Available online at www.sciencedirect.com

ScienceDirect

Procedia Computer Science 00 (2015) 000–000

Procedia Computer Science

www.elsevier.com/locate/procedia

Conference on Health and Social Care Information Systems and Technologies, HCist 2015
October 7-9, 2015

Web Platform for Serious Games Management

Tiago Martins[a]*, Vitor Carvalho[a,b], Filomena Soares[a]

[a]*Algoritmi Research Centre,University of Minho, Campus de Azurém, 4804-533, Guimarães, Portugal*
[b]*IPCA-EST, Campus of IPCA, 4750-810, Barcelos, Portugal*

Abstract

An expected increase in the number of older people with mobility problems will bring more concerns to the health professionals. One way to help both, professionals and patients, can be found in the development of serious games oriented to motor rehabilitation in physical therapy sessions. Optimization of game management, collection and processing of information, which are the health professional responsibility, can be achieved with the integration of a Back Office system in the game. Therefore, this article aims to present a modular system of Back Office, for centralized management of one or more games targeted for physical therapy.

Peer-review under responsibility of SciKA - Association for Promotion and Dissemination of Scientific Knowledge.

Keywords: Serious games; physical therapy; modular system; centralized management; Back Office.

1. Introduction

Several studies have shown that serious games have enormous potential in health intervention, including rehabilitation and physiotherapy. The pleasant atmosphere they create and the feedback forms which usually they include, promote the interests of patients, who are increasingly motivated and involved in their rehabilitation[1].

If the game itself is sufficient for patients to carry out the proposed activity, it may not be for health professionals. In fact, they have to make the management of the game, with regard to the profiles of players/patients, to the physical therapy programs, namely the proposed exercises, to the state of the disease, to its evolution, among others. It is in this information that the Back Office management becomes an important tool.

The original concept of Back Office has developed so fast that it can only be considered as the starting point to

* Corresponding author. Tel.: +351253510180
E-mail address: tiago.rodrigues@algoritmi.uminho.pt

Peer-review under responsibility of SciKA - Association for Promotion and Dissemination of Scientific Knowledge.

another concept, either in regard to operational efficiency, process automation, autonomy of the responsible for performing individual settings or even, regarding to the application areas[2,3]. And with the development of information technologies in recent decades, one of the areas that have benefited the huge potential of the Back Office was Informatics. Therefore, considering this area is defined Back Office as the set of features that, although part of a system, can not be accessed by all users. Everything in the system that is visible for all the users is called the Front Office. So we can say that the functions of Back Office of a system allow to authenticated users to manage their Front Office[3].

Demographic trends, whether in developed countries or even in Third World countries, point to a sharp increase in the number of elderly people, many of them will have motor problems. However, we will assist to a decrease of the active population. These facts will contribute, of course, to a relative decrease in the number of physical therapy professionals, so it will be necessary to equip them with technologies that can help in the difficult task of extending the independence of older people and improve their quality of life[4].

Given the facility and the flexibility that currently the Back Office offers the user to manage any system, it is imperative that it is one component of that system[3].

Following this trend, the aim of this paper is to present a modular solution of a Back Office that supports one or more games targeted to physical therapy, developed by this research team, allowing the management of the patients (players), of the staff, of the health units, and of the games themselves.

This article is structured as follows: Section 2 presents the State of the Art, Section 3 the Idea and Model Proposal, Section 4 the Back Office Design, Section 5 the Data Base, Section 6 the Users hierarchy and Privileges, Section 7 the Main Back Office Functions and Features, Section 8 the Messages and Alerts and finally, Section 9 the Conclusions.

2. State of the Art

Despite an extensive literature review, few serious games targeted for physical therapy and with Back Office systems integrated were found. Therefore, we opted for the presentation of serious games and applications that integrate them, regardless of the health sector. The StrokeBack is a telemedicine project using a virtual reality scenario aimed to rehabilitation, in home environment of patients who suffered a stroke. This design is complemented with a system in line of Health Personal Storage of each patient. An integrated solution of Back Office allows healthcare professionals to access the data of each patient, enabling them the constant monitoring of their health state and the development of rehabilitation[5].

