EXTENDING USER CAPABILITIES

USING BRAIN SIGNALS IN ADAPTIVE SMART SPACES FOR DISABLED CHILDREN

INNOVATIVE INTERACTIVE INTERFACES Laboratory

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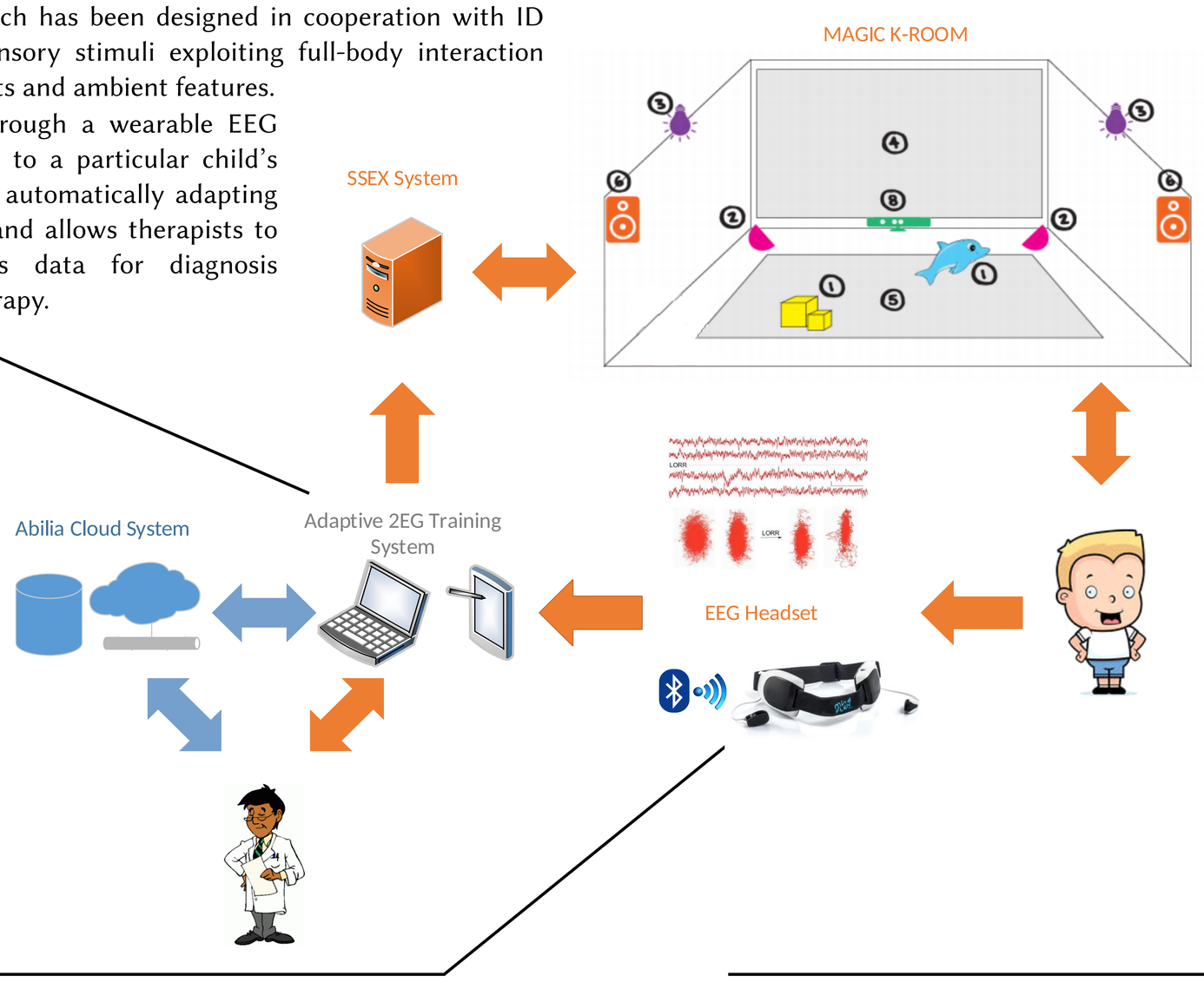
OUR RESEARCH

Our research explores new forms of technology-enhanced interventions for children with Intellectual Disability (ID). The paper presents an innovative smart space called Magic K-Room, which has been designed in cooperation with ID specialists and provides multisensory stimuli exploiting full-body interaction with various kinds of smart objects and ambient features.
Using brain signals acquired through a wearable EEG headset, the space is responsive to a particular child's level of relaxation and attention, automatically adapting the stimuli to the child's state, and allows therapists to automatically collect a child's data for diagnosis purposes or to fine tune their therapy.

