BrainControl Avatar: a robotic alter ego for students with severe disabilities

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Abstract.

Assistive technologies are essential to ensure that students with disabilities have access to inclusive and quality education.
BrainControl AAC is an alternative augmentative communication device based on Artificial Intelligence for human-machine interaction, able to offer a robust and usable interaction for daily use. This device fills a technological void for most patients who cannot use other assistive technologies on the market and who cannot meet their needs as the disease evolves. Applications range from communication to robotics.
A robotic avatar, in particular, thanks to a remote control, could be used for the participation to learning activities and social initiatives.

Keywords: Augmentative and Alternative Communication (AAC), assistive technologies, educational inclusion, robotic avatar, Brain-Computer Interfaces (BCI)

1 Introduction

Degenerative neuromuscular diseases or ischemic or traumatic brain damage can cause paralysis and communication problems. There are over 140 million people globally with paralysis due to neuromuscular degenerative diseases, stroke, traumatic injury or aging process.
About 93 million children, or 1 in 20 of those aged 14 or younger, live with a moderate or severe disability of some kind. [1]
Over 20 million of these are completely paralyzed and / or have communication difficulties.
With the advent of the computer new technological extensions of language are possible. The use of computers by children in difficulty is currently facilitated thanks to the availability of a wide range of interfaces and other aids that allow their use even for people with severe disabilities. The computer is in fact equipped with an almost unlimited ability to manipulate symbols.

Its potential and the versatility that characterizes it make it an increasingly extensive tool and an aid for the enhancement of human abilities and therefore for overcoming the handicap.

1.1 Issues

The average disability gap in school attendance stands at 30% in primary and secondary schools in 15 countries. More than 85% of disabled primary-age children who are out of school have never attended school. The average marginal effect of disability on primary and secondary school attendance is negative and significant (-30%), and countries that have reached close to universal primary education report high ratios of disabled to non-disabled out-of-school children and disabled children confront the same difficulties in participating in education, regardless of their individual and socio-economic characteristics. [2]
Usable and robust solutions that meet the needs of people with physical and communication disabilities are lacking. The existing solutions are often vertical, making it difficult to personalize the various types of disabilities and their evolution in the case of neurodegenerative diseases.

1.2 ICT technologies

It is important to ensure accessibility and universal design of infrastructure and information. This includes making the physical environment, all facilities, health centres, shelters and schools, and the organization of health and other services, including communication and information systems, accessible for children with disabilities.
ICT technologies provides disabled people with the chance to communicate and connect with friends, reduces their isolation and opens up avenues for their participation in political, economic, social and cultural life. Those who lack access experience frustration and exclusion.
At the strategic level the use of computers favors, in the disabled students, the acquisition of some skills: knowing how to select information and make choices; knowing how to monitor some operations mechanically, ability that allows the correction of errors and a better use of the instrument; to be able to monitor the activities to be carried out.

2 BrainControl AAC

BrainControl AAC is a framework based on Artificial Intelligence for human-machine interaction using biofeedback.

Its first application was addressed as Alternative Augmentative Communication (AAC) device, a primary need, consisting of two main modules: BCI AAC and Sensory AAC.
BrainControl BCI AAC is a Brain Computer Interface (BCI), based on a research line called "Motor Imagery" which uses 12 types of movements (6 rotations and 6 directions), such as up down, left, right, etc., it works like a “mental joystick”. [4,5,7,8,9,10]
These thoughts create unique patterns of electrical activity in our brain that can be identified. The general pattern of electrical activity is the same from person to person, with small differences that can be aligned with a calibration of the system.
The aim of the device is to overcome severe physical and communicative disabilities due to neuromuscular disease, ischemic or traumatic injuries and muscular dystrophies of various kinds, motor and communication disabilities. The device is therefore aimed, first of all, at patients who have an intact cognitive ability but who suffer from diseases that completely or partially paralyze the person.
It fills a technological void for most locked-in patients (those who cannot use eye-tracking systems) and meets many of the unmet needs for patients in less advanced states who are currently using or cannot use other assistive technologies on the market. BrainControl is also highly portable, whereas it consists of a tablet PC and a wireless EEG headset.
The first version of BrainControl AAC includes a sentence finder and a virtual keyboard. The interface uses a scanning method to move between available options and utilizes just one thought related to a movement to select the desired choice. The pre-defined sentences in the sentence finder are completely customizable, including the addition of images, audio feedback and the creation of sub-menus.
Over the last year the interaction modalities have been extended, thanks to the integration of multiple sensors, in addition to the EEG ones.
BrainControl Sensory AAC is a variant (non-BCI) of BrainControl BCI AAC, designed for patients with a residual movement of the pupil or of any other part of the body. It is a variant of the BCI AAC version, which does not use a BCI technology. It can integrate motion or infrared sensors, accelerometers, camera (image processing) and eye tracking. The interaction methods integrated to date are: eye-tracking (standard or easy mode), motion detection and touch (standard or easy mode) .

