CybSPEED project description: aims and means

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CybSPEED is a networking project funded by the European Commision involving partners from seven countries aiming to study and develop methodologies and cyber-physical technologies to improve educational resources addressing the needs of people with special educational needs. Emphasis is in the role that robotics systems can play and on the need to carefully assess the impact of such technologies on the children with special needs during the educational processes.

Key Words: Special education, social robotics

1 Introduction

The Cyber-Physical Systems for PEdagogical Rehabilitation in Special Education (CybSPEED) is a research and innovation staff exchange (RISE) project funded by the European Commision as Marie Sklodowska-Curie Action including academic institutions and SMEs in seven countries, four european (Bulgaria, Greece, France, Spain) and three countries abroad (Morocco, Japan, Chile). Starting date was December 1, 2017, with a duration of four years. It was proposed as a research network aiming to the development of innovative tools for children with special needs for its education. The target populations are children autism spectrum disorders (ASD), and other critical cognitive and behavioural impairments. While the positive effect of robotic interaction on ASD children has bee widely recognised in the literature, and there also studies relating improved cognitive abilities in healthy populations induced by robotic interaction or training, there is little known for other disorders such as the attention deficit or cognitive impairments. CybSPEED addresses a wide spectrum of children with special needs in diverse environments and demographic settings. Because the project network is so wide, there is a great opportunity to do across countries studies of the needs and potential impact of the introduction of cyberphysical systems in the educational processes. Experimental intervention studies must be subject to strict ethical assessment procedures, so they will be limited to specific sites and defined populations subject to rigorous recruiting procedures that will ensure the safety and well being of children.

This paper summarizes in Section 2 the project aims by a short description of intended experiments that are currently the subject of detailed specification and planning previous to actual realization. In Section 3 we present the project means to reach the intended goals, describing the cyberphysical resources that we are putting in action and the expected roles of each of the project partners.

2 Project aims

The cyberphysical systems may play a diversity of roles in the educational process, depending on the intended intervention and the needs of target population. They can be substitute of some traditional elements in the classroom or complementary to the actual educational resources. The project aims to introduce innovative educational resources and to measure the effect in a quantitative way. The following are some scenarios that we are contemplating as experimental settings:

- Joint attention is considered a pivotal skill in the education process, and critical for the positive evolution of some behavioural disorders, such as the autistic spectrum disorder (ASD) and the attention deficit disorders. Joint attention can be developed by the specific games involving social robotics. For instance, playing with pictogram communication can be a joint attention game if the robot only answers when the child and the assistant present the same pictogram. Measuring the impact of the cyberphysical system (the robot) in the game can be easily measured by keeping track of the game.
- Empathic response is very quick in the healthy children. When presented with video recording of robotic testing, e.g. pushing to fall a biped robot, they show very marked empathic responses, many of them protesting of the abuse. Enacting such tests or some theatrical representation may have a strong impact in some children with special needs, allowing for alternative ways to communicate and to help their understanding of social situations. Measuring such impact can be done by careful observation of their reactions, which can be done by some cyberphysical sensors, such as computer vision, motion sensors and neural activation sensors.
- Storytelling is a privileged mean to transfer knowledge and to promote interaction in the educational process. Storytelling by anthropomorphic robots has been found to be very effective in capturing the attention of the children, even when the plot is very linear and plain. Adding improved interactivity by enhancing the robot with dialog abilities using voice and pose recognition would provide a quite versatile tool for storytelling. Measuring the impact can be done by visual observation of the children attention and engagement in the story.
- Improving mathematical and spatial reasoning by robot programming is a specific educational goal that is being considered in many schools as an improvement of the standard curricula. For children with special needs, it can be a very effective tool to improve their education. The impact of such efforts can be easily measured by behavioural observation and improved academic marks. The question of whether children with special needs are more sensitive than healthy children can not be easily addressed in a context where children are segregated and live in quite different environments.

