Play for Health 2.0: Evolving P4H to a Web Environment Using HTML5 and JavaScript

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***Abstract*— Play for Health (P4H) is a telemedicine service consisting of a telerehabilitation platform to improve cognitive and physical deficits through the use of "serious games" and various videogames controllers. P4H is based on a client-server architecture. Its client-side application was developed in C++ using Ogre3D graphic engine and runs on GNU/Linux. The use of these technologies posed some hardware and software restrictions that were a threat to the continuity of the platform. The birth of HTML5 meant a revolution in the way of creating web applications due to its suitability to develop dynamic and multi-platform applications. The incorporation of HTML5 and JavaScript to P4H supposed a new client-side application that takes advantage of HTML5 features to overcome the limitations and functionalities that P4H had at that moment.**

Keywords - Telerehabilitation; serious gaming; videogame controllers; HTML5; JavaScript.

I. INTRODUCTION

Play for Health (P4H) is an integrated telerehabilitation system offering motor and cognitive training through serious games and multiple interaction devices [1]. P4H was presented at this congress in 2011. It is designed to be deployed at home or in clinical centers, and its philosophy is to rely on commonly available commercial off-the shelf videogame interaction devices (e.g., Kinect, WiiMote, dance mats).

P4H is based on a client-server architecture consisting of a distributed application structure that partitions workload among a provider of the service, called server, and the requesters of this service, called clients. P4H server is remotely accessed by clinicians through a web browser to program customized therapies for patients, assess their progress and adjust training parameters according to the evolution of each patient. P4H client is the application used by the patients to perform their therapies in an easy and intuitive way. The client manages therapies, captures different parameters during the execution of the exercises and sends them to the server.

Before its evolution, P4H client was a standalone application developed with the compiled object-oriented C++ programming language, and used the scene-oriented graphic rendering engine Ogre3D [2]. This standalone application only ran on computers with GNU/Linux Kubuntu distribution installed and presented important limitations.

P4H is a continuously evolving technology and its functionality is constantly being increased in order to cover a wider range of pathologies. Technological advances that allow to reduce deployment costs, to overcome limitations or to help the clinicians in making their decisions are incorporated to P4H.

HTML5 [3] is the fifth revision of the HTML markup language used for structuring and presenting content for the World Wide Web (WWW) and it is a core technology of the Internet. Its emergence has revolutionized web development due to its new tools and capabilities for creating dynamic web applications.

JavaScript [4] is an interpreted computer programming language that is directly executed on a computer without being previously compiled. JavaScript can be inserted into HTML pages and can be executed by all modern web browsers. JavaScript capabilities allow to interact with users, control the browser, communicate asynchronously with a server and alter the document content displayed.

The combination of HTML5 and JavaScript allows creating powerful multi-platform web applications, capable to run in a browser regardless of the hardware and software on the computer where they are executed. The incorporation of these technologies to P4H resulted on P4H 2.0. This is an evolution of P4H which maintains and expands its functionalities and solves many of its limitations.

In this document, P4H is described with special emphasis on the limitations of the client application that jeopardize their survival. Next, P4H 2.0 is presented and how the

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inclusion of HTML5 and JavaScript on the client overcame these limitations. Finally, the conclusion and future work are presented.

II. P4H: STANDALONE MODE

P4H development started in January 2009 under the framework of the strategy designed by Fundació iBit (former name for Fundació Bit) to carry out health processes in the context of rehabilitation using an open and scalable platform based on ICTs.

As a result, it was obtained a client-server telerehabilitation system that provides the services and resources needed to carry out at-home personalized rehabilitation programs, their adaptation to patient's evolution, and their supervision by the therapeutic team.

The client application is a standalone C++ compiled program with an architecture based on plugins in order to be easily extensible to new games and interaction devices. The communication among these plugins is done across a message-oriented bus. The main components of this application are:

- Core: Responsible for managing the essential procedures of the system and organizing the execution of plugins through services.
- Content plugins: They implement multimedia videogames developed jointly by clinical and technical partners, following the "Serious Gaming" [5] philosophy to work on the cognitive component of the rehabilitation process and on patient motivation. Fig. 1 shows a screenshot of one of the videogames included in this client. It consists of doing a puzzle selecting the pieces with the movement of a limb.
- Interaction Method plugins: They allow the patients to interact with the videogames and to work on the physical component of the rehabilitation process.

