

## Research Article

# Integrated Solution of a Back Office System for Serious Games Targeted at Physiotherapy

Tiago Martins,<sup>1</sup> Vítor Carvalho,<sup>1,2</sup> and Filomena Soares<sup>1</sup>

<sup>1</sup>Algoritmi Research Centre, University of Minho, 4804-533 Guimarães, Portugal

<sup>2</sup>IPCA, 4750-810 Barcelos, Portugal

Correspondence should be addressed to Vítor Carvalho; [vcarvalho@ipca.pt](mailto:vcarvalho@ipca.pt)

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Serious games targeted at physiotherapy can be a solution to help the physical therapy professionals. However, the entire game management, in its various aspects, is under the professional's responsibility. One way to reduce the professional management work will be to integrate a Back Office system in the game. Following this trend, the purpose of this paper is to present a modular Back Office system for centralized management of one or more games targeted at physical therapy.

## 1. Introduction

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

If the game itself is enough for patients to perform the proposed activity, it may not be for the health professionals. In fact, these professionals have to make the management of the game with regard to the players' profiles, their responsible peers, and their physical therapy programs and the state of the disease and its evolution, among other topics. Back Office development becomes an important tool in the management of this clinical information.

The original concept of Back Office suffered fast evolution with regard to either operational efficiency, process automation, application responsibility, or even the application areas [2]. Two areas closed to the Back Office concept are information systems and informatics. Therefore, Back Office is defined as the set of features and characteristics of an information system with different restricted areas. The Front Office is visible for all users. Authenticated users are allowed to change the system functions by using the Back Office [3].

Demographic trends, whether in developed countries or in third-world countries, point to a sharp increase in the

number of elderly people with motor problems. Otherwise, the number of people that work is decreasing. These facts will contribute to a decrease in the number of professionals dedicated to physical therapy. It will be required to equip the clinics with technologies that may support the health professionals in their task of assisting older people [4].

With this in mind, the purpose of this paper is to provide a modular solution of a Back Office that supports one or more games targeted at physical therapy, allowing the management of patients (players), of the staff, of Health Units, and of the games' performance.

This paper is structured as follows. Section 2 presents the state of the art in this topic, Section 3 states the idea and model proposal, Section 4 details the Back Office Design, Section 5 presents the database, Section 6 defines the users hierarchy and privileges, Section 7 shows the main functions and features of Back Office, Section 8 refers to system's messages and alerts, and finally Section 9 addresses the conclusions of the work.

## 2. State of the Art

Despite an extensive bibliographic search, only few serious games targeted at physical therapy and with integrated Back Office systems have been found. Therefore, we opted to present some serious games that have Back Office systems

regardless of the purpose of healthcare. StrokeBack is a telemedicine project using a virtual reality (VR) scenario targeted at rehabilitation in home environment of patients who suffered a stroke. This project is complemented by a system in line with Health Personal Storage of each patient. A Back Office integrated solution allows healthcare professionals to access the data of each patient, enabling them to constantly monitor their health status and their rehabilitation progress [5].

The Nu!RehaVR system is another rehabilitation teletechnology, based on VR, used in patients who have traumatic brain injury or have suffered from a stroke and, therefore, need 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 optimizing their quality of life. Nu!RehaVR integrates three distinct environments, one of them being the Back Office that the therapist can access to choose among the available exercises proposed by the doctor those which are most appropriate to each patient [6].

Within the scope of his doctoral thesis, Artemisa Dores [7] presents the development, the implementation, and the evaluation of the Computer-Assisted Rehabilitation Program-Virtual Reality (CARP-VR). It is a program with different environments that are simulations of real-life contexts, in which patients will perform diverse activities based on daily situations. To face the patient mobility problems, several training stations are located in different medical institutions. The architecture of this system includes a centralized Back Office, enabling performing synchronized remote updates and configuration of training stations. Furthermore, it also keeps the results obtained by each participant in each training session updated. With this 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 [8] recommend a wireless sensor network, which is a low-cost and easy-to-use system. The data is collected and stored in a database (acceleration and angular velocity at which the patient moves his/her limbs). One of the system components is the Back Office, which allows health professionals to access the information and check the physical performance of the patients optimizing the appropriate therapies.

Sheep Herding, Labyrinth, Letter Tracing, and Writing are four games embedded in an interactive application used to support, in a motivating and fun way, the rehabilitation of writing skills in people suffering from paralysis after stroke. The Back Office of the application allows therapists to adjust various parameters of the games, for example, the difficulty level of the game, adapting the exercises to the needs and interests of the patient [9].

Lanfermann and Willmann [10] registered a patent of a system and method for rehabilitation or physical therapy of patients with neuromotor disorders such as stroke. This invention consists of a camera system that records the patient exercises and an interaction system that gives the user instructions to start or stop a given exercise. The Back Office offers an easy solution for the therapist to watch the video

recording of the full exercise and to evaluate the patient's performance.

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 the referred applications enables the monitoring of patients with Parkinson's disease and another allows detecting epileptic convulsions. The sensor data are released in the Back Office, to be processed later [11].

### 3. Model Proposal

The authors felt the need to design and develop a generic and integrated system that allows the management of the information gathered from different serious games, in a single remote platform, supported by a centralized database (Figure 1).

