ASTRO: Autism Support Therapy by RObot Interaction

Massimo Pistoia, Marco Pistoia and Paolo Casacci

Abstract "Autism" is a syndrome that, according to the latest surveys, affects 1 child out of 100 and is the most characteristic group of pervasive developmental disorders. This work describes the experience gained through the "ASTRO" Project to develop a product able to support, by the means of new technologies, pre-school and school-aged children affected by Autism Spectrum Disorders and that can serve as a proper tool to be used during educational and rehabilitation activities. The goal was pursued by an ICT platform, endowed with a robotic platform, aimed at facilitating treatment of autistic children by ABA (Applied Behavior Analysis) methodology.

Keywords Living labs · Autism · Dyslexia · Robot · Learning · LMS

1 Introduction

Even though children affected by autism present different functional deficits, however, they are often able to use surprisingly different technologies such as PCs, MP3 player, TV, video games: tools used daily at home and sometimes at school. Teaching can find then a "rich soil" for what concerns the use of new technologies in order to foster learning by children suffering from autism and by taking into consideration that achieving new competences can go through those already learned, using technological devices as operational tools [1].

M. Pistoia (✉) · M. Pistoia · P. Casacci
eResult s.r.l., Piazzale Luigi Rava n.46, 47522 Cesena (FC), Italy
e-mail: massimo.pistoia@eresult.it

M. Pistoia
e-mail: info@eresult.it

P. Casacci
e-mail: Paolo.Casacci@eresult.it

F. Cavallo et al. (eds.), *Ambient Assisted Living*, Lecture Notes
in Electrical Engineering 426, DOI 10.1007/978-3-319-54283-6_23

The ASTRO project, co-financed by the Apulia Region in Italy by means of the Apulian ICT Living Labs programme, meant to create a multimedia robotic system integrated with the OMNIACARE software platform, developed by eResult, which enables to cope with diverse disability-related conditions. This was achieved by extending the features of the so-called OMNIACARE software platform for the delivery of didactical and cognitive exercises, in order to enable an interaction mediated by a robot to act as an intermediary in the process of socialization, reducing stress introduced by the absence of emotional inferences [2]. The realized system is suitable for domestic use as well, allowing the teacher to intervene in telepresence assisted by a parent. The development of human-machine interaction integrating IT tools with robotic devices provides a solution that contains flexible and customizable activities to suit different needs and characteristics. Such characteristics can be summarized as shift of the focus from learning to “doing”, in an educational design, organized and articulated, careful about timing and method of use, along with spurring self-use of the tool in order to enhance technical skills as well, increase self-esteem and gratification [3, 4].

2 Materials and Methods

The main goal of the ASTRO project was to develop a product able to support, by the means of new technologies, pre-school and school-aged children affected by Autism Spectrum Disorders and that can serve as a proper tool to be used during educational and rehabilitation activities. The goals of the project were pursued using a kit consisting of an anthropomorphic robot, NAO™, developed by the French company Aldebaran Robotics, and an LMS (Learning Management System) platform, developed on the OMNIACARE system, devised and produced by eResult [5, 6].

The ASTRO system, along with the services it provides have been shaped around the UCD methodology. It is a design philosophy and a process, which focuses the attention on the user’s need, expectations and limits in respect to the final product. The user is placed at the center of each step of the development process in order to maximize the usability and acceptance of the product, optimizing it around the needs of the users. The UCD methodology is characterized by a multi-level co-design and problem solving process. It requires designers to not only analyze and foresee how the user will utilize the final product, but to test and validate their assumptions at the same time by taking into consideration the end user’s behavior during the usability and accessibility tests (test of user-experience) into the real world. The UCD methodology leads to the creation of the final product through an iterative and interactive process that provides the development of a first prototype and a following test and assessment stage based on which to proceed with the development of the next prototype. Each cycle therefore leads to the creation of a product that is closest to the real and practical needs of the user. The aim of the UCD is to move from a high-fidelity prototype with a focus on users’ identified needs to an innovation. This means to include both business model aspects as well as designing a fully functioning innovation. The main objective is to re-design the innovation according to feedback gained in earlier phases.

The activities spent in the design and testing phases were conducted side-by-side with therapists who apply the ABA (Applied Behavior Analysis) methodology and with a parent association of autistic children. ABA is a program that is based on the principles of behavior modification, and which aims to intervene in children of preschool age with the mediation of parents and the support of operators. The ABA intervention has proven to be particularly effective in intellectual functioning, in the understanding of language and learning of social skills in adaptive behavior, in understanding and linguistic expression.

