Exploring of Possibilities on Emotiv-based Brain Computer Interface with Programmable Robots

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Talk Outline

- Potentials and perspectives of EEG based BCI in Robotics
- Emotional Intelligence
- Conclusions from previous studies - METEMS project
- Integration of Emotiv-based BCI with NAO for learning emotional Intelligence
- Teaching robots by imitation using brain-rewards (tracked by BCI)
- Ongoing research in CybSPEED project: BCI for robot control, assessment of child socio-emotional states, alternative BCI training phase
- EMOTIV-NAO/BigFoot software framework
- Conclusions

Potentials and Perspectives of EEG-based BCI in Robotics

- To control robots by brain in case of lost functionality or just for entertaining
- The play is fundamental and a right of every child (not verbal, partially paralyzed, with limited physical skills)
- Engaging and motivating assistive technologies (mediators) to enhance learning skills in a playful environment
- An alternative to strict protocol during the training phase of BCI system
- To assess the teaching process by monitoring the progress in order to provide feedback and evidences to special educators - mimic the personal behaviour on the robot (if the child avoid eye contact)
- To augment physical, cognitive, emotional and social intelligence to robot for teaching robots by imitation - using brain-rewards (tracked by BCI)
- Emotional Intelligence – human-robot interaction by emotions

Emotional Intelligence (EmI) – WHY?

EmI of children with SEN

- Emotions reading is a critical human skill. The way we make sense of others people behavior. A child to guess others feelings in order to decide on its next move
- Children with SEN have to be prepared for the real life and scenarios deployed on robots during the play have to handle the simplest social situations
- Learning by imitation of emotions on the robot(s) during the play - scores for emotional states provided by Emotiv are used (subjective)
- Calibration session is needed for training the BCI model (EEG patterns)
- Partial solution is to use the artefacts in EEG - from the face muscles, 3D gyroscope measuring of head movement, blinking
- Blinking rate and timing – children with SEN don't blink like typically developing children and by emotional games to teach them how to make sense of robot and own emotions

Emotional Intelligence (EmI) – WHY?

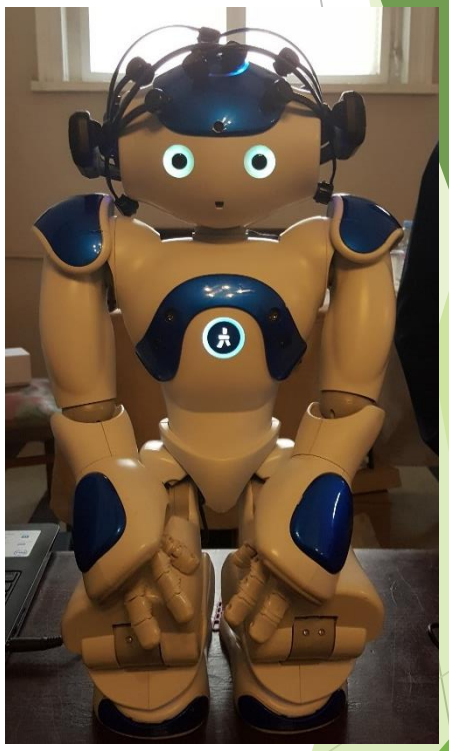
EmI of robots

- Robots of the future have to achieve physical, cognitive, emotional and social intelligence to coexist and cooperate with humans
- To teach robot how to be personal assistant (mediator) to special educators
- Augmented EmI physiologically and continuously in order to personalize the robot and HRI
- Robot to guess our feelings in order to decide on our next move
- EmI will help robot to catch quickly child attention and thus to enhance information perception during learning (verbalization in children with communicative problems)
- How human intelligence to be integrated into robots? – by ML or by augmentation

Conclusions from previous studies - METEMSS Project

Conclusions from previous studies - METEMSS Project (2)

- Children are attracted by robots spontaneously and emotionally
- This catch attention and enhance learning skills by imitation
- New modalities (nonverbal means) in HRI - eye gaze, virtual touch, brain electrical potentials and face/emotion recognition



Used in METEMSS

ASSISTIVE TECHNOLOGIES

Conclusions from METEMSS (2) – children with different profiles but special needs in common

- ✓ Avoid eye contact, speech and language disorders, not asking questions, attention deficit, hyperactive
- ✓ New play like activities for training of listening, understanding and speaking through learning skills for orientation in space, shapes, colours and emotions (emotion is the leading factor)
- ✓ Important role of emotions on decision-making –in the play the child needs to learn how to regulate its emotions in order to interact with robot (others) appropriately

Why to teach robots?