The games to be used by this system try to promote the patients motivation to carry out the conventional physical therapy exercises when they are performed in a clinical rehabilitation centre. Back Office system aims to make the management of serious games for the therapy to be used exclusively within the clinic, not with the objective of monitoring patients in remote environment since the supervision by a professional of physical rehabilitation is always imperative. In extreme cases, it may be used in home physical therapy, when accompanied by a professional, thus avoiding negative effects on the use of these games.

The main objective of this type of game targeted at physical therapy is to motivate the patients to continue with their rehabilitation programs as long as possible, since the traditional physical therapy exercises are repetitive and boring, which leads them to give up early on their treatments.

Although the games usually have score systems, more importantly than achieving any score, the main aspect is that the patient performs correctly each exercise. Therefore, the supervision by a health professional is extremely important in order to avoid excessive strain on the patient to get better scores, damaging his health.

As the authors' goal was to develop a modular solution to allow adding the management of new games, new features, and updates, among other functionalities, a web-based platform was developed.

The fact that the database and the Back Office system are located on a remote server allows users to access the application, anywhere and anytime, requiring only an Internet connection. Moreover, everything is centralized, both in research purposes and in the clinical information management. Remotely, the system administrator can install new games, fix bugs, update the application, and add new modules, among others.

The Back Office was designed taking into account some basic principles of safety, integrity, stability, and reliability. It is divided into five main areas: Health Unit's management, personnel management, patient management (players), games management, and statistics. All these areas are managed by

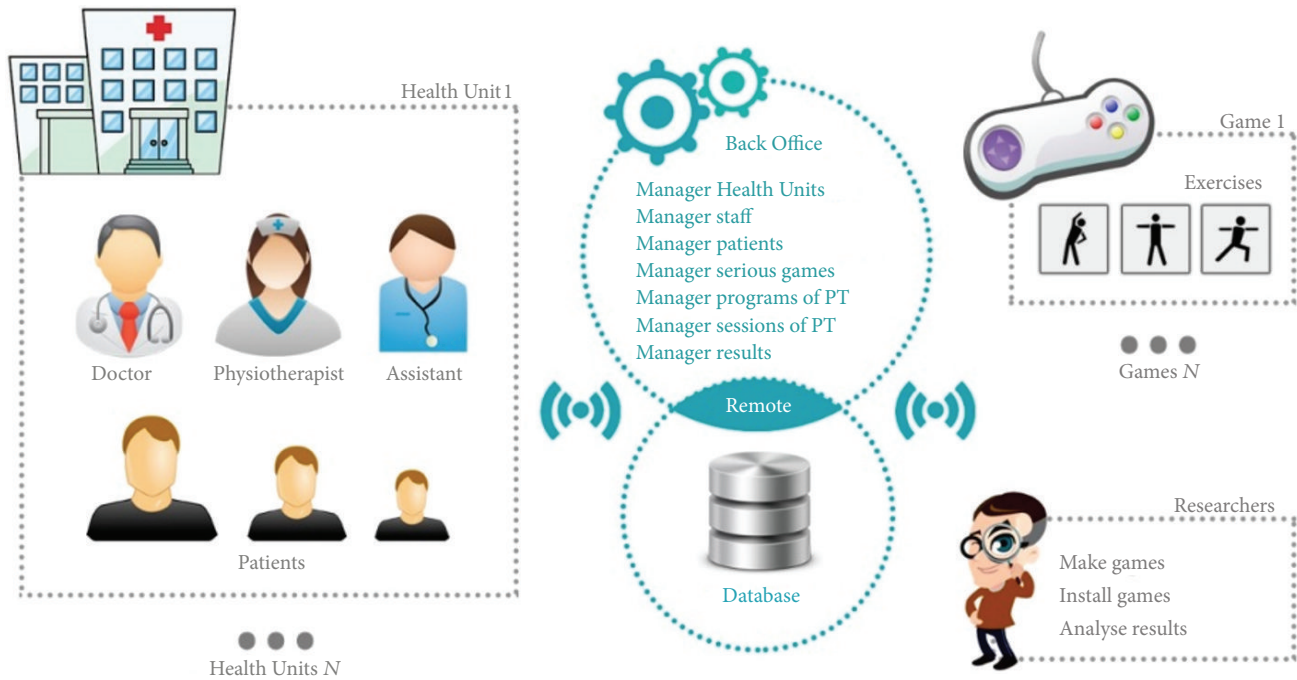


FIGURE 1: System generic architecture.

a hierarchy of users privileges (administrators, doctors, physiotherapists, assistants, and others), with specific limitations for each of them.

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

Although the final model of the application is more complex than that which is shown in Figure 2, this represents, generally, 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 to the Back Office and creates a patient (player) profile as well as his/her physical therapy program, citing the professionals responsible for it (physiotherapists and respective assistants). In the clinic, the physical therapist logs in to the game and chooses the player and his/her physical therapy program is loaded so that the patient (player) starts playing. The nucleus of this architecture is the database that stores all the generated information, and the Back Office is the manager of this information. The game makes use of this information to load the programs of the players and send all results to the database, which can be consulted in the Back Office by the doctor or by those responsible for the patient.

#### 4. The Back Office Design

When developing a web page, it should be taken in mind the warnings of the World Wide Web Consortium (W3C), which is the board responsible for recommending development standards for the Internet (web standards). Nowadays, with the diversity of devices (computers, smart television, smart

phones, and tablets) that allow access to the Internet, it becomes imperative to use these patterns in order to ensure that the solution is fully functional in most browsers. These W3C recommendations were followed by the research team to avoid in the future compatibility formatting problems.