The system Nu!RehaVR is another rehabilitation screen technology, based on Virtual Reality (VR), used in patients who have traumatic brain injury or who have suffered a stroke and, therefore, require long periods of rehabilitation. With this system, they feel encouraged to perform exercises increasingly difficult and complex, confident in the recovery of their autonomy and optimization of their quality of life. The Nu! RehaVR integrates three distinct environments, one of them the Back Office, to which the therapist can choose the available exercises, proposed by the doctor, which are that are adequate to each patient[6].

In her doctoral thesis, Artemisa Dores presents the development, the implementation and the evaluation of the Computer-Assisted Rehabilitation Program – Virtual Reality (CARP-VR). This is a program composed by environments that are simulations of real-life contexts in which patients will perform diverse activities based on daily situations. To address the patient mobility issues, various training stations are located in different medical institutions. The architecture of this system includes a centralized Back Office, enabling to perform synchronized remote updates and setting of the training stations. It also keeps updated the results obtained by each participant in each training session. With these data, the therapist can evaluate the patient's condition and his/her evolution, which allows him/her to define the appropriate training program.

For rehabilitation, Sarathkumar and Sawal recommend a wireless sensor network, which is a low cost and user-friendly system. The data collected in motion corresponding to the acceleration and angular velocity at which the patient moves his/her limbs, are stored in a database. One of the system components is the Back Office, which allows health professionals to obtain information enabling them to check the physical performance of the patients and thus they can define the most appropriate therapies[8].

Sheep herding, Labyrinth, Letter Tracing and Writing are four games embedded in an interactive application used to support, in a motivating and fun way, rehabilitation of writing skills in people suffering from paralysis after stroke.

The Back Office of the application allows therapists to adjust various sets of parameters, for example, the difficulty level of the game, and to adapt the exercises to the needs and interests of patients[9].

Gerd Lanfermann and Richard Daniel Willemann registered the patent for a system and the method for rehabilitation or physical therapy of patients with neuromotor disorders such as a stroke. This invention consists of a camera system that records the patient exercises and an interactive system that gives the user instructions to start or stop a given exercise. The Back Office offers an easy solution for the therapist to observe the video-recording of the full exercise and further evaluate the patient's performance[10].

Mercury is a platform that allows a wide range of clinical applications to be inserted in a wireless sensor network, for the acquisition and processing of high-resolution signals. One of these applications enables the monitoring of patients with Parkinson's disease and another allows detecting epileptic seizures. The sensor data are released in the Back Office, to be processed later[11].

3. Model Proposal

Following investigations that the team has been doing in the area of serious games targeted for physical therapy and, consequently, in the arduous and time-consuming task of creating back office systems for each one of the developed games, it was necessary the creation of a generic and integrated system which would make the management of the information, in a single remote platform, supported by a centralized database. So we can have several games, several health units, with their team and patients to work directly and in an organized way in a single system (Fig. 1).

Since it was intended a modular solution to ensure that it would possible to add, at any time, the management of new games, new features, updates, among others, a solution based on a web platform was designed.

The fact that the database and the Back Office system are located on a remote server allows the users to access the application, anywhere and anytime, through an Internet connection. On the other hand, it makes it more centralized, both in terms of research and the management of the information.

In a conventional system of local information management, researchers are required to go to the health units and to collect the information stored in databases. However, working in a remote environment, researchers, access at any time to the information and they can filter and treat it immediately. But at this level of physical distance, there are other types of problems such as: installing new games, bug fixes, updates to the application, adding new modules, among others. In these cases, the research team can perform these actions remotely, since the platform is unique for all health units.

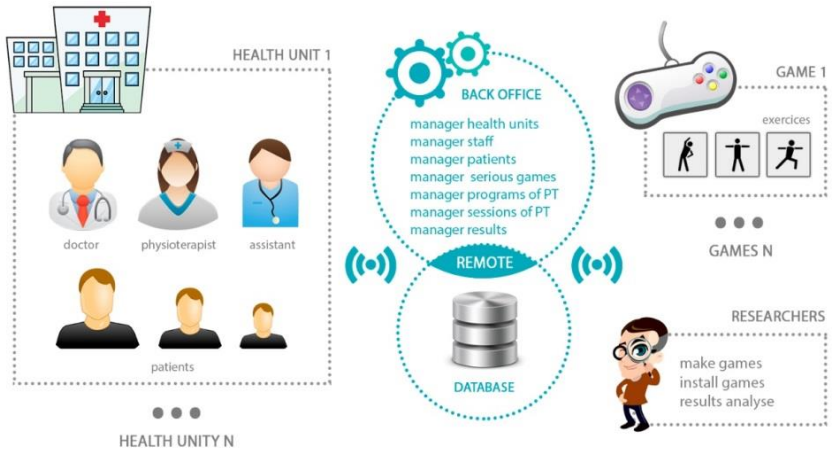

Fig. 1. Generic system architecture.

