Context-based learning games for children with cerebral palsy: a prototype

Elis Silva[1], Jorge Silva[2]

[1] Faculty of Engineering of the University of Porto,
University of Coimbra [2]
Rua Dr. Roberto Frias, s/n, 4200-465 Porto, Portugal,
{elissilva481@gmail.com, sasilva@dei.uc.pt}

Abstract. Currently, a part of population about one billion, about 15%, including children, are living with a disability, be visual, hearing or physical. People with deficiency can be overly dependent on their families, due the lack of support services. The Internet of things can provide a better life for these people and allows them to participate in the social and economic life. In this paper we describe an application developed for Android, a learning game to be use by children with cerebral palsy in context of learning in the classroom. The work was discussed with a group of specialist of APCC institution, and were identified limitations in the application use and have been proposed new challenges for application. In this paper were also discussed concepts on Wireless Sensor Networks and Internet of Things for people with disabilities

Keywords: Internet of Things, Cerebral Palsy, Wireless Sensor Networks.

1 Introduction

According to the World Health Organization (WHO), a part of population of about one billion, about 15%, including children, are living with a disability, be it visual, hearing or physical [1]. People with disabilities are often dependent on others to carry out everyday activities. The services that enable people with disabilities to have greater autonomy are limited. Therefore, these people cannot be fully integrated into society.

The IoT allows through low-cost applications the democratization and use of these technologies by all social classes. The IoT applications for people with disabilities are interesting, they aim to increase the autonomy of these people, or even to their caregivers [2].

Within this project in IoT, we made a partnership with the Cerebral Palsy Association of Coimbra-APCC. On The needs and areas of intervention collected together the institution, a greater emphasis was given to the shortage of learning games using the scanning method (selection mechanism widely used in games for people with cerebral palsy). Our goal therefore, was the development of a learning game for tablet with Android operating system, where this game involves the interaction of a child using the device with a toy.

In section 2 we describe the concepts of cerebral palsy, IoT and Wireless Sensor Networks. Section 3 describes the implementation of the architecture of Project, and the operation of the application and the technologies used. In Section 4 are presented

the final considerations of APCC institution about the project, and finally, section 5 presents the conclusion and future work.

2 Background

In this section are addressed the main concepts of cerebral palsy, and concepts about Internet of Things (IoT), and in particular applied IoT to deficiency and concepts and work on Wireless Sensor Networks.

2.1 Cerebral Palsy

Cerebral palsy is characterized by a group of disorders that affect the motor system, and the posture control. The Cerebral palsy appears early after an injury, damage or disorder of the central nervous system [3].

The treatment is palliative for cerebral palsy, since it is not possible to act on a healed injury. In addition to drug treatments, the therapies in general are widely used, such as speech therapy. The speech therapy consist the development of activities in scope the prevention, evaluation and treatment of disorders in communication. The Professionals use learning games as assistance in the performance of this therapy. However, there is little availability of these games on the market, the game "The Grid 2" is an example of a game that allows people with limitations in speech can communicate via computer. The Idea Project - Digital Divide with Teaching Interactive Accessible [4], which integrates contents of the 1st Cycle of the areas of Mathematics, Portuguese and Environmental Studies, allows users to use the scanning method for access to games. There are mobile applications, as the example of Proloquo2Go [5], for the iPhone and the Sleep Flex Lite [6] for Android, that use alternative communication as tool to improve the communication capacity of people with disabilities for speak. The applications are similar and allows that is issued a voice with to the selected information.

2.2 Internet of Things

For Domingo [2] the Internet of Things (IoT) is a technological revolution in computing and communications. For [7] the concept of IoT is like a vision where the objects in our world are identified only as part of the Internet, with important information and may be accessed over the network, which has dramatically impact in the professional, personal and social. According to [8], technological change allows a different form of communication between people and the things. Although there are different definitions for the Internet of Things, there are underlying concepts that normally appear when it comes to defining their goals.

The Internet of Things is closer to marking technologies, as the Radio-Frequency Identification (RFID), wireless sensor networks, actuators, mobile phones, the quick response code (QR codes), Near Field Communication (NFC), among others. The interaction and cooperation between these objects will occur only through addressing schemes aiming to achieve common goals, [9]. Among the numerous fields of

application where the technology of the Internet of Things will become very useful, we highlight following scenarios: homes and smart cities. An example of this is the project USEFIL - Unobtrusive Smart Environments for Independent Living [10], which have the goal to generate systems and services through a simplified approach with cost-effective solutions for older people, making use of Information and Communication Technologies (ICT). For smart cities, stands out the European project OpenIOT, that aims to facilitate the use of sensors in ICT-based services not only for smart cities, but also in industry and agriculture with solutions based on sensors networks service [11]. The Commodity project aims to develop an intelligent system for the analysis of combined medical data to make possible the provision of medical information directed to the treatment of a single patient [12].