In the past

- Machine Learning lets robots teach themselves
- When kinematics or dynamic models are difficult to be described and programmed in advanced - teaching robots as “programing by demonstration”
- Online or Offline

In the near future

- Since peoples are different physically, mentally, emotionally, socially, they need different robot roles and attitude
- We propose a new concept for teaching robots to become personal – using brain-rewards (tracked by BCI) and **augmented human essence** decision-making

Machine learning: Augmentation or Automation

- Do machine-generated decisions always lead us to the best outcomes? - right 80% (sometimes disastrous)
- Nearly every machine learning automation fails for the same reason – **human is taken out of the loop!**
- Machines learn from information while we learn from experience

Let the machine-learning do what it does best – discover repetitive patterns and learn repetitive task!

Let the human take decisions!

Let the human take decisions!

- Human uses unconscious brain mechanisms – no access to decision process;
- The speed of information processing in brain is still unreachable
- Simulation and visualization in decision making after listening body signals and emotions;
- New ideas and creativity – unconscious brain processing of memory, combinations of past experience, estimating outcomes and after-effects.

New teaching concepts:

- Robots to learn from repetitive tasks experience but only following the policy of positive brain or body feedback
- New ideas and decision making to be augmented to robots via **continues Human essence**

How human intelligence to be integrated into the digital world?

- Not digitally by pushing a button, clicking, dragging or speaking
- Biologically and continuously through emotions, movements or intentions
- Digital devices will connect to our physical, emotional and mental state and will be able to meet our needs and at the same time to learn from us
- Continuous interaction and feedback between the person and the robot, which will be permanently linked to each other, and the intelligence of the robot will begin to coincide with our own

Brain and Motion augmentation

- EEG-BCI systems will update and personalize the initial social behaviour and rules preprogramed according to the robots role
- BCI, EOG, EMG can give a physiological feedback to a robot
- Human motion capturing system extracts the observed poses in real time - give a “body language” feedback to a robot (motion sensing devices and technologies like “Microsoft Kinect” and “Leap Motion”)

Applications:

- Replacement of lost motion functionality from an accident or illness – using alternative motion sensing or BCI – wrist instead fingers, imaginary movements, emotions, facial expression, intentions.
- Evolve into technology to increase our memory and change our experience and skills in the future (machines learn from information repetitive patterns - we will learn **essentials**, experience)

Brain signals

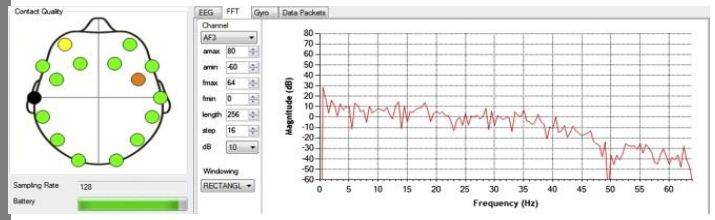
Smile

Wink

Frown

Emotions

Gestures



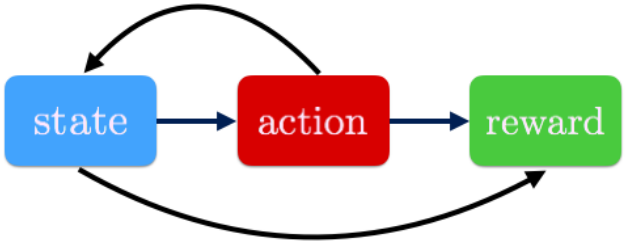
positive rewards

negative reward

State (observation)

