CybSPEED MSCA-RISE
#777720: vision and perspectives

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University of the Basque Country
An overview of project proposal
  ◦ Statement
  ◦ Beneficiaries and partners
  ◦ Experiments

Specific research topics:
  ◦ Dialog systems and storytelling
  ◦ Computational neuroethology

Conclusions and discussion
CybSPEED

Project proposal
RISE : Research and Innovation Staff Exchange
  ◦ Main objective is the exchange of staff (secondments)
  ◦ Between academia and industry
  ◦ Working on a common research and innovation topic

Output of the project
  ◦ Training (secondments achieved)
  ◦ Publications
  ◦ Experimental results
CybSPEED proposal

- **Cyber-Physical Systems for PEdagogical Rehabilitation in Special Education**

- **Aim:** to advance a novel framework for

  - analysis, modelling, synthesis and implementation
  - of Cyber-Physical Systems
  - for pedagogical rehabilitation in special education,

- based on a combination of

  - brain-aware robotics, cognitive biometrics, computational intelligence and reasoning in
  - humanoid and non-humanoid robots for education.
CybSPEED proposal

- CybSPEED project emphasizes the intrinsic-motivational approach to learning
  - by designing human-robot situations
    - (games, pedagogical cases, artistic performances)
  - And advanced interfaces
    - (brain-computer, eye-gaze tracking and virtual reality)
- Where students interact with the novel technology
  - to enhance the underlying self-compensation and complementarity of brain encoding during learning.
CybSPEED proposal

- Research on three levels
  - analysis of cognitive biometrics signals,
  - modeling of the learner-robot interaction and
  - development of novel instruments
    - towards an optimal design of Cyber-Physical Systems
    - for improved pedagogical rehabilitation in education
Consortium and partners
University of the Basque Country
Manuel Graña (coordinator)
Computational Intelligence Group
  ◦ Data analytics
  ◦ Image processing
  ◦ Neuroscience data processing
  ◦ Social Robotics:
    • Nao story telling
Institute of Robotics, Bulgarian Academy of Sciences

Maya Dimitrova (original coordinator in proposal)

Interactive robotics lab

Social robotics for special education
  ◦ Nao robot
  ◦ Working with daycare centers
  ◦ Experimental experience in children-robot interaction
  ◦ Observation tools: kinect, EEG
Easter Macedonia and Trace Institute of Technology
Vassilis Kaburlasos
Machine Learning and Lattice Computing
Social robots in special education
Signal processing and face recognition
Computer Vision Centre, Autonomous University of Barcelona

Bogdan Raducanu
- Experts in computer vision
- Person Monitoring
- Face and emotion recognition
University of Grenoble-Alpes, GIPSA-Lab and G-SCOP

Peter Mitrouchev

Industrial partnership experience

Rehabilitation technologies, specif. hand

Virtual reality technologies
Pediatric Rehabilitation Center, Kavala,
Yannis Aggelidis

Special education professional experts
- Autism Spectrum Condition
- Attention deficit
- others
Teatar Tsevete

- Experts in dramatization for educational purposes
- Design of scenarios
- Storytelling expertise
Centre Hospitalier Universitaire de Grenoble
Francois Motet
Rehabilitation and muscle reeducation
Hand surgery
New human machine interfaces for rehabilitation
Hassan II University of Casablanca
Omar Bouattane
Signaux Systèmes Distribués et Intelligence Artificielle
Image and signal processing
Robotics
Internet of things and embedded systems
- University of Chile, Research center on business intelligence
- Sebastian Rios
- Big data and data analytics
- Previous experience in biotechnical projects
Kyushu Institute of Technology

Hiroaki Wagatsuma

- Brain-inspired intelligent systems,
- neurodynamics,
- interactive robotics and neurorobotics,
- service robotics and
- reinforcement learning based robotics
Topology of the project

Advanced human-robot interfaces
Games and storytelling
Student progression measurement
Robot soft-adaptation
Behavior measurement
Neural activity correlation with behavior

Artificial perception
User awareness

CVC
UPV/ EHU
IR-BAS
Tsevete
PRAXIS
EMUtech
UH2C
UGA
CHU
Kyutech
CybSPEED experiments

- Precise experimental designs with our actual know-how
  - Greece (Praxis)
  - Bulgaria (IR-BAS at several locations)
  - Japan (Kyutech)
  - France (UGA)

- Ethical permissions procurement
  - Ethics is a critical issue in European funded projects

- Experimental setups
  - Protocols of intervention
  - Measurements and analysis
Praxis experiment