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

The system takes all necessary and legally required precautions to ensure the protection of information collected from its users through the Back Office. These precautions ensure safety online and offline of that information. Whenever sensitive information is collected or used, the data are encrypted using SSL certificates. Thanks to the 128-bit SSL (Security Sockets Layer), which protects the transmission of all sensitive data over the Internet, all information is treated with the greatest security. The user's privacy is ensured and the risk of interception of data during the communication is safeguarded. All passwords and sensitive data stored in the databases are also encrypted.

With regard to data protection, all those which are collected by the Back Office are treated according to Directive 95/46/CE that provides the notion that the collection and then the processing of data can only be made for legitimate purposes, with specific and defined goals, with data

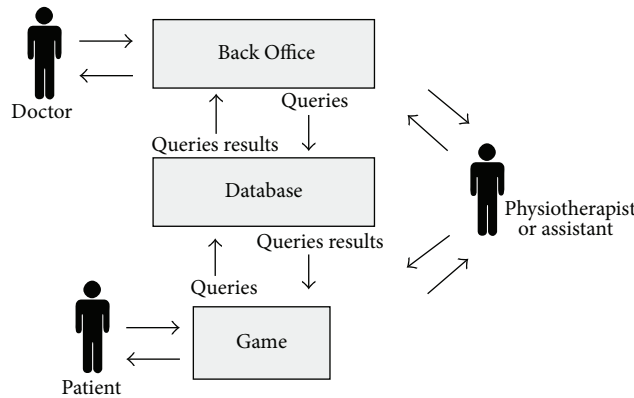


FIGURE 2: System behavior in a three-dimensional model.

accuracy and only allowing the identification of the holder at specified times. The law provides also the principle of prior authorization, so data processing can only be carried out with the consent of the owner. The system also follows Directive 2002/58/CE that establishes rules to ensure safety with regard to the processing of personal data, the notification of the violation of personal data, and the confidentiality of communications. In addition, it prohibits unsolicited communications whenever the user has not given his/her consent.

Another advantage in the use of the presented technological solutions is that they can run on free software such as Linux operating system and LAMP, which is a solution that incorporates the Apache (web server), PHP (programming language), and MySQL (database software) that allows running web applications of high availability and high performance.

In the graphic design field, we opted for a minimalist style with simple and clear elements (menus, tables, icons, and images, among others), 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 multiple types of games with different designs. The colors chosen for the graphics and the typography are between gray and blue, opting for a sans serif font type, which is the most used in this kind of application.

Considering that the Back Office is responsible for managing all the information at the level of Health Units and serious games, one of the difficulties is the way to overcome entropy, that is, the state of natural disorder of any system. For that issue, the research team had to take into account the architecture of the information, that is, the way how it is treated and is presented to the end user.

Usability, which can be defined in five dimensions (learning, efficiency, memory, strength, and satisfaction), may be the "key success" of an application. If the user does not feel comfortable in using a particular application, he/she tends to give up easily. Following this trend, we considered some guidelines for the organization of contents in the Back Office. First, the importance of creating a responsive layout, adaptable to different target devices (computers, smartphones, and tablets) was considered, with the aim of promoting adequate usability to its size and shape. Secondly, it was necessary to

idealize the organization structure of information. The main functions are accessible through a side menu on the left, always available from any part of the application. Along the main menus, submenus can be opened containing the main functions of the first. Navigation is rather intuitive and fluid, based on the logical structure of various applications that are on the market and have already been tested, such as Facebook (user research, user profiles, messaging between users, and boxes alerts, among others) (Figure 3).

## 5. The Database

The database plays a central role in the overall system as it is responsible for storing all the information generated in the Back Office and in the games.

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

The database structure was normalized to allow for efficient storage, low data redundancy, and efficient access to stored data.

The Entity Relationship (ER) diagram of the database is shown in Figure 4.

## 6. Users and Privileges Hierarchy

As mentioned, the Back Office contains several areas that are conditioned to a hierarchy of users. Figure 5 shows a flow chart with the structure of each section of the Back Office and the respective restricted areas.

The users' hierarchy is divided into five distinct classes: managers, doctors, physiotherapists, physiotherapy assistants, and others.

Administrators are usually research team users that can access all sections of the Back Office. Only administrators can install new games' modules, add Health Units, and access global and specific statistics of the use of games and of the Back Office itself.

In Back Office, doctors are responsible for creating the profiles of their patients, as well as their physical therapy





