Decreasing child patient anxiety during Preoperative treatment

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***Abstract*- Patients' anxiety during preoperative treatment poses a challenge which pediatric clinics needs to deal with. The purpose of this paper is to describe our team's proposal to reduce anxiety of pediatric patients using interactive technologies. Research has been conducted on existing solutions and brainstorming carried out to devise new ideas and improve on existing ones. Afterwards an attempt to prototype has been undertaken. As a result an interactive game has been developed as well as a mobile application that enables nurses to obtain preoperative measurements. Initial results and the feedback from the stakeholders suggest that our solution could have a positive effect on decreasing an anxiety in pediatric patients and could be easily adopted by the nurses.**

***Keywords*- anxiety, software interface, vital signs, wearable sensors**

I. INTRODUCTION

Since patients' anxiety during hospitalization is a wide ranging problem [1], the *Hospital Sant Joan de Déu*,the main stakeholder of this project, in cooperation with EPS team is seeking ways to this problem. The idea to deal with this issue has been suggested by nurses who primarily are affected by and who know the actual influence of anxiety. The calmness of the young hospitalized patients is quite important, especially during the preoperative treatment, as it could hander the nurses' work or influence the quality of the measurements as well as patient wellbeing. Any distorted measurements may pose a threat for patient's health inasmuch as they are basic indicators for an anesthesiology process [2]. A system presented in this paper introduces a solution for both of the problems. It is constituted by two basic elements: an interactive game that is supposed to diminish the level of patient anxiety and an application which is responsible for retrieving information about patient's vital signs from the used measuring device. Both elements are described in details in the results section.

II. METHODOLOGY

A complete route that was needed to design the system proposed in this paper, consisted of five main steps: research, design, development, testing and redesign as it is presented in iterative cycles including feedback from stakeholders and the involvement of end users in Fig. 1.

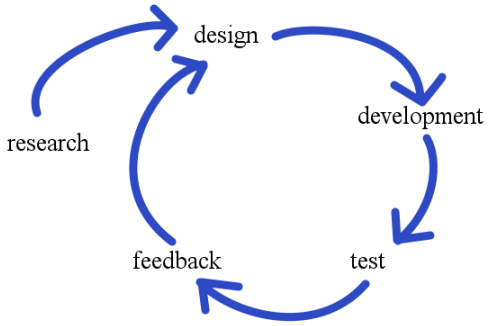

Fig. 1 Methodology of the project

A. Research

A significant part of the project was dedicated to the research in order to design a system that would be suitable for medical purposes. The research was divided into two main parts. One concerned the existing systems for measurement (old systems, used systems and interactive systems). From this research sensors, which could be used for measuring in our solution, have also been found. This is described further on in this paper. The second area was mainly based on psychological factors which could influences a child and the measurement. On the basis on this part a view has been gained on how to distract children during measurements and the need of it for this project. Having become acquainted with the current hospital's procedures and different possible solutions of reducing anxiety in well-established hospitals, the system presented in this article has been designed and developed. During the progress of the project tight cooperation with the hospital was significant for electing correct directions of further development. Besides correspondence with the representatives of the clinic, three crucial reunions have been organized.

TABLE I
Results of trial tests

Task description	Grade
Logging in to the application	1.57
Addition of a new patient	2.71
Browsing all patients	1.14
Returning to a previous view	1.00
Searching for a patient with a given name	2.29
Browsing measurements for a given patient	1.88
Connecting with Bluetooth device	4.43
Logging out from the application	1.00

B. Design and Development

An essential step during the course of the project was to design, both of an interactive game and an application, so as to provide a suitable solution for hospital environment.

During this part, mobile application dedicated for tablets with Android OS has been developed. Test Driven Development methodology has been partially adopted during programming phase making use of C# and Java languages. The interactive game was programed in C/C++ in Arduino software (Integrated Development Environment). Written so that further development is possible and easy to do.

C. Testing

In order to evaluate usability of the application graphical user interface (GUI), experts' opinion in this domain was asked for some suggestions. The suggestions that have been given were implemented in the GUI. Afterwards an on-line survey was conducted in which employees of the *Hospital de San Joan de Deu* in Barcelona also have participated to gather their opinions on key aspects. Results collected with the questionnaire has been used to redesign GUI before the real scenario tests.

Real scenario tests have been conducted thanks to support of the university international office and administrative staff. During the trials seven participants were asked to perform a given set of tasks and, afterwards, evaluate the ease of them. Results are presented in the Table 1 where 1 states for *very easy to use* and 5 for *very difficult to use*.