Experimental design is critical to achieve the project goals, and we are currently working with the education and rehabilitation experts in order to define experimental interventions and measurements trying these aspects. The cooperation of parent associations is critical in many regards to achieve some experimental success, obtaining empirical knowledge of the effect of robots in the educational and personal evolution processes. We would like to have the most natural environment

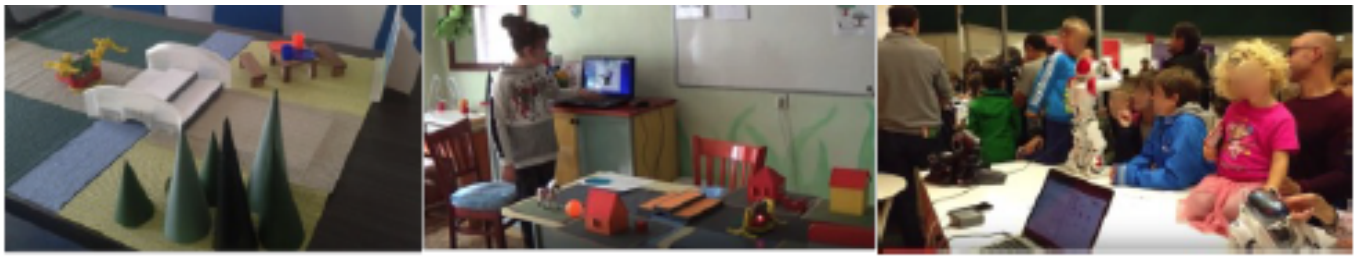

Fig.1 CybSPEED interaction scenarios.

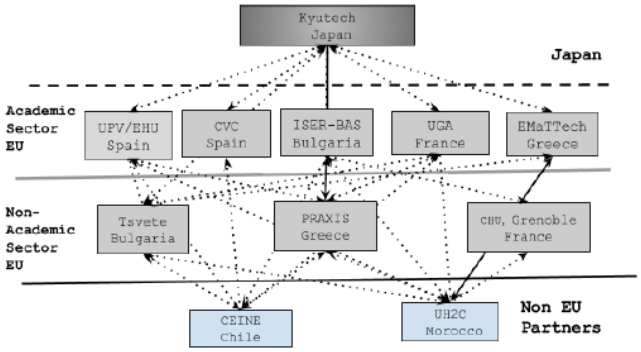

Fig.2 CybSPEED partners network.

for the experiments to be ecologically valid. Ethical requirements are rather rigorous for European Commission funded projects, so we need to follow strict ethical control procedures.

3 Project means

The project will be working on the development of improvements in the cyberphysical systems used to interact with the children as well as in the sensing and analysis of the children behaviour. We discuss here some of the working lines and the role of the project partners.

3.1 Computational Intelligence research

Many of the innovations intended are based on improved computational algorithms that we will be developing along the project. A special emphasis has been put on the development of Lattice Computing tools. Lattice Computing is an emerging branch of Computational Intelligence dealing with the formulation of data processing algorithms based on the lattice algebra instead of the conventional algebra. Lattice computing encompasses new learning algorithms to develop intelligent systems, as well as signal processing and data analysis tools. We intend to apply them to the analysis of experimental data, both from the robot sensors (e.g. child pose estimation, emotional cue recognition) and from the external behavioural sensors (e.g. body motion, face expression analysis, neural activity). A different area of computational resources development is the advance in interactive dialog systems that can be keystones for the achievement of improved storytelling abilities as well as to capture the attention of the children in conversational modes. We will also work on other computational tools, such as the morphological analysis.