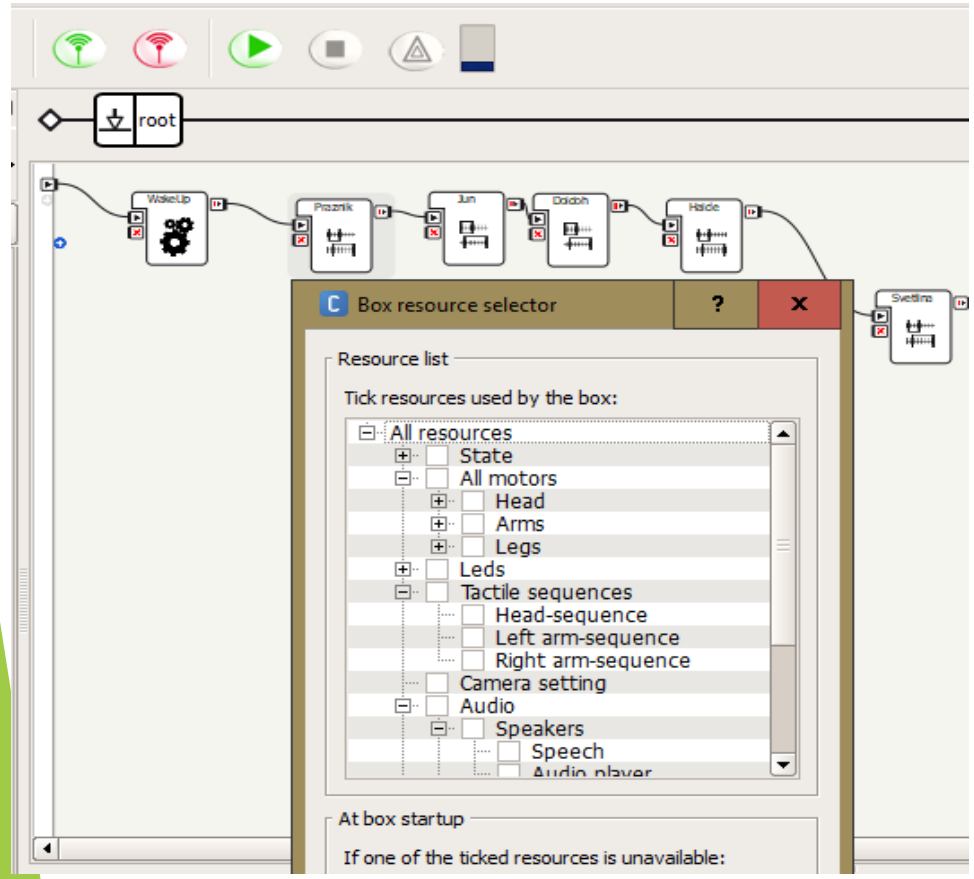
Action

Bio-Reward



prior knowledge by imitation

Training robots by body parts guiding and shadowing labelled and tailored to brain signals



Resource list used in the Timeline box

- To help learning process - prior knowledge by demonstration according to the role of the robot
- During the animation the desired movement is decomposed and uses switch case and raises event base on brain signals
- Raise Event: Stores in NAOqi's shared memory the given value at the given key, and spreads the event to all its subscribers
- ALMemory.raiseEvent

ALMemory.subscriber/ALMemory.subscribeToEvent

- RL focus on a key value – brain reward in a form of EEG feature

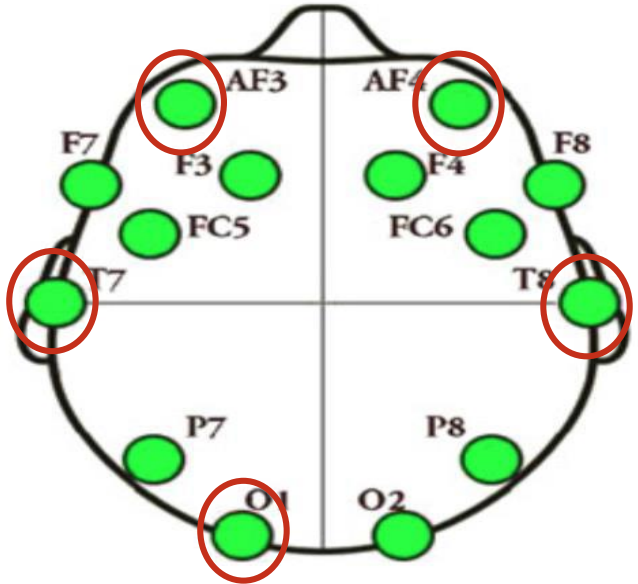
Exploring of Possibilities on Emotiv-based Brain Computer Interface with Programmable Robots in CybSPEED