Besides usability tests, functional evaluation has also been conducted. The test were carried out using *Angel Sensor* and have proved that the application satisfies the basic

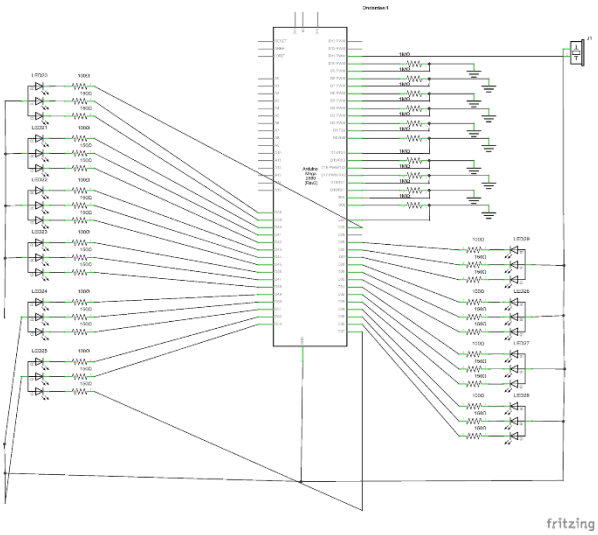

Fig. 2 Electronic circuit of the interactive game

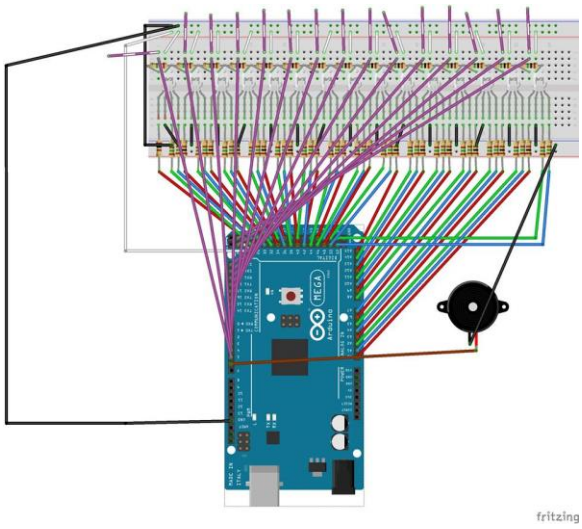

Fig. 3 Prototype of the interactive game

functionalities stated as the requirements. Unfortunately, because of shortage of time, the third evaluation has not been performed yet and should be a part of further development.

D. Feedback and redesign

Each kind of test has brought important information about what should be improved. Based on GUI experts' opinion, structure of the interface has been adjusted. Having conducted the online survey, the outlook of icons was changed to provide better comprehensibility. Real scenario tests gave a number of data about user behavior and reaction while using the application, what has been recorded. Furthermore, the progress of the project was under continuous supervision of Marta Diaz Boladeras and Cristobal Raya who supplied us with their valuable

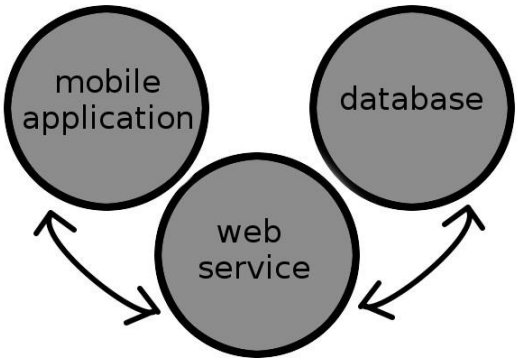

Fig. 4 Architecture of the application

feedback. All those sources of empirical data to validate the system performance were particularly important for development of application that fulfils all the requirements following the *user centered design* methodology.

III. OUTCOMES

A. Application

The application, developed during the progress of the project, is constituted by three separated elements. An architecture of the system is presented in the Fig. 4.

Web service

Web service is an intermediate between the mobile application and the database configured with the system. Thanks to it functionalities like: addition of a new patient, preview of stored patients, addition of a new measurement for a given patient and preview of stored patient's measurements have been provided.
A web service was developed in ASP.net technology using Model-View-Controller approach. Model is a set of classes of a web service that database records are mapped to. Controller is an element that manages database connections and transactions. View is a graphical representation of data- in the project being described in this paper, View part has been adapted as a mobile application. In order to preserve security of processed data, access to the web service might be limited to particular devices with specific IP address or physical address of the device.

Database

Database is an essential element of all systems that enables storing collected information. Among different types of databases, document-based one has been chosen. The main reason for that choice was the fact that this type of storage is more flexible, because it does not require rigid and known in advance scheme unlike table-based ones. Moreover, model of local storage servers has been resigned in favor of cloud

Fig. 5 Outlook of the mobile application

database that according to [3] is more beneficial, especially in terms of saving of money.