Based on this idea, it was built up what would be an ideal model for the Back Office, which should take into account some basic principles of safety, integrity, stability and reliability.

The Back Office is divided into five main areas: health units' management, staff management, patient management (players), games management and statistics. All these areas are governed by a user's privileges hierarchy (administrators, doctors, physical therapists, assistants and others), with specific limitations for each one of them.

In addition to the management functions, the Back Office is multilingual and its users can opt between English or Portuguese.

Although the final model of the application is more complex than that shown in Figure 2, this represents the application behavior in a three-dimensional situation (doctor, physical therapist and patient), whose goal is to create a physical therapy program based on the use of a serious game. In this case, the doctor logs in the Back Office, creates a patient profile (player) as well as his/her physical therapy program, indicating the professionals responsible for him/her (physiotherapists and respective assistants). In the field, the physical therapist logs in the game, chooses the player and his/her physical therapy program is loaded to the player start playing. The core of this architecture is the database that stores all the generated information, and the Back Office is the administrator of that information. The game makes use of that information to load the programs of the players and send all the results to the database, which can be seen by the doctor or by those who are responsible for the patient, in the Back Office.

4. Back Office Design

As already mentioned in the previous sections, it was decided to build a Back Office based on a web page. As the web design is a multidisciplinary field, it has become essential to consider various technical aspects such as programming, graphic design, information architecture, usability, among other issues.

When developing a web page, it should be taken into account the warnings of the World Wide Web Consortium (W3C), which is the body responsible for recommending development standards for the Internet (web standards). Nowadays, with the diversity of devices (computers, smart television, smart phones, and tablets, among others) that allow access to the Internet, it becomes imperative to use these standards in order to ensure that the solution is fully functional in most browsers. These W3C recommendations were followed by the research team to avoid compatibility problems with formatting in the future.

In the programming area were used various languages for different purposes. At the level of aesthetic and structural construction was used the HTML5 program together with CSS3 for setting styles. For interpreted programming, executed by the browser, it was used JavaScript with various frameworks based on jQuery. In what concerns to the server-side language, we chose to use PHP5, together with SQL to access to databases. The used languages are currently the most widely used because of reliability, safety and integrity, when programmed in accordance with the guidelines and recommended standards.

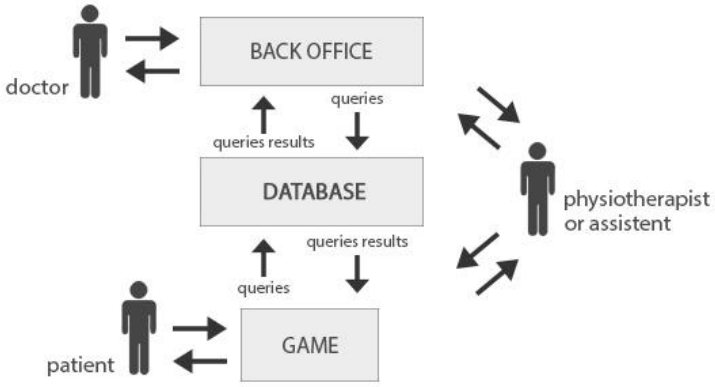

Fig. 2. System behavior in a three-dimensional model.

Another major advantage in the use of the presented technological solutions is the fact they can run under free software such as Linux (operating system) and the LAMP, which is a solution that incorporates the Apache (web

server), PHP (programming language) and MySQL (database software) that allow to run high availability and high performance web applications.

In the graphic design field we opted for a minimalist style, with elements (menus, tables, icons, images, among others) simple and clear, most of them created through Cascading Style Sheets (CSS). One of the application's goals was to make it neutral, without using the design of a specific game, in order to support several types of games with different designs. The chosen colors for both the graphics and for printing are between the gray and blue, opting for a sans serif font type, which is the most used in this type of application.