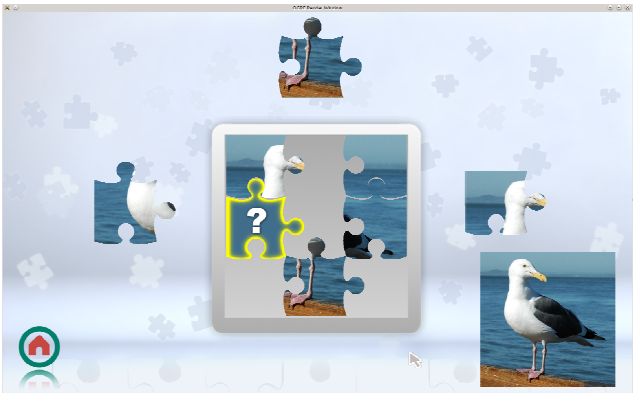

Figure 1. Puzzle videogame's screenshot

The P4H platform also provides a SDK (Software Development Kit), which includes an API (Application Program Interface) for the development of new plugins.

So far, P4H was evaluated in Hospital Son Llàtzer in Mallorca (Spain) [6]. It is also used as a technological base for the exergaming system developed in the project CuPiD (Closed-loop system for personalized and at-home rehabilitation of people with Parkinson's disease) financed by European Union - Seventh Framework Programme [7]. And, for more than 2 years, it has been used in several health centers in Mallorca by more than 100 patients with different pathologies among which stand out Stroke (53 patients), Parkinson Disease (11 patients) and Multiple Sclerosis (9 patients).

With P4H, the intended goal was achieved and it was obtained a low-cost open telerehabilitation system based on the use of videogames, fully developed using open-source software, and capable of interacting with most popular videogame devices.

Despite the good acceptance by the patients and the clinicians, the client application of P4H has some technical limitations that make it difficult to maintain and expand the whole platform:

A. *Dependence on Linux community*

It was decided to work with a stable and widely used Linux distribution, which was easy-to-use and familiar to Microsoft Windows users. Kubuntu, from Canonical Ltd [8], was the distribution that best fitted the project's requirements.

The release every 6 months of a new Kubuntu version became a handicap. It forced us to periodically upgrade the client application, in order to prevent it to become obsolete and keep the system compatible with new hardware products. Every upgrade has required to:

- Upgrade Ogre 3D graphic engine.
- Update dependences with external code libraries.
- Update scripts and internal code.
- Recompile code libraries and troubleshooting.

Kubuntu 12.04 LTS version, with 5 years of support and security updates, is the operating system currently used in order to minimize the impact of these upgrades.

Besides, using code developed by the GNU/Linux community allowed us to reduce the development times, but it increased the time and resources we had to spend correcting errors and adapting that code to the project's needs. These efforts were even greater when we had to update these libraries, replace them because their project was canceled, or upgrade the operating system.

B. *High dependence on hardware*

Ogre3D is a software framework which offers tools that help the developers in tasks such as design, development and representation of videogames providing services as 2D and 3D rendering, sound, artificial intelligence or scenes management, among others. Using this engine has been a key factor to the development of P4H, while it also limited it with its hardware restrictions.

Ogre3D requires a dedicated graphic card NVIDIA Geforce 2, 4 or higher; or an ATI Radeon 7500, 9600 or higher. The lack of manufacturer drivers compatible with the operating system used to run the client application forced us to use non-official drivers. These drivers were sometimes difficult to install, and they turned out not to be fully

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compatible with the graphic cards used, or, sometimes, they did not achieve the required performance from the cards.

Because of that, as well as hardware evolution and the appearance of new technologies (i.e., NVIDIA® Optimus™ for laptops), it was necessary to invest a considerable amount of resources to adapt P4H to these technologies.

Besides, that situation got worse because of the lack of ATI Radeon drivers for Kubuntu 12.04.

Therefore, the range of computers compatible with P4H was severely reduced. That often means an increase of the deployment costs because of the purchase of new computers by the patients.

C. Use of compiled code

When it came to plan and design P4H, compiled programming languages were the ones that best suited the project's requirements. The choice of C++ was determined by Ogre3D engine requirements.

Although the development of P4H would not have been possible without using a compiled language, during the last years, some limitations became evident.

C++ programming language has a slow learning curve, which makes it difficult for new programmers to join the development team.

Once the application is developed, or a new featured is added to it, the debugging, correction, and improvement process is not flexible, and it is time consuming, because of the code complexity and the need of recompiling and reinstalling the application every time.