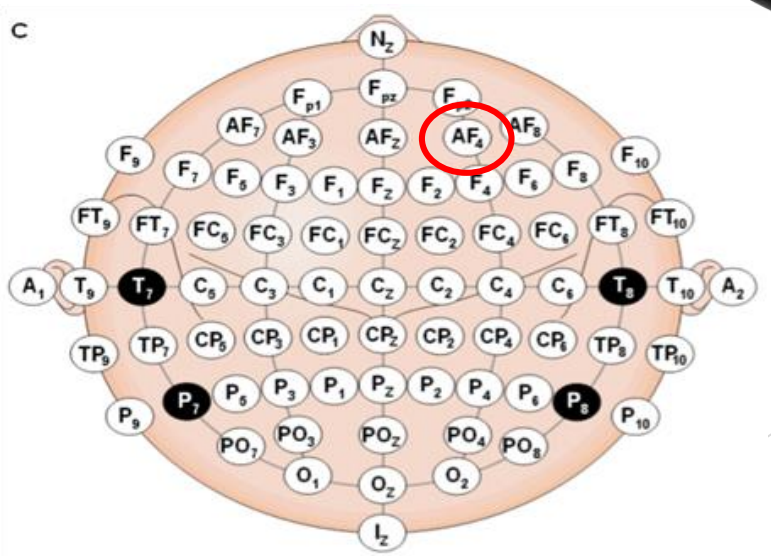
- To assists therapists in eye-tracking and storing emotions experienced by the child
- Neurofeedback self-regulatory training of attention, stress, excitement, boredom
- Using of Emotiv software: emotional and sub-conscious dimensions in real time - 6 different output scores - to robot commands
- Assisting the recognition of possible cognitive failures to alert the special educators accordingly
- Assessing effectiveness of pedagogical rehabilitation. Measuring the pleasure in play
- Alternative BCI training session for calibration of the models

EMOTIV EEG headsets

EEG-based BCI listens, records and transmits in real time the electrical activity of the brain

Emotiv Insight – 5 semi-dry polymer electrodes





Ongoing research in CybSPEED

- Research Ideas:

- Main idea – Integration of Emotiv-based BCI with NAO for emotional Intelligence – human-robot interaction by emotions

- Enhance the child immersion and keep attention emotionally - extend the interaction with the robots by transmission of feelings, thoughts, intentions and emotions just for controlling robot scenarios or neurofeedback self-regularity training

- Assist special educators in assessment of socio-emotional states by Brain-Computer Interfaces (BCI) and computer vision-based 3D external observations of motions

Ongoing research (2)

- Research Solutions:

Innovative integration of EEG based BCI and programmable robots:

- New series of tasks and scenarios developed and deployed on humanoid robot NAO for training of listening, understanding and speaking in playful learning environment for orientation in space, shapes, colours and emotions