The research team had to take into account the architecture of the information that is the way how it is treated and presented to the end user.

The usability which can be defined in five dimensions (learning, efficiency, memory, strength and satisfaction) may be the "success key" of an application. If the user does not feel comfortable in using a particular application, he/she tends to give up easily. That said, we considered some guidelines for the organization of the contents in Back-Office. First, it was considered the importance of creating a responsive layout, adaptable to the different target devices (computers, smartphones and tablets), in order to promote an appropriate usability to their size and shape. Second, it was necessary to idealize the organization of information structure. The main functions are accessible through a side menu on the left, always available from any part of the application. Next to the main menus, submenus can be opened containing the main functions of the former. Navigation is rather intuitive and fluid, based on the logical structure of various applications that are on the market and have been tested, such as Facebook (user search, user profiles, messaging between users, alerts boxes, among others) (Fig. 3).

5. Database

As we have already seen, the database plays a central role of the system, that is responsible for storing all the information generated in the Back Office and in the own games.

To ensure safety, reliability, availability and integrity of the database, we opted for the most currently used model, the relational, based on the concept of relationships where a relationship is a table of values.

The Back Office data structure has been normalized to allow an efficient storage, a reduction in its redundancy and an efficient access to the stored data.

The Entity Relationship Diagram (E-R) of the database is shown in Figure 4.

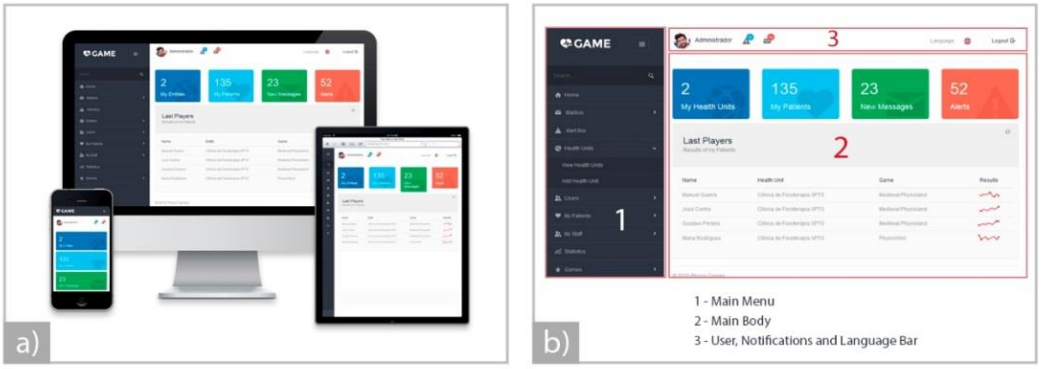

Fig. 3. a) Web application with responsive layout; b) Main areas of application.