3.2 Hardware related research

The project contemplates several hardware improvements in some educational robotic resources, such as the BigFoot robot developed by the Institute of Robotics of the Bulgarian Academy of Sciences. Also, the project needs to develop basic experimental sensing infrastructure that must be easily implemented in diverse environments and places. If we want to have reproducible experimentation, the behaviour observation infrastructure (cameras, EEG recording, wearable sensors, motion sensors) need to be easily calibrated and synchronised for the experiments which can take place in diverse physical environments. However, the project itself is not directed towards the construction of new sensors, but intends to exploit state-of-the-art off-the-shelf sensors, combining them to achieve the project goals. Also, the project will use as much as possible comercial social robots, such as the Nao robot, in the experimental design, benefitting from a growing community of developers offering facilities for the use of the robot in experimental settings.

3.3 Role of partners

The network structure of the partners, implemented via secondments, is illustrated in Figure 2. Here we dwell briefly on the capacities and expected contributions of the partners.

- Institute of Robotics of the Bulgarian Academy of Sciences (IR-BAS). The institution and the team leader Maya Dimitrova have great experience on the application of robotic systems in education, and formal connection to several institutions that work with children with special needs. The role of IR-BAS is central for the innovation of several robotic tools, such as the BigFoot robot. It is in charge also of setting up the formal conditions for several experiments involving diverse target populations which will be carried out in Bulgaria.
- Eastern Macedonia and Thrace Institute of Technology (EMaTTech), Greece. The principal investigator Vassilis Kaburlassos is a leader in the field of Lattice Computing. The research group is an emerging actor in the field of social robotics applications in education. The role of EMaTTech is centered on the development of computational resources based on Lattice Computing, while playing a strong role in the reproducibility of experiments locally in coordination with IR-BAS.
- University of the Basque Country (UPV/EHU), Spain. The research group lead by Manuel Graña has contributed also to the Lattice Computing field, and has experience in several areas of neuroscience and social robotics, with a current emphasis on storytelling and dialog systems. Its role as project coordinator will be to smooth successful project implementation. On the scientific side, UPV/EHU will contribute to experimental design and computational tools for both sensing and robot behaviour generation.
- PRAXIS Pediatric Rehabilitation Center, Kavala, Greece. This small enterprise has a long experience in the field of educational rehabilitation in the last 15 years.

They provide an observation and experimentation site along with their long experience record.

- University of Chile, Chile. The principal investigator, Sebastian Rios, has a long experience track on data processing. His group will contribute to the computational side of the project by providing algorithms and means to analyze the experimental data results.
- UGA University Grenoble Alpes Grenoble, France, The principal investigator Peter Mitrouchev at the GIPSA-Lab has experience on motor rehabilitation using virtual reality. Besides the contribution to experimental data analysis, it is possible to define experimental settings in virtual reality environments using their expertise and resources.
- NGO Theatre "Tsvete", Sofia, Bulgaria. They are experts in therapeutic applications of interactive theatre, mainly based on puppets, so they will contribute methodological tools for the development of experimental scenarios, including dialog systems.
- Computer Vision Center, CVC, Spain. They are experts in computer vision, and its principal investigator, Bogdan Raducanu is an expert in face and emotion recognition, so they will strongly contribute to the quantitative measurement of experimental results.
- Kyushu Institute of Technology, Kitakyushu, Japan (Kyutech) the group lead by Hiroaki Wagatsuma has big expertise in development of robotic systems, from housework to automated diriving cars, as well as in the measurement of neural activity and behaviour in actual game environments. Their expertise in experimental deployment as well as data analysis by morphological analysis will be key for the achievement of project goals.
- Hassan II University of Casablanca, Morocco, UH2C, the group lead by Omar Bouattane has a long track of experience on image processing and sensor information processing in several domains. Their contribution to the experimental design and deployment, as well as the subsequent data processing will be significant for the success of the project.

The network of secondments is complemented by several training and communication activities, such as summer schools, training meetings, and summer courses directed to the general public. The network is open to collaboration with new institutions in the development of tools and diffusion of the advances and research conclusions. We strongly believe that education is the key to the evolution of societies, and to the improvement of conditions of children at risk. We are also convinced that robotics will be playing a big role in the future, both as a contribution to improve children skills and as an assistive technology, helping both teachers and children in many unforeseen ways.