To make the installation and updating processes faster and more flexible, it was necessary to implement a Debian packages repository. This way, these processes became faster and simpler, and it made it possible to remotely control them. However, the installation and the update of the application can still be too complex for some users, especially when it comes to the installation in patients' homes.

All these technical limitations represent significant costs of development and maintenance that make the system not competitive, and they hinder its growth potential. After analyzing and comparing the costs of continuing with the current client application or shifting to a web environment, we concluded it was more efficient and economical, at medium and long term, to change the technology used in the client application and invest efforts in the development of a new client.

III. P4H 2.0: WEB MODE

P4H 2.0 has been developed throughout year 2013 with the aim of overcoming the limitations of P4H, and making it evolve to a more competitive and transferable system. In particular, they have been pursued the following goals:

- Lower down the deployment costs: In P4H, these costs went from 1500€ to 2000€ per kit depending on the plugins it had to include. Most of the investing was due to the purchase of a TV screen and a computer that met all the hardware requirements. On the other hand, P4H 2.0 runs on a web browser independently of the hardware. This makes the access easier to a greater number of users, and it reduces installation costs, because it can run on patient's own computer.
- Increase the number of pathologies treated: This depends on the number of videogames and interaction methods available in the platform. As mentioned before, in P4H the development of a new videogame or a new interaction method plugin was a tough and resource consuming task. In P4H 2.0, they are used programming and support tools with much less complexity.
- Improve usability: In global terms, the usability of P4H was good and well accepted by a large number of users. However, the installation and updating processes on the client application had some technical difficulties that required a technician to be carried out. On the other hand, P4H 2.0 only needs a web browser.

From a technical point of view, P4H 2.0 keeps the server-side application to manage patients and therapies as well as the plugin-based architecture in the client application to carry out the therapy as in P4H.

Thus, the main difference between both modes is the technology used in the client application. P4H 2.0, instead of a compiled programming language and Ogre3D engine, has been developed using a scripting language such as JavaScript and Cocos2d-HTML5 engine [9].

Cocos2d-HTML5 is the HTML5 version of Cocos2d-x engine [10]. The main reasons to use this engine were:

- It uses JavaScript, HTML5 and Cascading Style Sheets (CSS). This speeds up the development of web applications and eases its maintenance. The use of these technologies allows developing multiplatform applications that only require a compatible web browser.
- It is an active project, well documented and with a wide community of users.
- It is open source under MIT License [11].

A. Content plugins

Resulting of the experience acquired with P4H and the analysis carried out with the medical team, the following videogames classification was established for P4H 2.0:

1) Sequencing: These are games in which the patient has to plan and execute a sequence of tasks to reach a goal. For instance, doing constructions or daily living activities.

2) Memory: In memory games, the patient has to remember sequences of images, sounds or elements positions in order to achieve a goal. For instance, pairing images or repeating a melody.

3) Attention: In these games, the patient has to choose certain elements on the screen according to a selection criterion. For instance, choosing elements depending on their morphology or applying interferences as Stroop effect.

4) Puzzles: When playing these games, the patient has to build a figure by correctly combining their pieces in which it has been split.

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At the moment of writing this paper, 2 videogames have already been developed according to this classification:

- Images: It consists in finding pairs in a board of cards. Fig. 2 shows a game's screenshot with some pairs already matched.
- Colours: It consists in touching objects in a scenario depending on certain selection criteria. Fig. 3 shows a game's screenshot in Go/No-go game mode where the user has to touch the green spots.

Figure 2. Images videogame's screenshot

Figure 3. Colurs videogame's screenshot

Although each videogame has its own gameplay, they have some points in common:

- Difficulty-level-based configuration: Each level consists of a set of parameters with pre-established values. They reduce the amount of time needed to program the therapies, and they allow implementing an automatic level change. Levels have been set after analyzing patients performing the games.
- Reward-based system: These rewards are given to the patient, as he achieves certain goals related to speed, skill or fidelity. The aim of this reward system is to encourage patient's motivation and adhesion to the system
- Parameter recording: During the execution of the therapy activities, a lot of data relating to times, successes, and errors is collected. This data is processed at the client application and sent to the server where it will be stored and delivered to the clinicians in the form of charts.

JavaScript Object Notation (JSON) is used to store the configuration values for the difficulty levels and rewards, as well as to store the recorded parameters and exchange this data with the server.

B. Interaction Method plugins

The key feature of P4H was its capability to integrate and combine different interaction methods and videogames. This allowed for working with the therapies cognitive and physic components independently. Keeping this feature in P4H 2.0 has been a fundamental requisite.