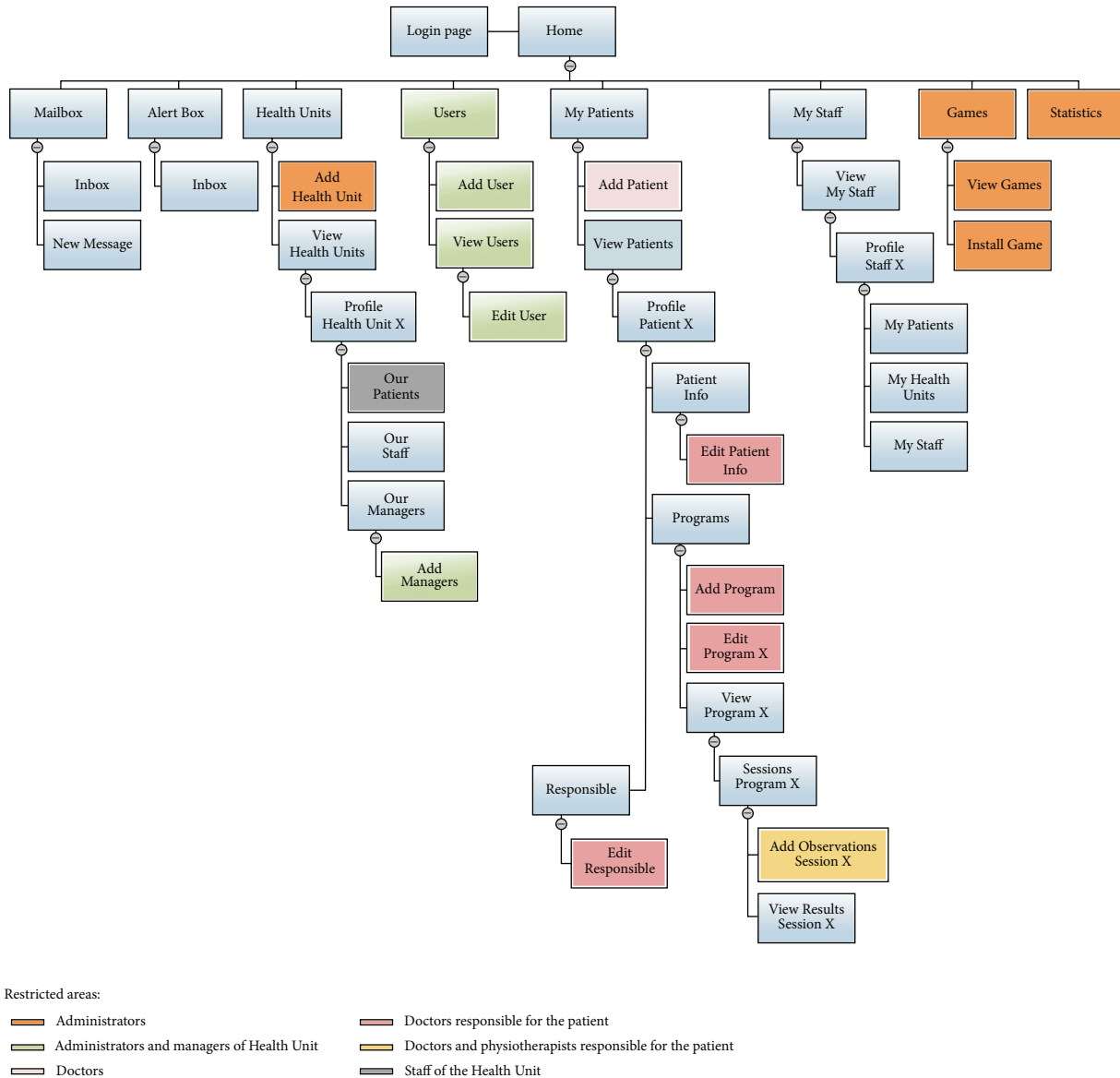


FIGURE 5: Organogram of the various sections of the Back Office.

The class “others” may be associated, for example, with a Health Unit director.

The manager is a secondary class that is a complement to the primary (doctor, physiotherapist, or others), which allows the user to manage the staff (team) of his/her Health Unit, with the possibility of adding, for example, doctors, physical therapists, assistants, or even new managers.

## 7. Main Functions and Features of the Back Office

Currently, the system is autonomous, aiming especially at doing the management of the staff of Health Units and their users with the use of serious games.

When accessing the Back Office, a login page appears. Each user must enter his/her username 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 score of the latest players. On the side (always present), the menu is displayed with the main sections (it varies according to the hierarchy level of the user). At the top, a notification bar of alerts and messages, a language selector, a user menu, and the “Log Off” option are also presented.

Before any other task, the administrator must install the serious games on the computers of the Health Units. The administrator may install the game modules, which are contained within a ZIP file. He/she accesses the submenu “Install