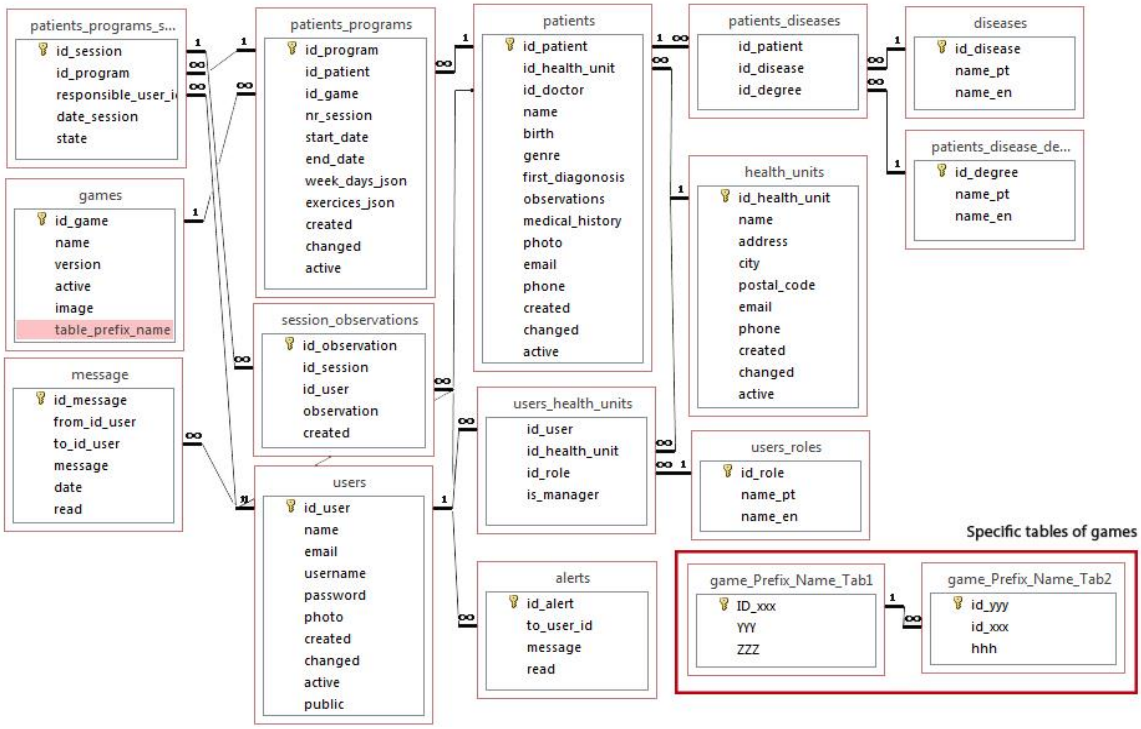

Fig. 4. Diagram E-R of the Back Office database.

6. Users and Privileges Hierarchy

The Back Office contains several areas that are subject to a hierarchy of users. To understand the hierarchy of the user privileges, these are divided into five distinct classes: administrators, doctors, physiotherapists, physiotherapy assistants and others.

Administrators are usually the research team users and they can access all sections of the Back Office. They can install new modules of the games, add health units and access to global and specific statistics of the use of the games and of Back Office itself.

In the Back Office, doctors are responsible for creating the profiles of their patients, as well as their physical therapy programs based on serious games, delegating responsible people (physical therapists and assistants) for monitoring those, in the field. They can carry out these tasks and edit the information at any time.

Physical therapists are responsible for complying, together with their patients, physical therapy programs created by the doctor that delegated them to do so. During the execution of a physical therapy program they can enter the Back Office, choose the physical therapy session for a particular patient and write additional information that can be found in future. Physical therapy assistants can only navigate through the areas common to all users.

The class "others" may be associated, for example, to a health unit director and it is only relevant if he/she has a secondary class "manager".

The administrator is a secondary class that supplements the primary (doctor, physiotherapist, or other), which allows the user to manage the staff (team) of his/her health unit and he/she can add to it, for example, doctors, physical therapists, assistants or even new managers.

Figure 5 shows a flow chart with the structure of all sections of the Back Office and the respective restricted areas.