3 different interaction methods have been developed:

- Kinect: For body movements and postures detection using the Microsoft XBox console 3D camera.
- Dance pad: For lower limbs movement detection by detecting the pressure made on the sensitive areas of a dance mat.
- Mouse: For fine movement detection of the upper limbs using a computer mouse.

The main technical difficulty found in P4H 2.0 was the integration of these devices with the videogames that run on a web browser. Especially in the case of the Kinect camera.

To integrate the Kinect camera to the client application, the Zigfu Development Kit (ZDK) [12] has been used to develop the plugin which accesses to OpenNI API [13] through JavaScript calls.

OpenNI (Open Natural Interaction) is an open source framework that provides APIs to develop applications that interacts with the user in a natural way. This framework makes it easier to communicate with devices sensors, such as those of Kinect or ASUS Xtion, and the perception middleware in charge of analyzing and understanding the data collected from the scene through the use of computer vision algorithms.

At low level, all interaction methods must work with native code to be able to communicate with the videogames controllers. This implies the installation of a driver for each of the interaction methods, and it is the only connection between P4H 2.0 and the operating system which it is running on. Drivers for all the developed interaction methods are available for Microsoft Windows 7 or higher.

IV. CONCLUSION AND FUTURE WORK

The main result of this work is an HTML5, CSS and JavaScript application that allows patients to carry out their rehabilitation therapies at home playing videogames on a web browser using different interaction methods.

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Compared to P4H, P4H 2.0 achieved the following goals:

- Make the client application independent of the hardware on which it runs. This has significantly reduced the compatibility restriction of P4H, which implies a considerable decrease of the installation costs and allows more patients to use the application with the computer they already had at home. In these cases the cost of acquisition of the system has been reduced to the cost of the videogame controllers used.
- Open the platform to other operating systems. The execution of the therapies on a web browser makes the application independent of the operating system. This means that we can reach a larger number of users, and that the portability costs to other operating systems are eliminated.
- Simplify videogames and interaction methods development and maintenance. This means a considerable decrease of implementation costs and response times to incidences and modifications.
- Eliminate installation and update processes for the client application. Now the updates are made on the server, and patients only need to access it through their browsers. The only installation the user needs to carry out is the installation of the interaction methods drivers. This installation process is very simple, and it is done once and through a setup assistant. Thus, the installation and update costs have been reduced because it is not required a technician to carry it out at patients homes.

Even though P4H 2.0 is completely developed and operative, it is planned to increase its added value with new games and interaction methods.

At the moment, it is been developed a plan to deploy the system in some health centers of ib-Salut (Public Health Service of the Balearic Islands) as a previous step before its deployment at patients' homes.

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REFERENCES

[1] F. Tous et al., "Play for Health: Videogame Platform for Motor and Cognitive Telerehabilitation of Patients," The Third International Conference on eHealth, Telemedicine and Social Medicine (eTELEMED 2011), IARIA, Feb. 2011, pp 59-63.

[2] http://www.ogre3d.org/ 10.03.2014

[3] http://www.w3.org/html/wg/drafts/html/master/ 08.11.2013

[4] https://developer.mozilla.org/en-US/docs/Web/JavaScript/ 22.01.2014

[5] M. Zyda, "From Visual Simulation to Virtual Reality to Games," Computer, vol. 38, no. 9, Sept. 2005, pp. 25-32, doi:10.1109/MC.2005.297.

[6] M. A. Farreny et al., "Play for Health (P4H): a new tool for telerehabilitation," Rehabilitación, vol. 46, no. 2, Apr. 2012, pp. 135-140, doi: 10.1016/j.rh.2012.01.001.

[7] F. Tous et al., "Incorporating Rehabilitation of Parkinson's in the P4H Platform using a BAN," XIII Mediterranean Conference on Medical and Biological Engineering and Computing (MEDICON 2013), IFMBE Proceedings, vol. 41, 2014, pp. 1481-84, 10.1007/978-3-319-00846-2_366.

[8] http://www.canonical.com/ 10.03.2014

[9] http://www.cocos2d-x.org/wiki/Cocos2d-html5 08.11.2013

[10] http://www.cocos2d-x.org/ 08.11.2013

[11] http://opensource.org/licenses/MIT 15.01.2014

[12] http://zigfu.com/en/zdk/overview/ 08.11.2013

[13] http://www.openni.org/ 08.11.2013

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