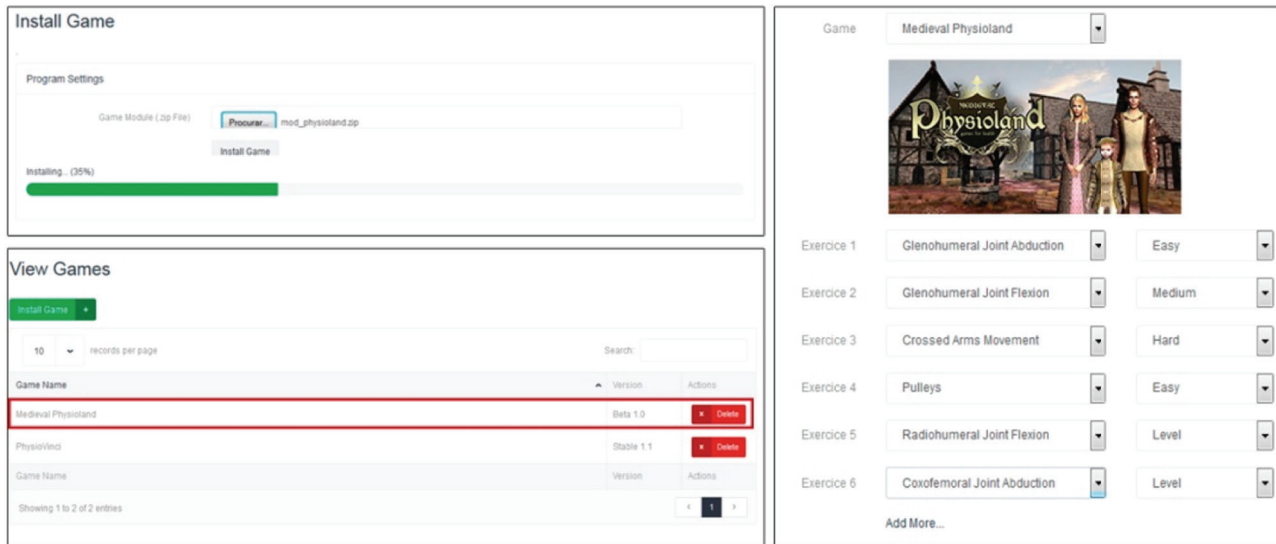


FIGURE 6: Process of installing a new game module.

Game” on the “Games” menu, selects the file containing the modules of a game specifically created for use with the Back Office, and clicks “Install.” These games will be the basis for physical therapy programs (Figure 6).

The games are available to be downloaded online and installed locally. Whenever there is a new update, the game will ask for the same update. Local administrators should only have the necessary permissions to do so.

The games modules contain the information specific to each game, like exercise and difficulty levels, among other parameters. They also contain scripts that create tables in the database to keep the results and game parameters, but they also provide the pages that serve as a basis for consultation and management of the results obtained from the sessions. Thus, the Back Office can manage several games, regardless of the Back Office structure, with the only necessary requirement being to install the respective modules.

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

When there are yet no Health Units, the administrator is responsible for adding them. He/she must enter the submenu “Add Health Unit,” on the “Health Units” menu. Then, a form is presented to fill in with all the Health Unit information like name, address, telephone, and email, among other relevant information. After the creation of the Health Unit, it is required to add a user “manager” of that Health Unit (Figure 7).

From here, the administrator or the new manager of the created Health Unit can edit its information and add staff as well as new managers, but only administrators can eliminate a Health Unit.

As previously stated, only administrators and managers of a Health Unit can add new users (staff of a Health Unit). It should be noted that a user may be associated with various

Health Units, with the same position or different positions. Only administrators can add new users with the position of administrator. To add a user, it is needed to access the submenu “Add User,” on the “Users” menu, and fill in the user’s profile (name, Health Unit, and position, among others).

In the management of users, administrators can see all the users of all Health Units, being able to edit them or delete them. However, managers can only see the users of the units they manage.

User profiles are only available to the elements of the Health Units, unless the user profile is defined as “public.” If it is a public profile, the users of other Health Units may contact him/her and see the Health Units where he/she is associated (Figure 8).

The task of creating (or eliminating) patient profiles is exclusive of doctors; only they can create a patient profile. For this, the doctor must access the submenu “Add Patient” on the menu “My Patients” and fill in the form with patient information like Health Unit (he/she can only choose a Health Unit he/she belongs to), name, date of birth, email, phone, diseases and respective degrees, and medical history, among other relevant information. The doctor should also choose the persons (physiotherapist and assistants) who will be responsible for him/her during physical therapy sessions (Figure 9).

Patient profiles are only accessible to staff of his/her Health Unit.

After creating a patient profile, the doctor responsible for him/her can create physical therapy programs based on the serious games. The doctor has to access the patient’s profile, enter the tab “Programs,” and click “Add New Program.” The page presents a form where the doctor chooses the game and the respective physical therapy exercises he/she wants his/her patient to perform, sets the number of sessions

### Add Health Unit

Name:

Address:


City:

State:

Postal Code:

Phone:

Email:

Upload Image:   
[Change](#) [Remove](#)


### Add Manager of Health Unit

Health Unit:

Role:

Name:

Email:

Upload Image:   
[Change](#) [Remove](#)

### View Health Units

[Add Health Unit](#) +

10 records per page Search:

Name	City	Managers	Active	Actions
Clinica de Fisioterapia XPTO	Planeta Terra	Anabela Santos	Yes	<a href="#">Profile</a> <a href="#">Edit</a> <a href="#">Managers</a> <a href="#">Delete</a>

Showing 1 to 1 of 1 entries

FIGURE 7: Creating process of a Health Unit.

**Users** | [View Users](#) | [Add User](#)

**View Users**

10 records per page Search:

Name	Username	Health Unit	Role	Actions
Administrador	admin	No Health Unit	Administrator	<a href="#">Profile</a> <a href="#">Edit</a> <a href="#">Delete</a>
Anabela Santos	anabela	Clinica de Fisioterapia XPTO	Doctor	<a href="#">Profile</a> <a href="#">Edit</a> <a href="#">Delete</a>
António Soares	asoares	Clinica de Fisioterapia XPTO	Doctor	<a href="#">Profile</a> <a href="#">Edit</a> <a href="#">Delete</a>
Jóão Francisco	joaofrancisco	Clinica de Fisioterapia XPTO	Doctor	<a href="#">Profile</a> <a href="#">Edit</a> <a href="#">Delete</a>
Sofia Costa	sofia	Clinica de Fisioterapia XPTO	Physiotherapist	<a href="#">Profile</a> <a href="#">Edit</a> <a href="#">Delete</a>

Showing 1 to 5 of 5 entries

**António Soares** | Doctor | 1 Health Units | 4 Staff | 3 Patients | [Send Message](#)

[My Health Units](#) | [My Staff](#) | [My Patients](#)

Health Unit	Location	Actions
Clinica de Fisioterapia XPTO	Cidade XPTO	<a href="#">View</a>

FIGURE 8: Creating process of a user profile.