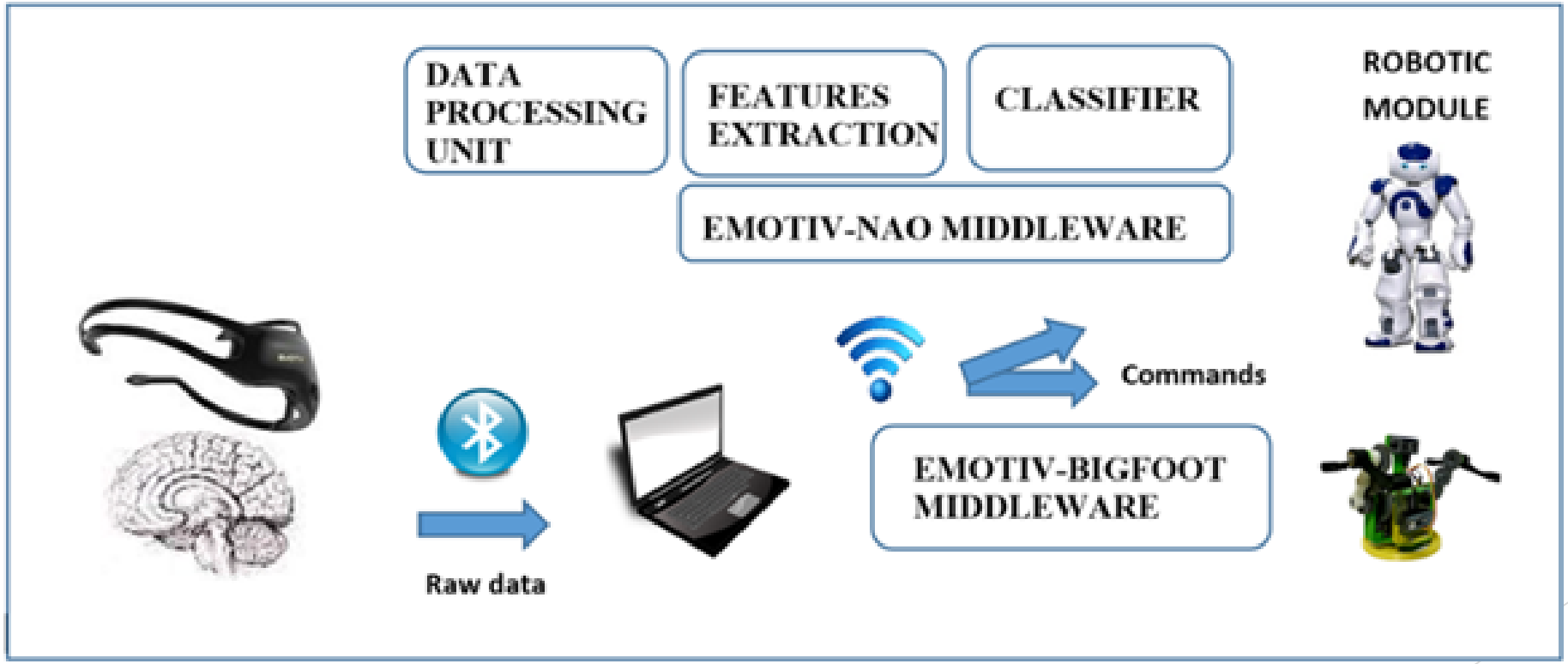
- New brain-robot game for "playing through emotions" for orientation in experiencing simple emotions by imitations

- Building an Emotiv-NAO/BigFoot/EmoSan software framework to translate brain signals into robot commands;