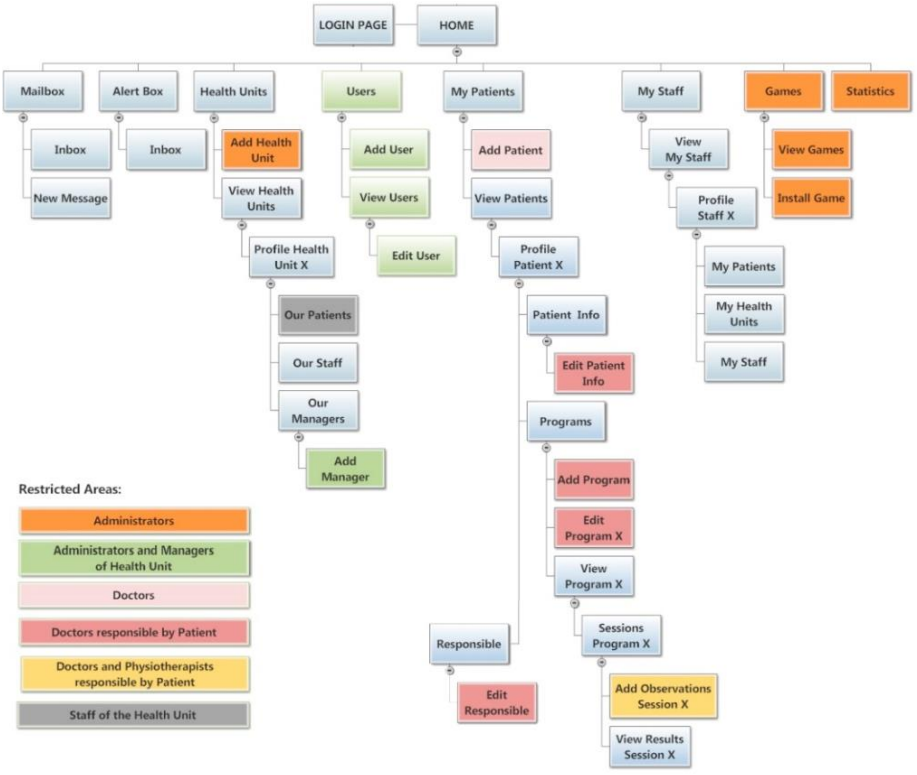

Fig. 5. Organization chart of the various sections of the Back Office.

7. Main Functions and Features of the Back Office

When we access the Back Office, a login page appears. Each user must enter his/her user name and password and choose the language he/she wants. After this authentication, the user is redirected to the main page of the Back Office, a dashboard that presents some notifications, such as new alerts, new messages, and results of the last players, among others. On the side (always present) displays the menu with the main sections (it varies according to the user hierarchy level). At the top, also always present, is an alerts and messages notification bar, a language selector, a user menu and the "Log Off" option.

Before any other task, the administrator must install the games that will be the basis for the physical therapy programs based on the use of serious games. In fact, these games are installed on the computers of health units, but with regard to their interconnection with this Back Office system, the installation of modules of game management is required, in the Back Office itself (Fig. 6).

The administrator can install the modules of a game, which are contained within a ZIP file. For that simply access the submenu "Install Game", of the "Games" menu, select the file that contains the modules of a game created specifically for use with the Back Office and click "Install". When the process is complete, the new game is available to be used in the section of physiotherapy programs.

The modules of the games contain information specific to each game, such as exercises, difficulty levels among other parameters. They also contain scripts that create tables in the database, to keep the results and game parameters as well as they provide the pages that serve as a basis for consultation and management of the results obtained with the use of games. Thus, the Back Office can manage various games, regardless of the structure of each one, being enough for that, installing the respective modules.

Administrators are the only users that can make the management of the modules of games, from their installation to their removal.

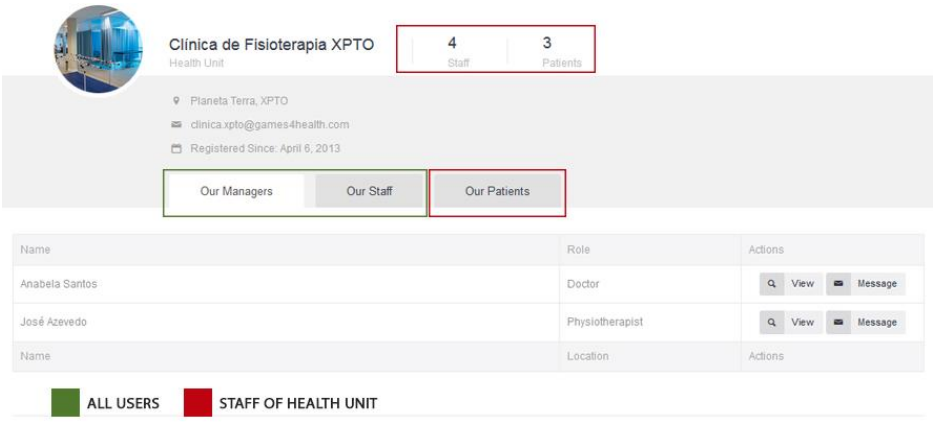

Fig. 6. Example of a profile of a health unit.

When there is still no health unit, the administrator is responsible for adding it by entering the submenu "Add Health Unit", in the menu "Health Units". Then, a form must be filled with all the health unit information such as name, address, phone, email, among other relevant information. After the creation of the health unit, it is required to add a user "manager" of that health unit.

From here, the administrator or the new manager of the created health unit can edit its information, add staff and also new managers, but only the administrators can delete a health unit.

As previously mentioned, only administrators and managers of a health unit can add new users (staff of a health unit). A user can be associated with various health units, with the same position or different positions in each of them. Only administrators can add new users with the role of administrator. To add a user, simply enter the submenu "Add User", of the "Users" menu, and fill in the user profile (name, health unit, job title, among others.) (Fig. 7).