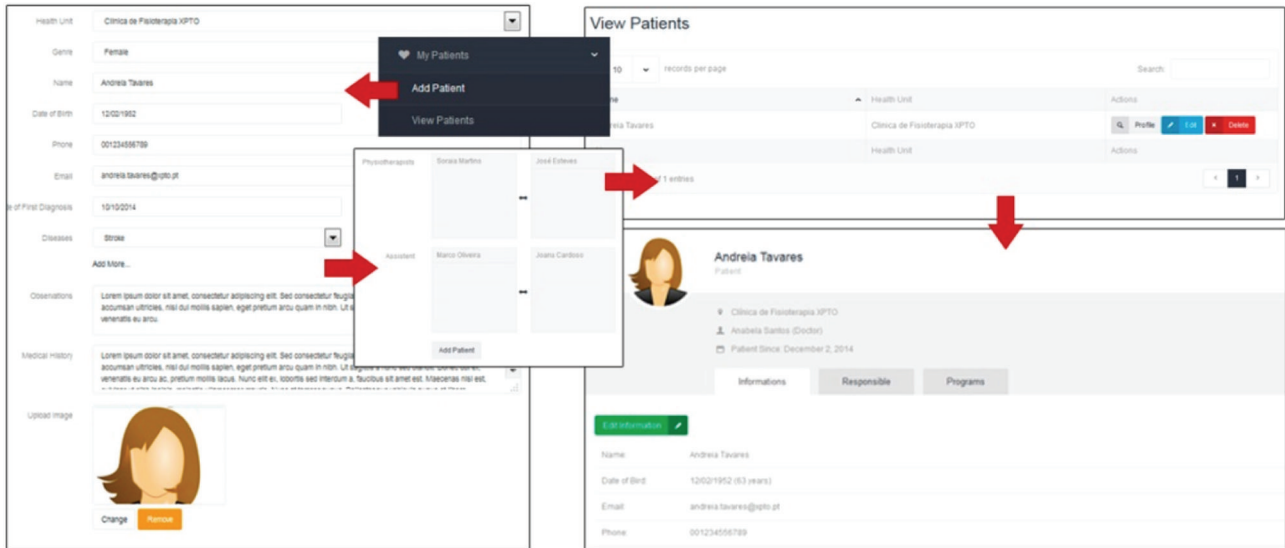


FIGURE 9: Creating process of a patient's profile.

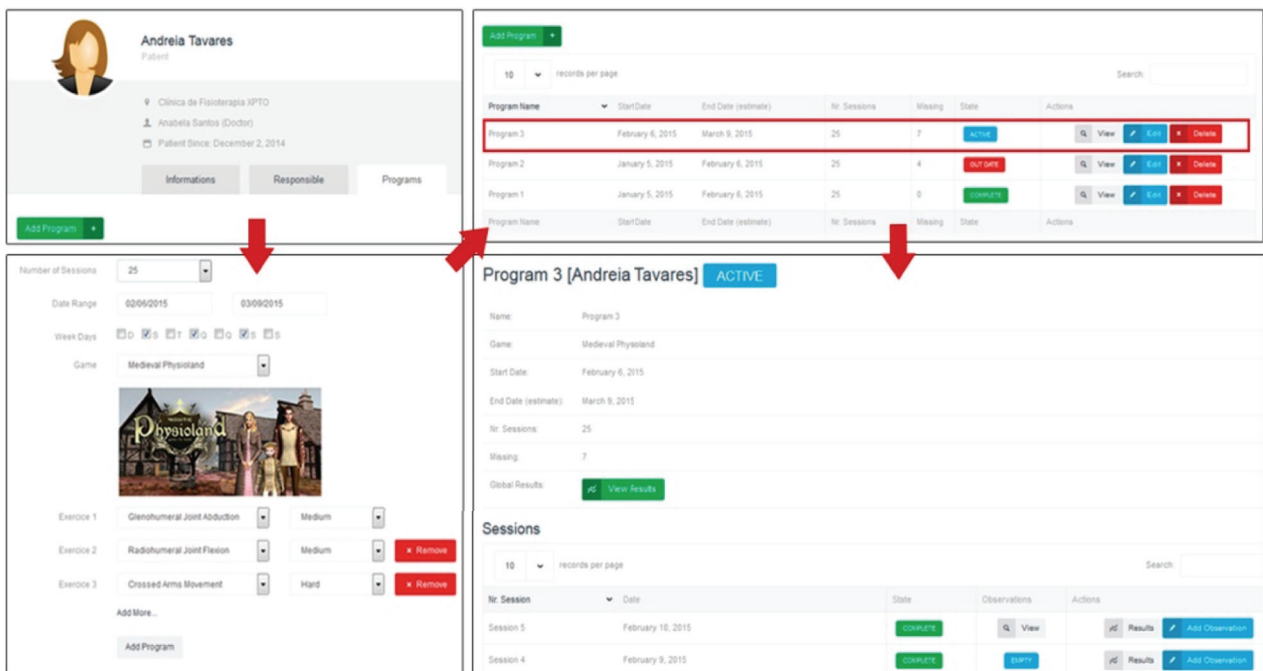


FIGURE 10: Creating process of a physical therapy program for a particular patient.

and the start and end date (forecast) of the program, and chooses the days of the week on which the patient must play (Figure 10).