MONITORING AND CONFIGURING TOOL

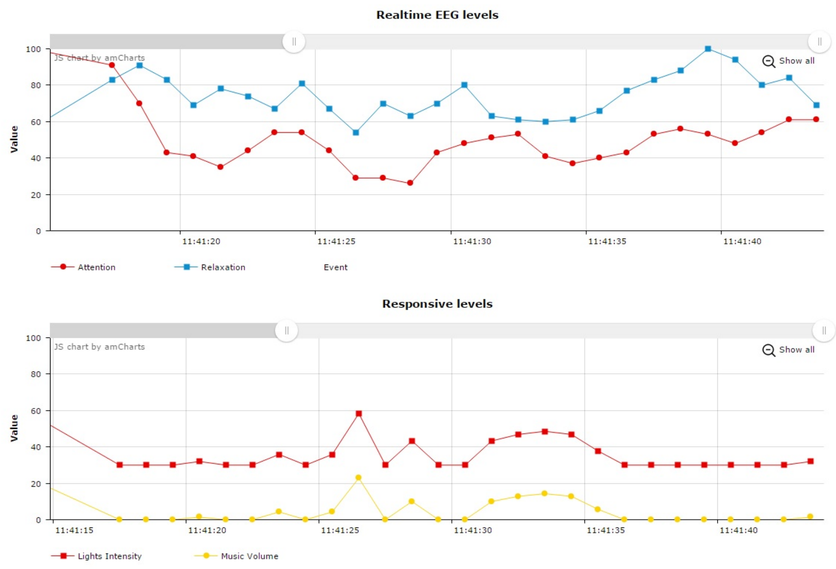
The Maigc K-Room brings forth an incredible innovation that broadens the scope of all the collected data, going beyond the simple local database storage. It comes integrated with a cloud-based application where data can be stored, visualized and analyzed both batch and at run-time (Fig.1) and with a setup panel where therapists can set the therapy session (Fig.2).



EEG HEADSET

To detect and acquire brain signals we use an EEG headset. This headset is integrated into a more child-friendly helmet to make wearing it less invasive and more pleasurable.
The device can compute **relaxation and attention levels**, and trasmits data via a **Bluetooth** interface.

Fig.1 EEG LEVELS AND ADAPTATION VISUALIZATION



The graphs show attention and relaxation levels (upper one) and music's volume and lights' intensity during an intervention.
On the y-axis there are the level and intensity values.
On the x-axis there is the time of the day.

In the **Realtime EEG** levels graph (the upper one) the blue line is the child's relaxation and the red one is the child's attention.
In the **Responsive levels** graph the red plot is the light intensity and the yellow one is the music volume.

FUTURE WORK

We will explore the benefits of each different feature of the smart space.

We will investigate the effectiveness of our adaptation mechanism in terms of appropriateness of the current adaptation functions.

We will explore ambient adaptivity in the context of other tasks that children can perform in the Magic K-Room.

THE SMART SPACE: MAGIC K-ROOM

The Magic K-room (Fig.3) provides an innovative multisensory, interactive environment that incorporates virtual scenarios on large displays or projections with ambient music, smart objects (such as a soap-bubbles machine), smart luminous balls and cubes, ambient smart lights and a Philips Luminous Carpet TM (a carpet with cutting-edge super thin LED technology to display graphics and words)[1][2]

AUTOMATIC ADAPTATION

Adaptation is a fundamental requirement of any intervention with ID subjects. We have explored automatic adaptation, which uses children's attention and relaxation levels as the source of adaptability, and exploits the device employed for automatic data collection purposes [3].
The Magic K-Room can adapt its stimuli based on the children's current state as modelled by the data generated by the EEG headset, without the need of any manual intervention.
In defining the automatic adaptation strategy, it is important to remember that many impairments associated to ID are ascribed to the inability to properly synthesize input stimuli and to abnormality in the neurological mechanism that controls the capacity to shift attention between different perceived signals.

Hence, exposing ID children to too many variable stimuli simultaneously could be counter-productive as the child would be easily overwhelmed and become distracted or anxious.
We decided to focus initially on the adaptation of light and music stimuli only (separately or in a combined way).

The mapping between relaxation levels and smart room luminous and sound stimuli is modelled by a set of **adaptation functions** that implement the ambient adjustments that therapists would do manually on the environment as they observe changes on the child's relaxation state.

Example of adaptation functions are "linear", "quadratic" or "PID", which differ in the speed at which the room changes according to the variation in the child tracked level.

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Fig.2 CONFIGURATION TOOL

Configuration tool of the Magic K-Room:
example of adaptation specification of an intervention.

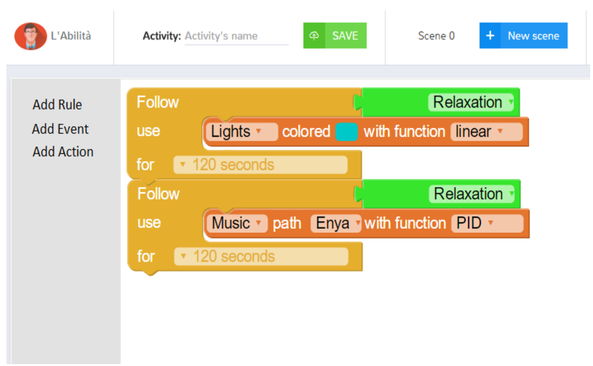

Fig.3 CHILDREN IN THE MAGIC K-ROOM

A child in the Magic K-Room wearing the headset and experimenting the adaptation.
The Magic K-Room can adapt ambient lights and music based on the children's current state as modelled by the data generated by the EEG headset, without the need of any manual intervention of caregivers during children's activities.