- Carried out in actual educational rehabilitation sessions
  - Good ecological validity
- Intervention
  - The child is presented with robot
  - The robot carries out simple game of passing a ball and requesting the child to put it someplace
  - Measurement: time to answer or to make eye contact.
    - Longitudinal study
Children recruited in a local daycare center
Automatic memory and attention effects in learning from a Humanoid robot
Listening to a zoology lesson and story telling by Nao robot
Measurement of attention by human observer
ASC, Cerebral Palsy, General Developmental Disorder
Students recruited ad hoc
Automatic memory and attention effects in learning from a Humanoid robot
Listening to a zoology lesson and story telling by Nao robot
Measurement of attention by EEG and eye tracking
CHILDREN WITH COMMUNICATION DISORDERS

Centre of Logopedics at Faculty of Public Health, Health Care and Sport To South-West University "Neofit Rilski" Blagoevgrad

DayCare Center "Zdravets", Bansko

Test: Nao versus human
Interactive games following spoken instructions and noises:
- Shapes
- Transportation means (train, auto,...)
- Shopping
- Emotions (sounds of)
- Body sounds

Measurement
- Human observation
- Anonymous visual (kinect depth or IR image)
Dialog systems and storytelling
Dialog systems
Dialog systems

Extra-linguistic environment

Language understanding
Recognition hypotheses
Speech recognition

Interpreted dialogue act
Intended response

Dialogue management

Generation
Utterance to synthesise
Speech synthesis

input speech signal (user utterance)

User

output speech signal (machine utterance)
Seq2seq dialog systems
Intelligent assistants

- Apple Siri (2011)
- Google Now (2012)
- Microsoft Cortana (2014)
- Google Assistant (2016)
- Amazon Alexa/Echo (2014)
- Facebook M & Bot (2015)
- Google Home (2016)
- Apple HomePod (2017)
Example assistant interaction

User

find a good eating place for taiwanese food

Intelligent Agent

Good Taiwanese eating places include Din Tai Fung, Boiling Point, etc. What do you want to choose? I can help you go there.
Simple taxonomy

- **Task oriented:**
  - There is a desired outcome of the interaction
  - The progression to the desired end can be traced
  - Success can be measured easily

- **Conversational**
  - The bot is engaged in open-ended interaction
    - Searching
    - Counseling
    - Assistive for elders
    - Teaching or mentoring
Storytelling with Nao
Offers a structured framework for oriented dialog

- Aiming towards an end
- Has a logical sequence yet it may be open
- Repetition is always welcomed by children
- It can be entertainment and/or training
- It is engaging
Representation of the overall structure: the plot

Is there a prototypical structure?
  ◦ Joseph Campbell “The hero’s journey”
Storytelling as a dynamic process

- System states
- The plot as a graph
- Transitions between states
  - Induced by the audience interaction
  - Automated walk over the plot
- Innovation and creativity?
Attention assessment

- First requirement for interaction
- Assessing by the robot
  - Auditive cues
  - Visual cues
  - Response time from the robot
Robot acting

- The robot needs to enact the story
  - Text to speech with emphasis and prosody
  - Gesture generation
    - Gesture + voice language description
    - Text to gesture + voice

- Acting
  - Dramatic pause
  - Audience querying and interaction
Modeling the audience

- Assessing plot understanding from
  - Queries from the robot to the audience
  - Questions from the audience

- Rewriting the story on the fly
  - Simplification
  - Reformulation
  - Explanations
Computational neuroethology
Some definitions
Elements of computational neuroethology
Example study
Resources and Commercial solutions
Ethology: study of animal behavior
  ◦ phenomenological, causal, ontogenetic, and evolutionary aspects
    • Its relation with brain function is increasingly interesting
  ◦ its core is the description and characterization of behavior,
    • typically of intact freely moving animals in their natural environment.
    • Increasingly quantitative
A human observer,
  ◦ rather than simply writing down a description of what he or she sees,
  ◦ will score incidents of specific behaviors
    • defined according to certain generally accepted criteria

Computational support improves accurate observation
  ◦ Interactive video annotation
  ◦ Statistical data processing
Human observation limitations

- It is slow
- It is imprecise and subjective
- It is low dimensional
- It is limited by the properties of human vision system
- It is limited by human language
- It is dull, extremely boring work
Computational ethology

- Sensing: i.e. Computer vision
  - Segmentation of objects
  - Tracking
  - Identification of sequences

- Data analysis and interpretation: i.e. Machine learning
  - Supervised Learning:
    - Learning from examples selected by the human operator
  - Unsupervised Learning
    - Clustering: discovery of aggregations of similar patterns
Example 1

Toward a Science of Computational Ethology
David J. Anderson and Pietro Perona
Neuron 84, October 1, 2014
Drosophila melanogaster. Vinegar fly

- dyadic (pairwise) interactions such as male-female courtship and male-male aggression,
- higher-dimensional interactions within large (>10) groups of flies
- How are they encoded in DNA?