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

All physiotherapy sessions for a particular patient are recorded in his/her current physical therapy program and the results may be consulted by all those responsible for the

patient. The physical therapists and the doctors of the patient can also insert comments on a particular session.

The pages that display the results are specific for 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 performed (Figure 11).

General statistics of the application are only available for administrators and serve to have an overview on using the

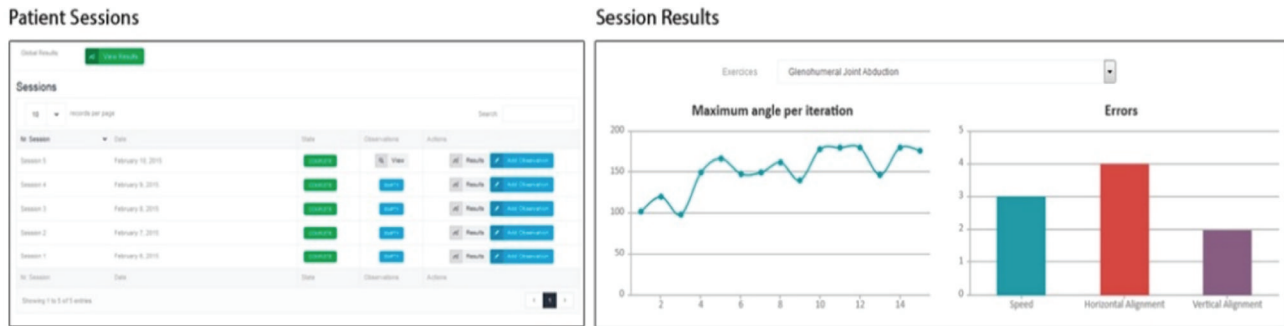


FIGURE 11: Specific results of a physical therapy session.

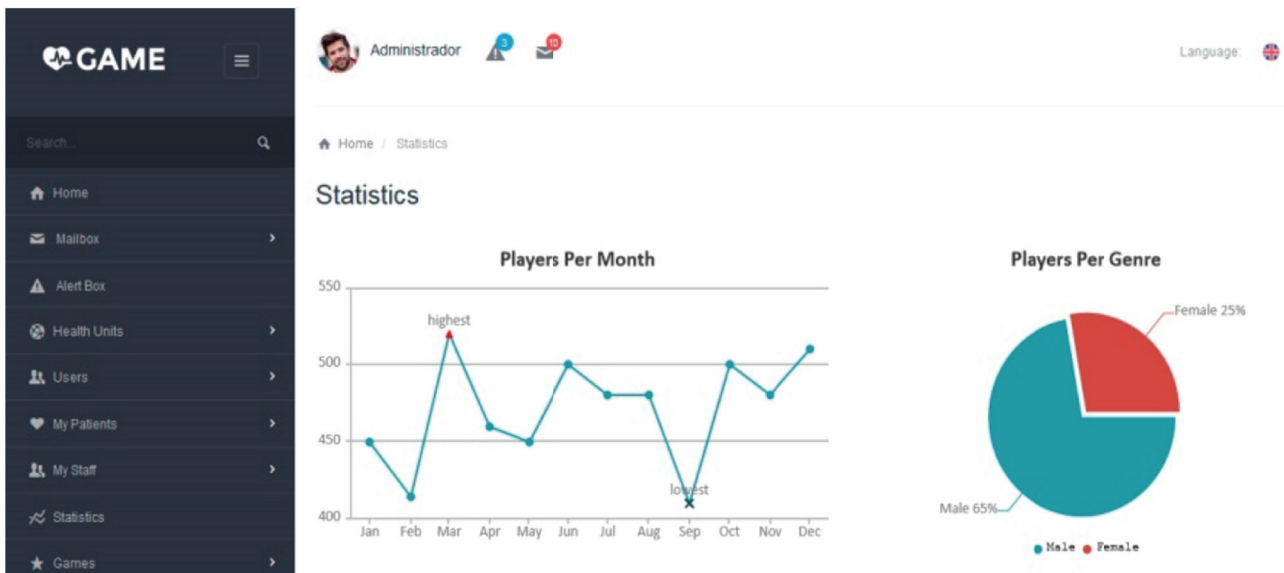


FIGURE 12: General statistics for administrators.

Back Office and installed games (access the menu “Statistics”; and a variety of graphics are presented with results on the use of the application, such as number of daily, monthly, and annual access instances and number of new registrations of users, patients, and Health Units, among others). With regard to the games, there is also an analysis of the number of players per month, by gender, and by fulfillment of a physical therapy program, among others (Figure 12).

## 8. Messages and Alerts

The exchange of messages between the staff members of a Health Unit and among elements of another unit may become interesting in the sense of sharing knowledge, solutions, and results.

Alerts are messages that the system sends to the users and the patients. Several alerts are scheduled to be sent automatically to doctors and physical therapists, like absence of the sessions, performance report, weekly evolution of the patients, and end of physical therapy program, among other relevant alerts.