2.3 Wireless Sensor Networks

Wireless Sensor Networks (WSNs) differ in several aspects of traditional computer networks. Usually consist of many nodes scattered in a region, in order to take measurements of some phenomenon, for example, seismic measurements of a volcano. The collected data are send to a base station, for to be analyzed and treated.
The nodes have energy limitations, because in many cases, are in inhospitable regions or of difficult access, and must have mechanisms for self-configuration and adaptation because of losses of nodes (either by destruction of equipment or due to complete loss of their power supply source) or the insertion of new nodes [13].

In WSNs, each node may be equipped with a set of sensors, such as temperature, pressure, humidity, light, sound levels, and other. The combination of these devices provides WSNs be used in a wide range of applications such as [14]: **Agriculture and environment**, where is possible perform the measurement of the fertilizer level in the whole extension of the property. These systems provide to farmer a precision farming leading leading to lower costs, because the farmer just need to perform a new application of fertilizer in deficit regions. **Military applications**, monitoring of strategic regions can be performed by magnetic sensors and vibration thereby allowing identifying moving enemy troops and assist in the decision-making process during the battle. **Medical Applications** enables you to perform the monitoring of vital signs of patients, organ functioning as the heart and detect the presence of substances harmful to man.

2.4 Internet of Things for people with disabilities

The Internet of Things can provide a better life for people, particularly for people who need support, because of their disability. Therefore, the IoT can help these people with special needs to enhance their social life, offering in their daily activities the assistance they need, providing greater autonomy, independence and economic participation. There are many current projects discussing architecture IoT for people with disabilities. In [2] had proposed the IoT architecture for applications aimed at people with disabilities. This architecture was divided into three layers: the first layer

is the perception, the main function is to identify objects and collect sensitive information to the context of the environment of people with disabilities is comprises for sensor means, actuators, tablet, PC, Smartphone, RFID, among others. The second layer is the Network and its main function is the transmission of information obtained from the perception layer. It consists of wireless networks, Internet, and so on. Have the Application layer is a set of intelligent solutions applied to IoT technology, in order to meet the needs of users.

The European Union (EU) in the IOT-i EU project [15] suggests another proposal of IoT architecture. This project aims to create a unified system for IoT community, aiming to align the community members in a vision of IoT exclusively for the Internet of the future. Thus, it was intended to avoid causing the fragmentation the IoT in several different solutions of the application domain. However, one of the first projects worldwide to IoT was the SENSEI FP7, whose goal was to build an architecture that allows the integration of sensor networks and wireless actuators. The work influenced other projects about architecture of the Internet of Things, such as the IOT-i EU FP7 previously described, and FI-WARE project with the main objective of creating APIs (Application Programming Interface) open to developers and suppliers through a common architecture.

3 System Overview and Architecture

In this section we will present a overview of the application and the architecture the project developed, as well as the technologies used.

3.1 Application and General Architecture

The android application is a learning game called "Game of Animals" designed for use by children with cerebral palsy. Designed for tablets with android operating system. In this application were made initially the settings by tutor. This setting will establish communication with the multithreaded server and from that will define the set of questions that will appear in the game to the student. With these initial settings completed, students can learn about a number of animals previously defined in the application, and when deemed necessary start the exercises through a Quiz system.

To carry out the management of the activities with the students, the tutor (teacher / parent) has on your domain a system called Tutor System. This system is capable of perform administering all the necessary resources so that each student can receive adequate exercise to their learning needs.

In Figure 1 is show the project overall architecture. This architecture consists of the android and tutor applications, by multithreaded servers and UDP, besides the sensor nodes. In the following paragraphs are briefly described each module of architecture.

The multithreaded server is responsible for providing all questions and alternatives in carrying out activities in the Animal Game. It also gets all the answers that the student chose during the course of exercise, inserts the data in the database and finally sends the UDP server what action should be performed by the toy node. Upon receiving the request from the multithreaded server, the UDP server is responsible

