Smart Objects for Speech Therapies at Home

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Abstract. The pervasiveness of Internet of Things (IoT) devices is commonly used to create domestic ambient to support people daily life. In this paper we explore how IoT devices can be used in the smart home to administer the therapy to children with speech disorders. The speech therapist manages and controls patients' therapies by using End-User Development methods and tools.

Keywords: IoT, Smart Home, Speech therapy, End-User Development.

1 Introduction

The value of Internet of Things (IoT) technology is acknowledged in many scenarios of Ambient Assisted Living (AAL) [1], [2]. As several IoT devices are available today in a smart home, researchers are working a lot on smart home systems to be used by physicians and other therapists to remotely assist their patients living at home. Built-in IoT sensors can be exploited to monitor the health status of a person or to administer a therapy. As an example, a software and hardware prototype of a modular pill dispenser has been proposed in [3], [4]. It can be configured, according to the user's needs, with multiple pills, in which each pill is associated with a small smart box. The therapy, as well as the alerts are set using a mobile phone app.

This concept of "home hospitalization" both improves patients' life, who remain more comfortably at home and avoid hospitalization, and reduces healthcare costs. For this reason, smart home technologies are gaining a momentum in becoming assistive technology in home assistance.

IoT devices are also considered to support learning and to improving the quality of life for children with autism spectrum disorder. In [5], smart technologies are exploited for an IoT infrastructure for AAL scenarios where children with autism live in their homes with smart objects, communicating to the outside world in an intelligent and goal-orientated manner. Lack of space prevent us to report on several other proposals available in literature.

However, patients live in very different situations and have variable needs and behaviors. Our research aims at bringing innovation in AAL contexts by proposing new approaches to build spaces equipped with smart devices for monitoring patients' behavior, still fostering an independent lifestyle. We capitalize on years of experience on End-User Development (EUD), a research area whose goal is to support non-technical end users in the creation of products and services tailored to their needs and desires [6],

[7], [8], [9]. Our current objective is to propose innovative AAL paradigms that empower end users to co-design, customize, evolve, and control the ecology of smart objects, which communicate with the outside world in an intelligent and goal-oriented manner. Providing such objects with new capabilities usually requires programming efforts.

Some approaches have been proposed in literature to support non-technical users to configure smart object behavior. However, most of them provide pre-packaged solutions for remotely controlling single smart objects without any possibility of adaptation to specific domains and contexts of use. Task-Automation (TA) tools overcome this limitation: users can specify object behavior by graphically sketching the interaction among the objects or defining event-condition-action (ECA) rules (see, e.g., [10], [11], [12]). However, the adoption of TA tools is still limited. Indeed, tools based on graph metaphors do not match the mental model of most users, while tools implementing ECA rules allow a trivial synchronization of smart-object behaviors, without the possibility to define powerful constraints on events activation and actions execution [13]. An example is IFTTT (If This Then That) [14]. The EFESTO platform offers a visual interaction paradigm to enable end users to easily express rules for smart object configuration that are more powerful than the rules created by a TA tool like IFTTT. EFESTO permits to build rules coupling multiple events and conditions exposed by smart objects and to define temporal and spatial constraints on rule activation and action execution.

This paper focus on the smart home as a medical setting for “speech therapy”. Thanks to EFESTO, the therapist can easily create ECA rules to control the smart objects involved in administering the therapy, as it is described in the next section.

2 Speech therapy through games and smart objects

Speech disorders or speech impediments are a type of communication disorder where “normal” speech is disrupted. They affect the vocal cords, muscles, nerves, and other structures within the throat, due for example to vocal cord damage, brain damage, muscle weakness or vocal cord paralysis. Some speech disorders improve with speech therapy: a professional therapist guides the patient through various exercises to strengthen the muscles of face and throat. Children have to exercise also at home, but they often find some exercises boring and either they do not perform them correctly or do not perform at all, and this is not verifiable by the therapist.