All the work was scientifically supervised by an independent third party represented by the University of Foggia (Italy). The project team designed and implemented a set of exercises for the autistic children, which aimed to improve parent-child relation by initially stimulating attention with actions initiated by the robot, later substituted by the parent to continue the interaction. All in all, the robot acted as a facilitator for the parents to gain attention from their children.

3 Technology

The ASTRO project was realized using two main ICT technologies, one hardware and one software. The hardware platform was a NAO™ robot, while the software application was OMNIACARE.

NAO™ is a hi-tech robotic device characterized by 25 degrees of freedom, which allow it to perform even the most complex motions and it is suitable for structured and unstructured environments. It is equipped with:

- Ultrasonic proximity sensors pointing towards different directions, that allow to detect and evaluate the physical distance;
- Pressure sensors located under the lower limbs;
- Advanced multimedia system with 4 microphones and 2 speakers;
- 2 CMOS cameras designed for speech synthesis, space location, face and object recognition;
- Interaction sensors such as 3 touch areas above the head of the robot;
- 2 infrared led and 2 contact sensors on the front of the lower limbs.

The OMNIACARE platform is a multi-functional hardware and software system, specifically developed by eResult for the remote monitoring and assistance of frail users. By providing tools to patients and caregivers, the system improves quality of life of those people who need particular assistance in daily living and to those who take care of them. OMNIACARE's software architecture is modular: each element realizes some specific functions, as to be able to dynamically adapt to a variety of situations and environments. The system allows exploitation of more or less functionalities in a seamless way, by using specific elements, while the overall system keeps running. The system architecture is open to any potential development by just adding new modules.

To cover the aspect of support to children affected with learning or developmental disorders, the platform implements a Learning Management System that administers provision of multimedia exercises, aided by Information and Communication Technology tools, to make the learning or therapy process more playful, usable and effective. The system also records the pupils' answers and feedbacks to ease teachers and therapists in their effort to properly assess children's capacity evolution and growth.

OMNIACARE comprises the following elements:

– Central Server;
– Home Server;
– External hardware systems (robot, sensors, interaction and parameter collecting devices);
– Webcam;
– Smartphone and tablet (Android-based).

The webcam is connected to the Internet through a Wi-Fi router. Operators and therapists can use it to monitor the local environment and to support patients and caregivers by working on the system themselves, through the Central and Home Servers. This is an optional feature that can be disabled by the end user for privacy reasons.

The Central Server (CS) is the main element of the system. User profiles, device configurations and all system data reside on the CS. The CS also provides the web interface that operators and therapists use to interact with the system, in order to customize exercises and therapy for pupils. Configurations can be done on the CS by the tutors only, to avoid unauthorized modifications by the users or caregivers. The Home Server and the hand-held device periodically synchronize data and download configurations from and to the CS. The CS has been built on the eResult's OMNIAPLACE software development platform, and it inherits its inner characteristics (Fig. 1):

– Hierarchical data structure.
– Web-based user interface.
– Advanced data navigation, display and search.
– Extensive data export functionalities.
– Granular user privilege management.
– Structured system event management.
– Information traceability.

The Home Server (HS) acts as a gateway that interfaces with detection sensors and external devices managing all of the diverse communication protocols. The HS collects data from the devices and provides configuration data exchange to proper manage them. The HS also consolidates and conditions data and sends them to the

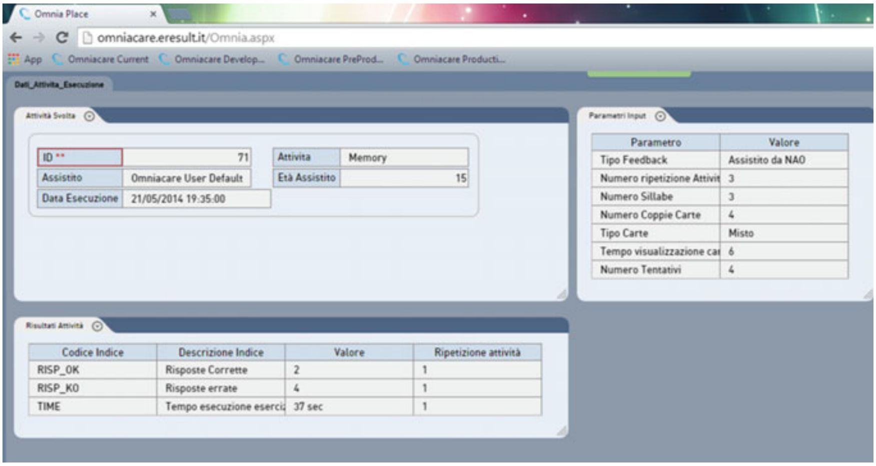

Fig. 1 OMNIACARE central server (CS)