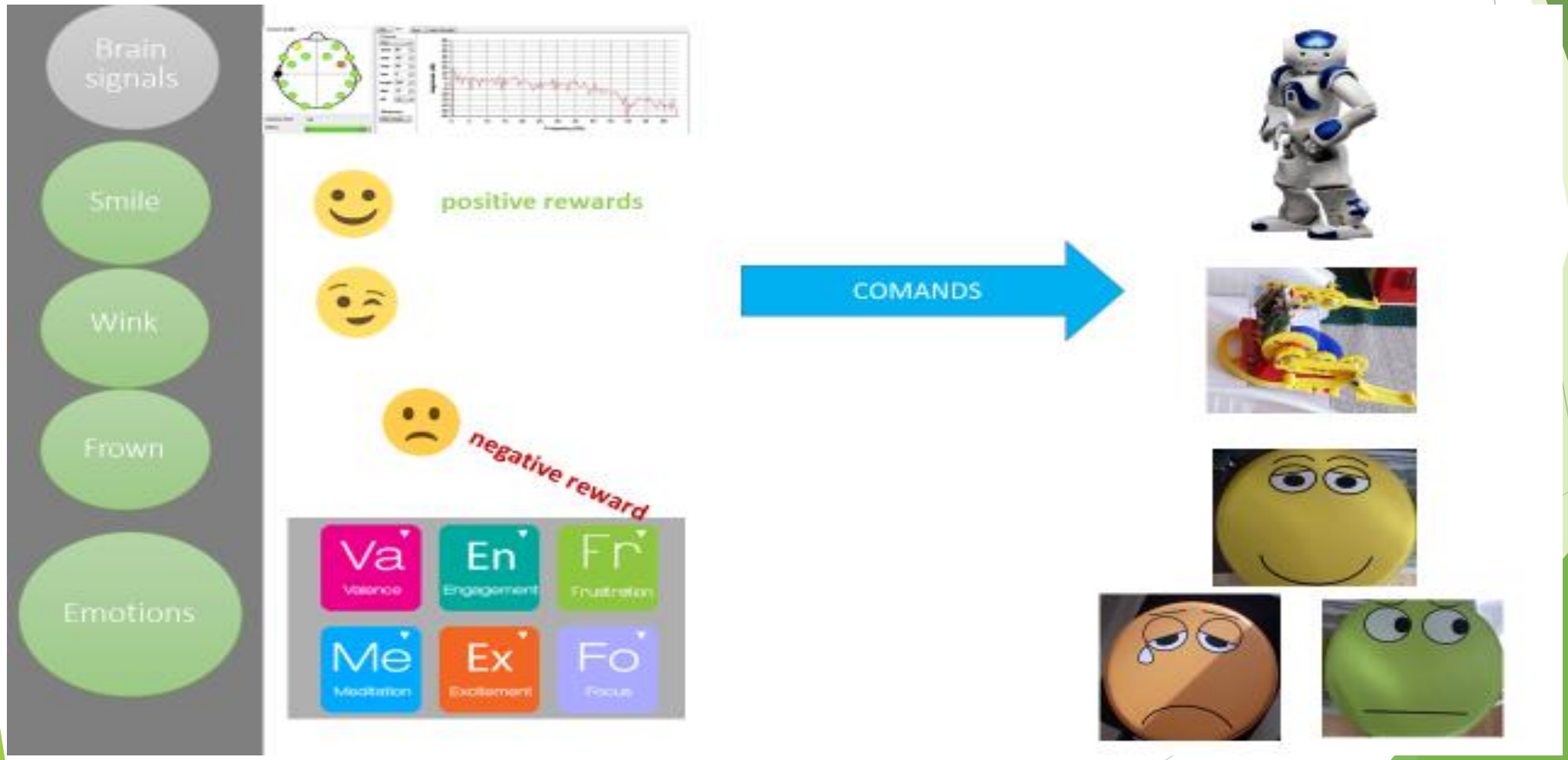
- **New acquisition protocols to extract brain activity during eye blinking**

- Alternative BCI training session

BCI-Robot software framework for brain control or assessment



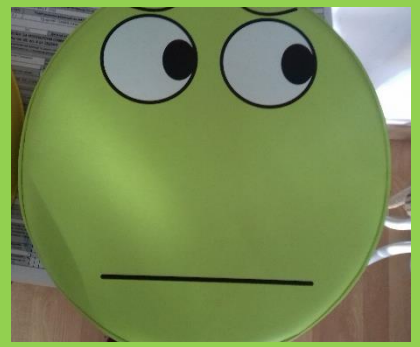
Brain-robot game for learning skills by imitation to help the child to become more emotionally engaged with the social world



Conclusions

- An innovative model how to augment to robots physical, cognitive, emotional and social intelligence and vice versa experience and memory to humans
- The potential of the BCI-ROBOT frameworks to help children with SEN to learn through play by neurofeedback self-regulatory training where emotions are inputs in the play
- The potential of the EMOTIV-ROBOT frameworks for providing a natural interface to teach both children and robots by imitation
- Using modern technologies in play like BCI and robotic systems, children with SEN will feel confident and will be prepared for the future life
- Ethical and philosophical issues should be followed when we use the neurofeedback in-the-loop of CPS
- Ethical and philosophical issues when using brain-reward in teaching robots by imitation

Questions and Remarks?



THANK YOU!