We describe in the following how we are using a gamified application to stimulate a child in performing the exercises of a speech therapy. The value of games in stimulating and engaging children to perform activities is well known and we have used them in various contexts (see e.g.[15], [16]).

A tablet app has been developed for children. Figure 1 presents screen shots of the game, which requires performing exercises to gain points. The player is represented by a small dragon that, moving on a pathway in a park, from left to right, pushes on a red button to perform the associated exercise (see Figure 1 left). Figure 1 right shows an exercise in which the child has to guess a figure representing a whale. Below each button on the dragon path there are three stars that show the level of accomplishment of the specific exercise (an award for the obtained result). The button becomes green once the three awards are obtained, i.e., the exercise is completed. The child can also see its position in a “children ranking”.

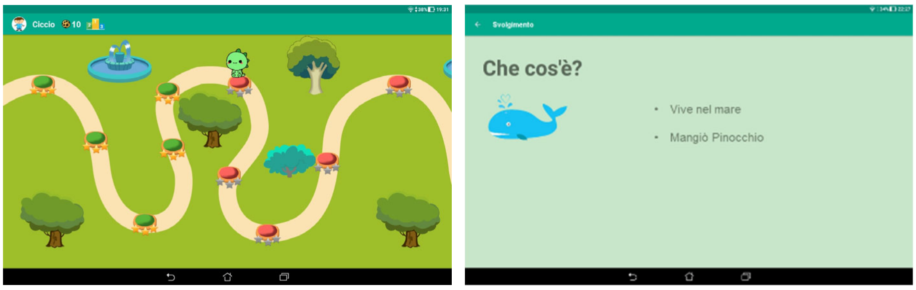

Figure 1: The tablet app. Left: the game main page; right: a specific exercise

A further app, called remote controller, has been implemented to be used by child’s parents or caregivers to “certify” the real accomplishment of each exercise. Due to lack of space further details of this app and on how the children ranking is generated are not reported.

The speech therapist can create and modify speech exercises. S/He can adapt the therapy to the child (Figure 2 left) and get feedback on the child progress (Figure 2 right). By defining ECA rules in the EFESTO platform the therapist controls the IoT devices installed in the child home and orchestrates them to achieve a specific emotional response by the child, which favors exercise execution. For example, if the therapist knows that the child loves a TV cartoon, s/he can set a time for an exercise just before the beginning of the cartoon, which will be an award at the end of the exercise.

This is better presented by the following scenario. The speech therapy consists of one exercise a day of about 10 minutes. The child home is equipped with IoT devices: smart lamps and human body sensors in each room, smart speakers and a smart TV in the living room, where the therapy is supposed to be administered, because the TV will play the cartoon at the end of the exercise. The cartoon starts at 17:30, thus at 17:10 the smart home provides the child with two kinds of alerts: the tablet will send a notification, while smart light in the room the child is switch on and/or change color in green and start flashing. This indicates to the child that it is time to do the exercise. The lights on the way to the living room also switch on or become green to indicate the path to the living room, where the child starts the exercise.

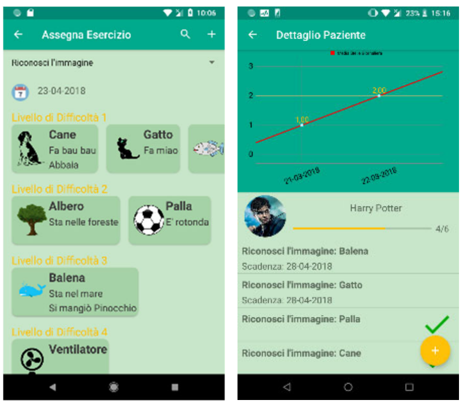

Figure 2: The therapist app allows to modify the therapy (left) and to get feedback about child progress (right)

So far, only some formative evaluations have been performed on the developed prototypes. More experimental studies are planned to validate our approach.

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