only for forwarding this request by port serial device to the base station, which in turn forwards via radio to toy node, which should be your action according to the response of each student. Finally, upon receiving the message, the toy node performs the action of turn on the green light when the answer is right and turn on the red light when the answer is wrong.
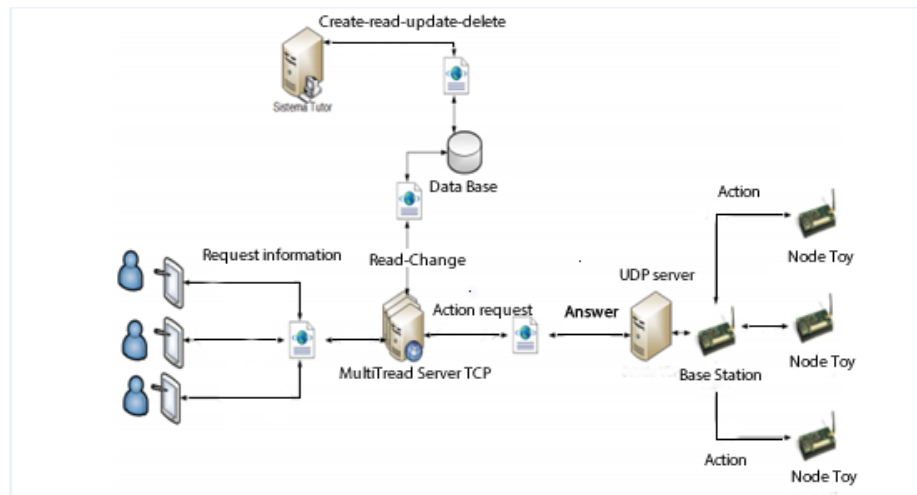

Figure 1 - General architecture of the Application

3.2 Technologies Used

We have used Java programming language for development the android application. We use sensors MicaZ (Datasheet MicaZ), which are third-generation devices that enable low power consumption, and are able to work with wireless sensor networks in 2, 4 GHz e 868/916 MHz [16]. In addition, support the date transmission rate of 250 kbps. These nodes also have temperature sensors, humidity, and pressure, among others. We also used a MicaZ base station that was connected to the Linux server (Ubuntu operating system), and so was able to receive via serial port application android information and send action commands to the sensor node.
In the project was used the MySQL 5.5.29 database to store game information. The management program date base was choosing was due mainly to be open source.The choosing this management program was due mainly to be open source, besides having excellent performance and stability, requires little hardware resources [17].

3.3 Multithreaded Server

To make it possible verify the actions and intentions that the student or tutor wanted done while executing the application android.was created a communication client-server through socket able to meet all the needs of users for example: verify that the answers are correct, provide the questions customized to the student that is playing and save the student's performance in the database. Also, being able to provide at the same time this service to more than one user. The message that starts the operation, part of the android application system when it starts to perform the setup procedure the game environment by tutor. The message sent is responsible for establishing communication via socket with the multithreaded server. Then the tutor forwards the code identification of the student to the server. On receiving the message, the server checks whether the ID code of the student is valid, then forwards for android application all groups in which the student is associated.

The tutor makes the pick of the bunch, and mainly the type of activity that the tutor want to accomplish with the student can motivate this choice. Upon receiving the chosen group, the server forwards all the issues and alternatives associated with the group for the android application. Having all the information necessary for the completion of the quiz is then available the opportunity to start the game. For each question in the quiz, the android application forwards the response to the server.

Then the server identifies whether the answer is correct or incorrect and make available for android application the updated score of the student, along with the name and at most the score of 2 students who belong to the same group. This repeats until the last question is answered.

3.4 UDP server

The UDP server the same way that the multithreaded TCP server also is implemented via socket, using mostly different communication protocols. The choice of the UDP protocol instead of the TCP protocol, to performing communication between two servers, is justified by the fact that protocol UDP is shown more appropriate for data stream in real-time, thereby being more suiting to ensure the concept of cause and desired effect in the system.

The message that starts communication between the two servers, is sent to UDP server after multithreaded server check if the response sent by android application is correct or wrong. To perform the communication has been established two types of messages, one for when the response is correct, being asked that the green light turn on by the toy node, and another message when the answer is wrong is requested that the red light is lit. After receiving one of two messages, The UDP server encapsulates the message through their own TinyOS library that provides a Java interface at the application level for sending messages, and forwards, via serial port to the base station.

3.5 MicaZ

Described above, for the construction of the infrastructure of hardware necessary for perform the interaction among the application and the toy, we used two MicaZ devices for construction of this architecture. A device is used to serve as a base station and assist in communication and sending messages to other software. The second device was meant to serve as own toy node and create interface with the student during the game. The activity begins after the base station via the serial port receive one message from the UDP server, then begin the message reading process, being initially identified for which toy node this message refers. From this, each student can interact with your toy of shape independent of the others. Before starting any message forwarding process for toy, a check is performed if can use the of system radio of device, otherwise, this request is then routed to a queue until their use is allowed. With the availability of all resources necessary to initiate communication with the toy, is then created a message from the below written communication structure. In this structure two attributes bases are defined, one for the identification of the toy node and the second for the message content.