2.1 Smart Multimodal Platform

BrainControl AAC is a multimodal and horizontal platform (see Fig.1), customizable and adaptable in order to meet the specific needs of each patient at any time and responding to the different degrees and types of impairment caused by the pathology.
The heart of the system is a pattern classifier of signals coming from wearable biometric sensors (EEG, inertial, etc.) and / or environmental (2d and 3d cameras), based on a Machine Learning and Artificial Intelligence technology for the personalization of the different needs in various patients.

Thanks to a modular and personalized approach BrainControl AAC allows to fit the heterogeneous needs of the patients and, for patients with neurodegenerative diseases, to use the same device despite disease progression. The system give the patients the opportunity to interact and communicate.
The primary objective is to use the platform as a AAC device.
In the near future it will be validated, through a clinical trial, as a tool for the functional and cognitive assessment of patients. Future versions will implement advanced home automation features (lights, alarms, temperature, etc.) and robotics (humanoid robots and exoskeletons).
It is in validation phase a prototype version for controlling external devices: electric wheelchair, drones, robots.

Fig. 1. A horizontal multimodal platform

2.32 Use of grids for educational purposes

As already mentioned above, BrainControl AAC includes a sentence finder and a virtual keyboard. The sentence finder consists of grids that are completely customizable, it is possible to add images, audio feedback and to create sub-menus/grids.
It is possible to use the grids to convey to the student didactic contents and multiple choice questions to facilitate the learning process (see Fig.2), plan and design an individualized education, adapting proposals according to the students needs.
The device could be useful for catching the attention, stimulating verbal production and helping the student improve mnemonic capacity.
The teacher could modulate the proposal in different ways and take advantage of different settings: analogical, iconic, representative, symbolic.

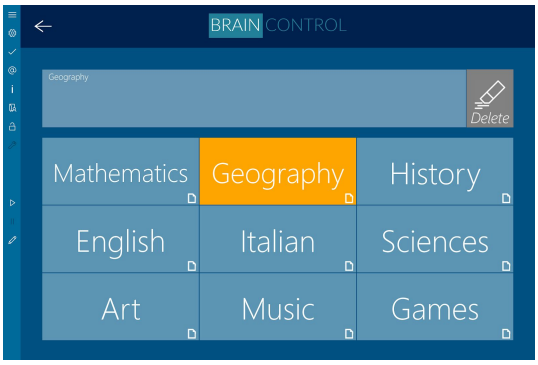

Fig. 2A Choice of subject (ex. Geography)

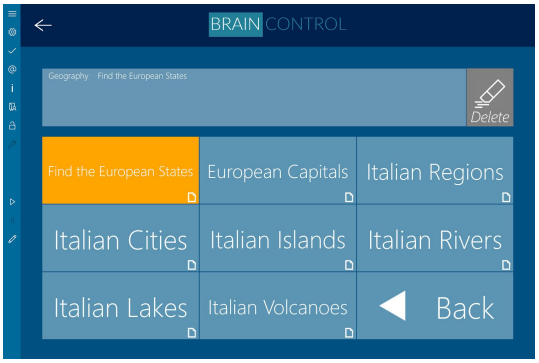

Fig. 2B Choice of topic (ex. "Find the European States")

Fig. 2C More choice options (with intruders)

Fig.2 (A,B,C) An example of a customizable grids for learning facilitation

2.3 BrainControl Avatar

The control of an robotics devices, such as exoskeleton, prosthetics, etc. is one of the primary objectives of ongoing trials.
Immediate attention was paid to the creation of robotic avatars, an alter ego realized through the integration of commercial devices equipped with a camera, speaker and microphone, which the patient can control in his movements and through which he can interact remotely. [3](See Fig.3)
Through the Robotic Avatar, it is possible to interact by remote control and to move in the environment.
The BrainControl Avatar can help children with disabilities to participate in many learning activities and social initiatives.
Assistive technologies are essential to ensure that children with disabilities have access to inclusive and quality education and it means the difference between enjoying their rights or being deprived of them.

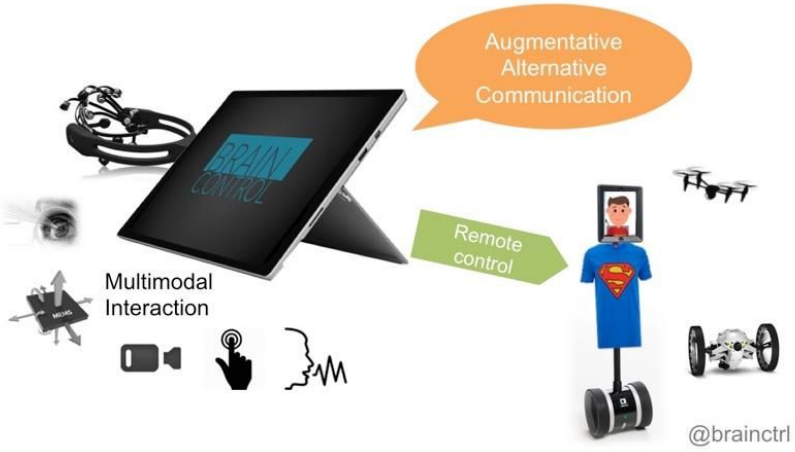

Fig. 3. BrainControl for the communication and the interaction.

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