Courtship: (highly variable) series of actions

- Humans use an aggregate measure: “courtship index” (CI)
  - similar CI values may reflect different underlying behaviors
Sequence of human observer-defined actions in courtship behavior. The actions may vary in their duration and the length of the interval between them. The sequence is not necessarily irreversible.
Summary of Steps in the Automated Analysis of Social Behavior

Each of the four steps (detection, tracking, action detection, and behavior analysis) requires validation by comparison to manually scored ground truth. The ethogram illustrates different behaviors performed during male-male and male-female social interactions.

Neuron 2014 84, 18-31 DOI: (10.1016/j.neuron.2014.09.005)
Increasing the throughput of behavioral analysis

Eight different behaviors (A) were automatically scored from video recordings of 20 flies walking in an arena. (B) Two minute trajectory of a single male fly detected among 20 in the arena. (C) Upper: raster plot for behaviors exhibited during the trajectory in (B); lower: translational and angular velocities superimposed on a 30 s segment of the raster plot. (D) Behavioral “vectors” for female, male, and fru1/fru1 mutant male flies. Each column represents a single fly and each row a single behavior. Numbers at top refer to experiment and number of flies tracked.

Neuron 2014 84, 18-31 DOI: (10.1016/j.neuron.2014.09.005)
Looking for correlations between
  ◦ behavior observation and
  ◦ neuronal structure and activity

Traditional works:
  ◦ neural anatomy differences between species, genres, etc
    • Relation between brain size in frogs and ambient weather seasonality

Recent works:
  ◦ Neural activity differences: EEG, fMRI
In summary, the clever use of virtual reality, machine learning, and miniaturized recording devices has the potential to dramatically increase our understanding of how neuronal activity underlies cognition and behavior. This path can be enabled by developing technologies to quantify and interpret animal behavior, at high temporal and spatial resolution, reliably, objectively, over long periods of time, under a broad set of conditions, and in combination with concurrent measurement and manipulation of neuronal activity.

Brain manifesto

new technologies for mapping, monitoring, and manipulating neural activity based on genetic targeting of specific neuron subtypes

→ beyond correlation to establish causal relationships between neural circuit activity and behavior.

→ critically dependent on the ability to assess quantitatively, and with a high degree of spatiotemporal precision, the behavioral consequences of neural circuit manipulations.

study of aggression in *Drosophila*
temperature-dependent manipulations of neuronal activity to identify a small cluster of neurons that controls aggression

*Neuron* 2014 84, 18-31 DOI: (10.1016/j.neuron.2014.09.005)
Neuroethological studies of fear, anxiety, and risky decision-making in rodents and humans

*Current Opinion in Behavioral Sciences* Volume 5, October 2015, Pages 8-15
Neuroscience has ignored the natural conditions under which anti-predation evolved.

Survival circuits underlie dynamic threat reactions and decisions-making actions.

Threat signals flow through corticolimbic to midbrain circuits.

Ethologically inspired paradigms provide an insightful window into fear and anxiety.
Predator-prey scenarios
Experiment design

(a) Defensive Attack (Flight)

Intensity of Behavior (A.U.)

Distance From Predator to Prey (A.U.)

(b) Distant

Proximal

Proximal = vmPFC

Proximal = PAG

(c) Midbrain

(d) Box 3 Approach-Retreat

(e) Plus

Minus

Dorsal Amygdala

BNST

Current Opinion in Behavioral Sciences
Example 3

Challenge
https://paris-saclay-cds.github.io/autism_challenge/
IMPAC
IMaging-PsychiAtry Challenge: predicting autism
A data challenge on Autism Spectrum Disorder detection

Deadline: July 1, 2018 - 8 pm (UTC)

44 Days
16 Hours
32 Minutes
32 Seconds
A big data challenge

Brain images from more than 2000 individuals

Patient vs Control distribution

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Gender distribution

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Age distribution

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Multimodal imaging data

Structural MRI

- Preprocessed with FreeSurfer and FSL
- Gray matter volume, area, and thickness
- Average for each Desikan cortical parcel.

Functional MRI

- Resting state fMRI
- Time series extracted on different atlases
An experimental setting for neuroethological human robot interaction

Too far from ecological validity in special educational needs!
Commercial products

Noldus

Innovative solutions for behavioral research

Powerful software tools, fully integrated labs, expert consultancy.
Trust our 27 years of experience to make your project a success.

"You make our lives easy and each new version of EthoVision is testimony to
the fact that the company is frankly put, the best at its game in the world."
DR. D. WOLMARANS, NORTH-EAST UNIVERSITY, SOUTH AFRICA

CONTACT US
Free CATALOG
Conclusions

- CybSPEED involves quite diverse beneficiaries and partners
- We are in the consolidation starting phase
  - Solving bureaucratic issues
  - Translating general statements of the project proposal into precise working lines
We are carrying out experiments using our current know-how

We are developing new tools for
- Smart interaction
- Behavior measurement
- Correlation of behavior measurement and neural activity
Discussion

- Bringing Computational Neuroethology into the school
  - Ethics questions
  - Technological questions
  - Scientific questions