Patient profiles are accessible only to the staff of their health unit and options such as delete or edit are only available to their doctors.

After creating a patient profile, the doctor responsible for him can create physical therapy programs based on serious games developed by the research team. For that it is enough to access the patient's profile, enter the tab "Programs" and click "Add New Program". The creation of physical therapy programs page has a form where the doctor chooses the game and the respective physical therapy exercises he/she wants the patient to perform, sets the number of sessions, the start and the end date (forecast) of the program and chooses the days of the week where the patient must play.

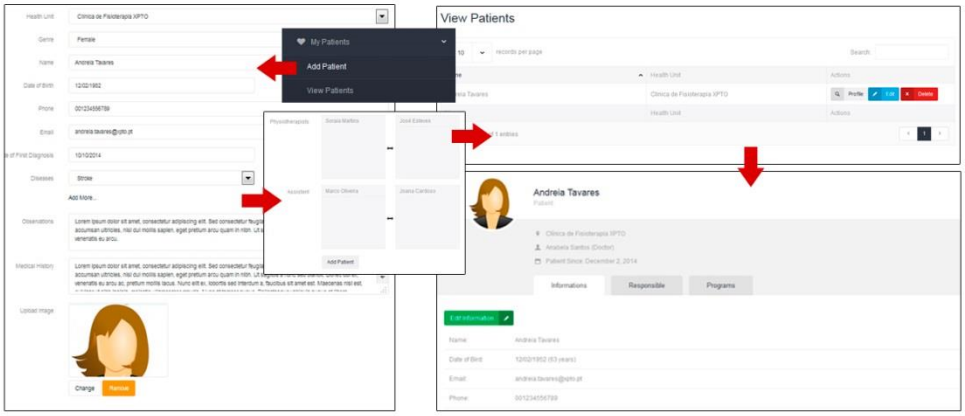

Fig. 7. Creation process of a patient profile.

Only physicians responsible for the patient can edit or delete a physical therapy program, however, physical therapists and assistants can consult it.

All sessions of physiotherapy of a given patient are recorded in his/her current physical therapy program and the results will be available to all the responsible for this patient. Physical therapists and doctors of the patient can also insert comments in a particular session.

The display pages of the results are specific to each game, since each of them has specific objectives. Doctors, physiotherapists and assistants can consult the individual results of each session or of all sessions already carried out (Fig. 8).

The general statistics of the application are available only to administrators and allow having an overview of the use of the Back Office and installed games. The administrator needs to access the menu "Statistics" and a variety of graphics, with results of the application use, such as: number of daily, monthly, annual accesses; number of new users registrations, patients, health units, among others, are presented. With regard to games, there is also an analysis of the number of players per month, by gender, by compliance or not of a physical therapy program, among others (Fig. 9).

8. Messages and Alerts

The exchange of messages between the staff members of a health unit and even among elements of another unit may become interesting in the sense of knowledge sharing, solutions and results, attention calls and team spirit.

Alerts are messages that the system sends to the users and to the patients themselves. Several alerts are scheduled to be sent automatically to doctors and physical therapists, such as: absences from sessions; performance report; weekly progress of patients; end of physical therapy program, and other relevant alerts.

If patients wish, they can receive an email or a phone alert for scheduled physical therapy sessions, as well as for their absences and their weekly results.

The notification bar, always present in the top of the page, indicates to the users, the number of new alerts and new messages they have; they can access them directly as well as to the previous five messages.

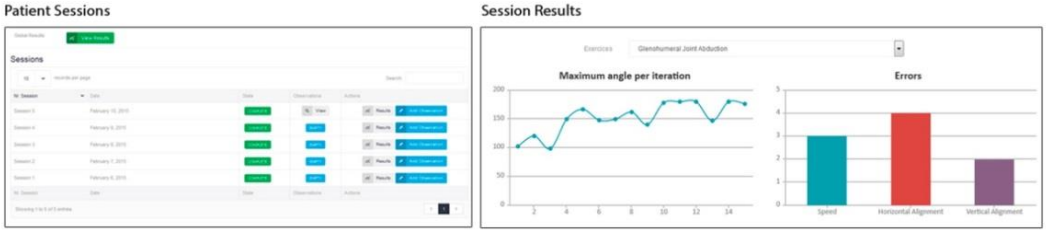

Fig. 8. Specific results of a physical therapy session.

