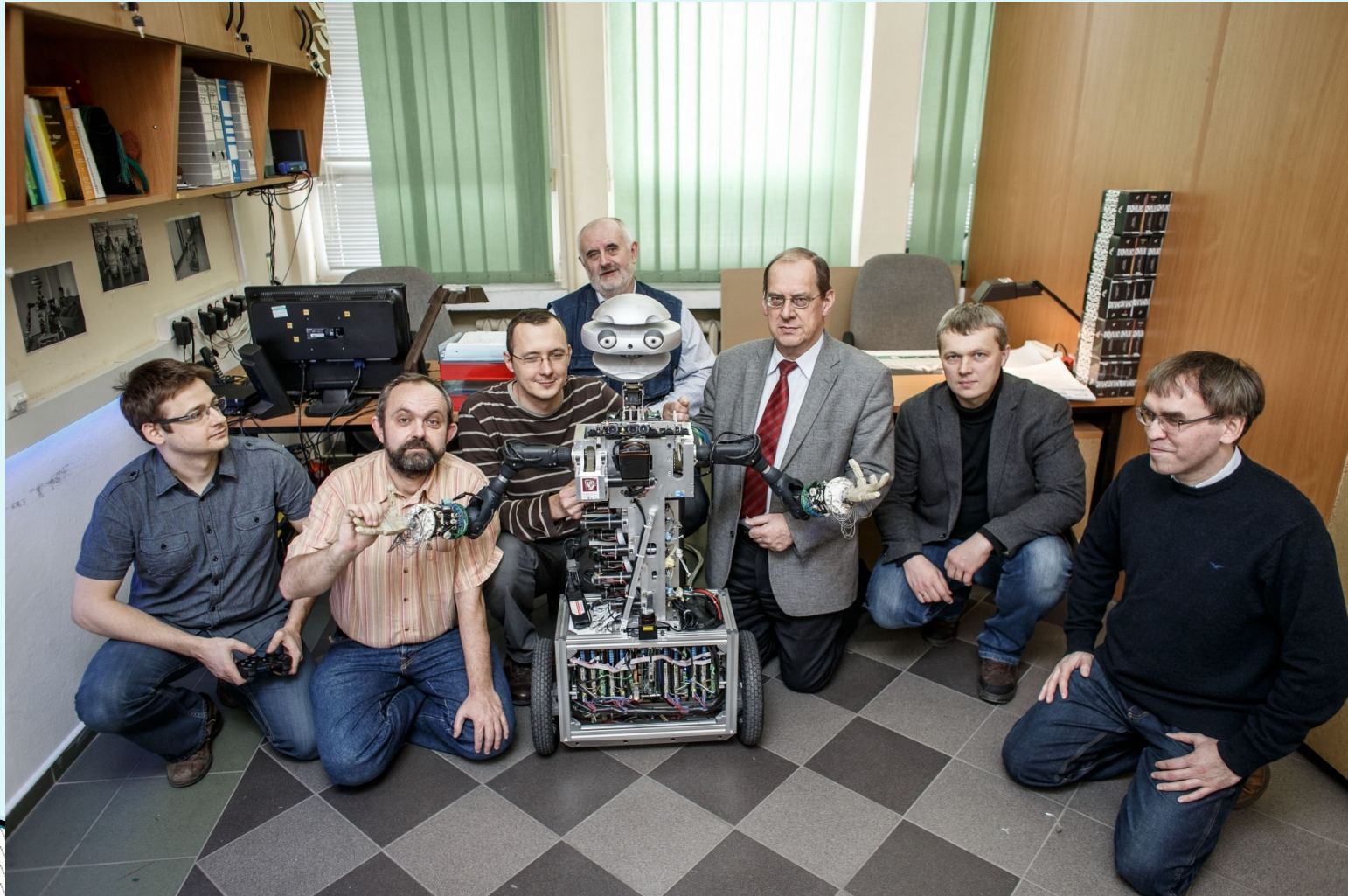
Conclusion

Special thanks to Jan Kedzierski, MSc, for help in preparing this presentation.

http://flash.lirec.ict.pwr.wroc.pl/

Thank you very much for your attention!