GUI

Mobile application is an interface between a nurse and a measuring device. It has been designed in a way that provides required functionalities preserving high flexibility of the system in terms of measuring device being used currently.
As communication media, Wi-Fi and Bluetooth Low Energy have been chosen. While Wi-Fi is widely used protocol of global communication- required to connect to cloud database, Bluetooth Low Energy provides device-independent [4] transmission medium for devices in the proximity (up to 100 meters [5]). But the major reason for choosing this protocol among the others is significantly less energy consumption in comparison to other technologies [6] .
Mobile application consists of eight distinguished views (activities) that supply different functionalities.

LoginActivity is the first one which is presented to a user after starting application. *LoginActivity* has been developed as a security precaution that reduces a thread of unauthorized access to the actual application.
Having singed in, *MainActivity* is being shown to the user.. This one enables the user either to search for a patient or to add a new one.

If the option of addition a new patient has been chosen by the user, *AddPatientActivity* is being displayed which let the user add a new patient, having already input all required patient's data (name, last name, age and security number). Otherwise, if preview of patients has been opted, *AllPatientsActivity* is being displayed. The list of patients is provided in this view. Whereas a desired patient has been elected, *DecisionActivity* is being presented to user to allow him/her either browsing patient's measurements without establishing Bluetooth connection or connecting with a measuring device so as to obtain vital signs' values. Having chosen the first option, an HTTP request is being sent to Web service asking for a list of measurements that would be displayed in *AllMeasurementsActivity*. Otherwise, when obtaining measurements has been opted, *BleConnectionActivity* appears as a realization of measuring device-independent system. Within this view, ability to choose any peripheral measuring device is provided, as long as it satisfies *Bluetooth Low Energy* standards. If a Bluetooth Low Energy peripheral has been elected from a list, *PatientScreenActivity* is being displayed. As a part of this activity, functionalities of requesting for measurements, saving measurements and browsing stored measurements are supplied. Mobile application has been designed in order to assure high usability and functionality. So as to achieve it, a set of usability heuristics suggested by [7] has been applied as well as advices of experts in this field. The sample view of the application is presented in Fig. 5.

B. Interactive game

An interactive game is an essential element that has been designed in order to diminish patient's anxiety by focusing child's attention on the interactive game and to obtain measurements simultaneously.

The game has been developed to fit the needs of the children within the age of three to ten years old. Due to being flexible and having more than one option how to play, it has been decided to create a game rather than to buy one existing game. Also by doing so it might be gained the option to implement some extra measurements in the game, like for example the measuring of a child height during his playing process.
An electronic circuit of the game is presented in the Fig. 2.
A prototype, developed during the progress of the project, it constituted by ten capacitive buttons. Touching each of them: lights respective RGB LED diode with color set in advance, play build-in sound which is also pre-set. There are three 'modes' in the game, the first one is a free play: a child is freely, by own choice, pushing buttons which will light up the button the child pressed and make a sound typical for that button (if sound is turned on).

Fig. 6 Final outlook of the interactive game

The second option is that a child presses a button and it will light up playing a heartbeat sound which is slower or faster depending on the button the child pressed.
The third option is showing the way to a child to play a melody. At the start there will be one led which is on, this is the first note of the melody. If the child presses the button the LED will fade and another will light up, continuing until the melody is done. If the child presses a wrong button sound will be heard but the LED that represents the right note will not turn off. At the end the right melody will be played completely.
In order to adjust the game to a hospital environment, the game provides a button that enables a nurse to turn the sound on or off.

The interactive game has been developed using Arduino Mega 2560 micro-controller. An outlook of the electronic prototype is presented in the Fig. 3.

Besides electronic prototype, final three- dimensional appearance of the game has been designed in CAD-based application. The design is presented in the Fig. 6.

IV. DISCUSSION

A. Conclusions

Three elements have been developed as deliverables: the conceptual design of the interactive game, the electronic prototype of the interactive game and the complete mobile application together with the web service, database and the graphical user interface. The design of the application has been adjusted according to the data collected with an online

survey to target users, the inspection of two experts on interaction and interface development, and the tests with users.

The application has been tested for retrieving pulse value from Bluetooth Low Energy peripheral called *Angel Sensor*. While application usability has been proven, *Angel Sensor* has been indicated as a not recommended measuring device.
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B. Recommendations

Because of the limitation of time, several issues have not been achieved. As a next step of the project, tests for the actual anxiety reduction should be performed so as to evaluate final usability of the whole system. Also test evaluating GUI usability should be performed repeatedly in order to examine improvement of interface readability. Moreover, several types of measuring devices should be examined in order to indicate a set of the most sure and suitable measuring peripherals.

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