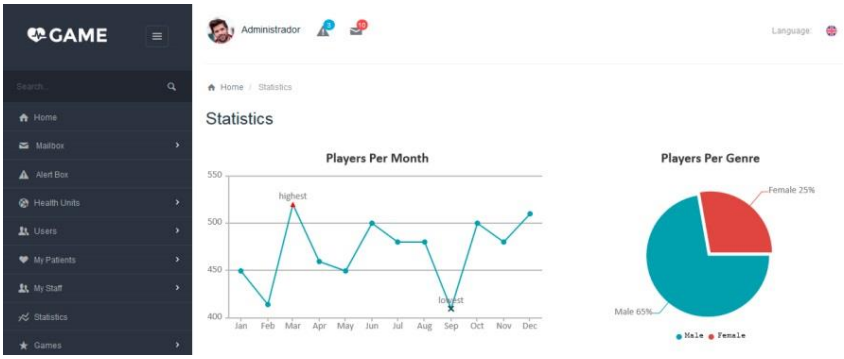

Fig. 9. General statistics for administrators.

9. Final Remarks

The Back Office is an indispensable tool for the management and information processing generated by a system. The fact that the Back Office developed by the research team manages, in a centralized way, all the information from various serious games spread over several health units, allows a time management efficiency and results, both in a professional and research level. The ability to install management modules of new games makes it flexible, offering benefits to physiotherapy professionals, researchers and, above all, to the patients who are the target of the investigation.

As future work we intend to use the information collected by this Back Office system to perform evolution analysis of patient rehabilitation.

Acknowledgements

This work has been supported by the FCT - Foundation for Science and Technology - under the project: PEst-UID/CEC/00319/2013. The authors also thank to the FCT by the doctoral fellowship funding SFRH/BD/74852/2010.

References

1. Martins T, Carvalho V, Soares F. Monitoring of patients with neurological diseases: Development of a motion tracking application using image processing techniques. *International Journal of Biomedical and Clinical Engineering (IJBCE)* 2013; **2**: 37-55.
2. King, MJ. *Back Office and beyond – A guide to procedures, settlements and risk in financial markets*. 2nd ed. Petersfield, Hampshire, UK: Harriman House; 2003.
3. Martins PMO. *Back Office para Plataformas web de gestão de conferências científicas: Desenvolvimento e avaliação* (Dissertação de mestrado). Faculdade de Ciências Empresariais – Universidade do Porto, Porto; 2013 (in portuguese).
4. Valenti S, Fioretti S, Maurizi M, Panti M, Leo T. Teaching motor disability assessment over the Web: MODASPECTRA. *Educational Technology & Society* 2002; **5**: 184-192.
5. Vogiatzaki E, Krukowski A.. Serious games for stroke rehabilitation employing immersive user interfaces in 3D virtual environment. *Journal of Health Informatics* 2014; **6**: 105-113.
6. Gervasi O, Magni R, Zampolini M. (). Nu!RehaVR: virtual reality in neuro tele-rehabilitation of patients with traumatic brain injury and stroke. *Virtual Reality*2010; **14**: 131-141.
7. Dores A.. Reabilitação cognitiva através de ambientes virtuais: inovações metodológicas e tecnológicas (Tese de Doutoramento). Instituto de Ciências Biomédicas Abel Salazar da Universidade do Porto, Porto; 2012 (in portuguese).
8. Sarathkumar B, Sawal R.. Towards a hi-fi wireless sensor network for rehabilitation supervision. *International Journal of Engineering Sciences & Research Technology* 2014; **3**: 7063-8.
9. Curtis JS, Ruijs LS, De Vries MH, Winters R, Martens J-B. Rehabilitation of handwriting skills in stroke patients using interactive games: A pilot study. *Proceedings of the 27th International Conference on Human Factors in Computing Systems*; 2009. p. 3931-3936.
10. Lanfermann G, Willmann RD. *U.S. Patent No*. 2009/0299232. Washington, DC: U.S. Patent and Trademark Office; 2009.
11. Lorincz K, Chen B, Challen G, Chowdhury A, Patel S, Bonato P, Welsh M. Mercury: A Wearable Sensor Network Platform for High-Fidelity Motion Analysis. *Proceedings of the 7th ACM Conference on Embedded Networked Sensor Systems*; 2009. p. 183-196.