Table 1 - Communication Structure

```
typedef nx_struct BlinkToRadioMsg {
        nx_uint16_t nodeid;
        nx_uint16_t counter;
} BlinkToRadioMsg;
```

For the filling up of message content is checked what action was originally requested by the UDP server, and then represent it in a 16-bit integer, being assigned a value of "0x01" to turn on the red light and the value of "0x02" to turn on the green light. With all the completed fields is carried the send of message for the toy.

4   Considerations APCC

In the final phase of the project, was necessary to perform a presentation to the APCC professionals of, for to understand the functioning of the developed system. Were had presented the tutor system and the android application, showing systematically the features of each application, such as example of a registration of a new student in the Tutor application as also the action triggered for toy node to each right or wrong in the Animal Games.

Were presented some limitations in the application. These limitations refer to some requirements that were not possible to develop in this project, as an example: the application to be tested using a switch to trigger some information of the game. This occurred, because we do not had that equipment for the tests. Another limitation that

do not posed was the toy with sound feedback and move. This toy would use to promote a stimulus reinforcement in the game with the children. The application developed for the institution presents the needs raised in the beginning of this project. These needs are mainly related to the motor difficulties of children with cerebral palsy to access applications on your computer, requiring mechanisms that allow such access, as the use of switches and adapted keyboards.

Was very important to development tutor system to use by professionals who are to accompany the student during an activity. In APCC is currently not used an application that allows this type of management, because through this application, the tutor can perform several actions to make custom game for each child's learning needs.

APCC are used various games, such as The Grid 2 that is used in therapies talking and activities in the classroom with the using the switch the use of switch simplifies much the lives of people with motors commitments, for this reason are widely used in various activities of daily life, the example of the wheelchair handling.

Just as is done training with children to use the switch, is being developed recently training in the institution for the use of the Tablet. This training is to establish small advances with handling hand to touch the device screen. Yet is not used any application developed for Tablet that has the scanning mechanism, and which allows the use of the switch, because the institution is unaware of any such application. The animal game developed in android is a good starting point for the creation of several other applications that can be used by children with cerebral palsy.

In general, the game has several features not found in other; one example is the group games. The functionality of the group of play is not intend to encourage any competition among students, because each has its difficulties and limitations, but allow greater socialization of students in the classroom.

Another feature of the application is the inclusion of actual toys that interact with the application in android. These light stimuli fired every right or wrong during the game arouse students' attention and interest in learning the game. The prototype presented of the application with the interaction with the toy not properly done; it lacked the coupling of the sensor nodes that trigger the light effects in the toy. It is expected that in addition to the light effects are also presented sound effects and movement in the toy every learner response.

Although some limitations that were not implemented in the project, the implementation involves a large part of the requirements raised by the institution to develop an application that can be used by students in the APCC.

5 Conclusion and Future work

In scope of the Internet of Things in the development of learning games with toys coupled with sensors nodes, an application was created in android. This game offers a simple interface with mechanisms that allow children to have access to same. The access mentioned here refers to mechanism sweep just mentioned. The application was developed in accordance with the set of requirements drawn up together with APCC institution. We show here in the project not only the application for children, but also a dedicated application for tutor. The application prototype has been tested and shown to the professionals of the institution, and so allowed us to conclude that the system developed for the APCC meet most of the requirements mentioned.

The developed application differs from the games already used by the institution, at first was developed specifically for devices, such as tablets and smartphone, that for the moment are not used by APCC any game available for use in these devices. The advantage of an application used in Tablets are related to portability of the device, that is, allow the same may be coupled in a wheelchair for children, and being smaller than a laptop and lighter, this factor has become paramount in the implementation of usability.

In this work the main objective was fulfilled, to create an application at low cost to allow monitoring by tutors or parents in the development of the activities carried out by children at play performed in the classroom and also at home, and even the inclusion of devices represented here by us toys in the application, interacting in real time with the virtual game, according to the answers given by the students. The IoT in this context was important because it allowed the integration of the actual represented by toy with sensor together with the application in android.

For possible future work, we highlight the creation of new functionality of interaction with the toy. These features relate particularly in developing more strengthening mechanisms of stimuli such as sounds and movements. The tutor application will be important to develop new features to make it more manageable application by tutors. An important issue is the possibility of the tutors can create custom questions may choose images and sounds that appear in the Animal Game.

In this project was not possible to use a switch to test the operation of the android application, we used the touch on the device screen to trigger the information. Will be very important for the next work the switches to be incorporated (switch) as triggering devices for children, as it will facilitate their access in the use of applications in android.

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