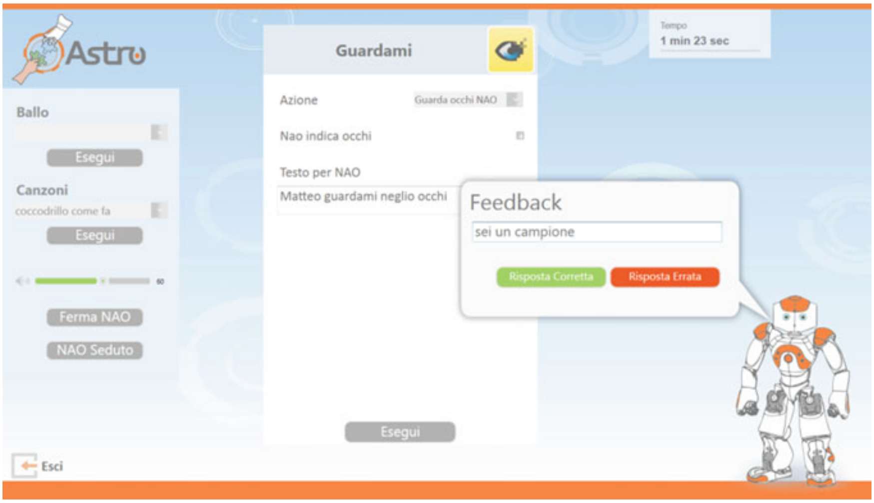

Fig. 2 OMNIACARE home server LMS screen

CS, according to the established rules and timing, while at the same time providing warning or alerts in case of a detected anomaly.

As concerns the LMS system, the HS also contains the software engine used for exercise administration and the user interface module to display such exercises to the pupil, along with the interaction control dashboard for the therapist/teacher to manage behaviors of the NAO™ robot (Fig. 2).

Different access to information and functions can be granted on the HS-based LMS platform to different users, according to their needs and competences, by a web interface present on the CS configuration page [7].

4 Results

The ASTRO Project result assessment revealed that 63% of involved children positively reacted to the robot's presence, showing curiosity, happiness, interest; 18.5% showed negative reactions; 18.5% of children showed an alternate behavior, sometimes afraid or indifferent, sometimes curious. In some cases, negative expressions depended on technical problems interfering with, or blocking, the experimentation session. 48.1% of children satisfactorily responded also to direct interaction with the robot. It was important for the experimentation to note how easily children would physically approach the robot, spontaneously approached and touched in most cases.

As to families, parents were actively involved in the ASTRO co-design and experimentation phases. 81.5% of families declared themselves satisfied by the experimentation, in some cases expressing amazement for "the progress obtained [by their children]". Even those who were doubtful in the beginning of the project, progressively gained confidence during the course of experimentation, due to the gradual successful improvement in their children's interaction. In 90 sessions, parents participated in exercise execution, using the system and stimulating children to establish a direct contact with the robot, by singing and dancing with it and giving expressions of encouragement. This allowed the robot to play a role of functional game and raising interest and curiosity in autistic children, unlike the stereotyped games they typically use in a solitary manner. Thus, the robot facilitated the relation between child and parents. Parents, on their side, discovered a new way of living a joyful and playful moment with their children, at the same time useful to stimulate their cognitive and behavioral abilities [8].

In a limited number of cases, intensive intervention and help by the therapist was necessary, because the parent was not able to properly use the PC and thus easily discouraged; or, for the fact that the parent, while desiring to cooperate, was not able to oversee the child and use the system at the same time. Some families decided to leave the project because the exercises from the system were too simple for the chronological age of the children. This criticality emerged as a side effect of the need to experiment the possibilities offered by the system as a mediator in the parent/child relation. In fact, the proposed exercises were rather simple, in order to ensure the active involvement of parents allowing them to carry out the session autonomously, with the simple supervision of the therapist. This prevented the system to adapt to the need of the single patient. From the experimentation, it nonetheless emerged how the preparation and behavior of therapists are critical to the success of the session. It is important that they invest time in preparing the setting before the session itself, eliminating any distractors and arranging preliminary plans along with required procedures.

The ASTRO project led to the conclusion that the realized intervention, designed to make parents protagonists in their children's treatment, makes a step in the right direction towards the awareness of the possibilities they have to make a difference with their own kids [9]. Parents were all available to further experiment and gave suggestions for improvements.

Acknowledgments The authors thank Prof. Stefania Pinnelli from University of Salento and Dr. Giovanna Avellis from Innovapuglia SpA for the essential contribution to this paper. This work has been funded by Apulia Region, under Regional Operational Programme ERDF 2007–2013 Action 1.4.2 supporting the growth and the development of SMEs specialized in the delivery of digital contents and services.

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