If patients choose, they can receive in their mailbox or on their mobile phone alerts for scheduled physical therapy sessions, as well as their absences and weekly results.

The notification bar, always present on the top of the page, indicates to the users the number and the content of new alerts and messages (Figure 13).

## 9. Final Remarks

The Back Office is an indispensable tool for the management and processing of information. The Back Office developed and presented management in a centralized way, with all the information gathered from several serious games spread over different Health Units, improving the efficiency of time management and results, in terms of clinical approach as well as in terms of research. The ability to install management modules of new games makes it versatile and powerful. Thereby, it will benefit physiotherapy professionals, researchers, and, above all, those who are the target of the investigation, the patients.

The serious games management platform oriented for physiotherapy becomes unique because, instead of having

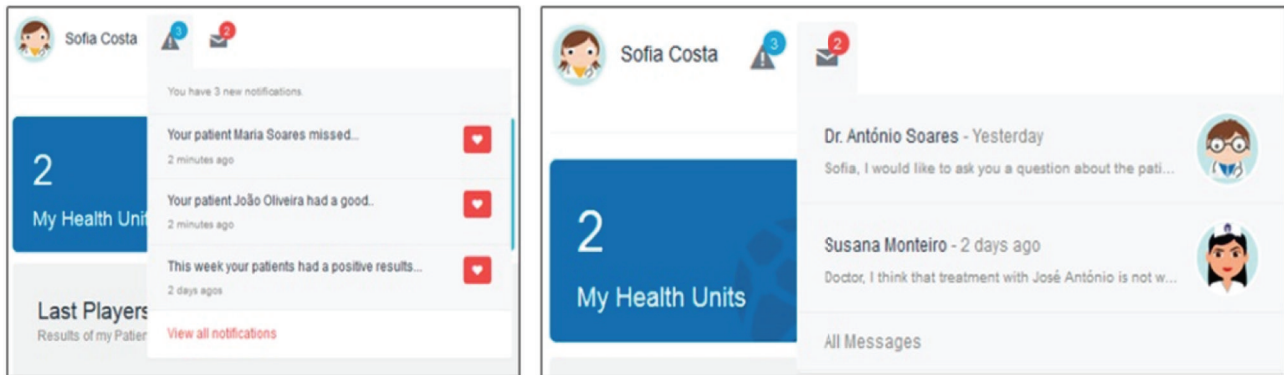


FIGURE 13: Boxes of alert notifications and messages.

multiple Back Office systems for different games, it includes the management of several games, also including the staff management of Health Units, thus avoiding the information redundancy generated by different systems. This allows the management and the treatment and filtration of all information generated by the system.

As future work, we intend to use the information collected by this Back Office system to perform the analysis of the patients' rehabilitation progress. Moreover, future work data will also include the acceptance level of the system by all the actors involved, including the patients and the health technicians.

## Competing Interests

The authors declare that they have no competing interests.

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## References

- [1] T. Martins, V. Carvalho, and F. Soares, "Monitoring of patients with neurological diseases: development of a motion tracking application using image processing techniques," *International Journal of Biomedical and Clinical Engineering*, vol. 2, no. 2, pp. 37–55, 2013.
- [2] M. J. King, *Office and Beyond—A Guide to Procedures, Settlements and Risk in Financial Markets*, Harriman House, Petersfield, UK, 2nd edition, 2003.
- [3] P. M. O. Martins, *Back Office para Plataformas Web de Gestão de Conferências Científicas: Desenvolvimento e Avaliação*, Universidade do Porto, Porto, Portugal, 2013.
- [4] S. Valenti, S. Fioretti, M. Maurizi, M. Panti, and T. Leo, "Teaching motor disability assessment over the web: MODASPEC-TRA," *Educational Technology and Society*, vol. 5, no. 1, pp. 184–198, 2002.
- [5] E. Vogiatzaki and A. Krukowski, "Serious games for stroke rehabilitation employing immersive user interfaces in 3D virtual environment," *Journal of Health Informatics*, vol. 6, pp. 105–113, 2014.
- [6] O. Gervasi, R. Magni, and M. Zampolini, "Nu!RehaVR: virtual reality in neuro tele-rehabilitation of patients with traumatic brain injury and stroke," *Virtual Reality*, vol. 14, no. 2, pp. 131–141, 2010.
- [7] A. Dores, *Reabilitação Cognitiva Através de Ambientes Virtuais: Inovações Metodológicas e Tecnológicas*, Instituto de Ciências Biomédicas Abel Salazar, Porto, Portugal, 2012.
- [8] B. Sarathkumar and R. Sawal, "Towards a hi-fi wireless sensor network for rehabilitation supervision," *International Journal of Engineering Sciences & Research Technology*, vol. 3, no. 4, pp. 7063–7068, 2014.
- [9] J. S. Curtis, L. S. Ruijs, M. H. De Vries, R. Winters, and J.-B. Martens, "Rehabilitation of handwriting skills in stroke patients using interactive games: a pilot study," in *Proceedings of the 27th International Conference Extended Abstracts on Human Factors in Computing Systems (CHI '09)*, pp. 3931–3936, Boston, Mass, USA, April 2009.
- [10] G. Lanfermann and R. D. Willmann, U.S. Patent no. 0299232, U.S. Patent and Trademark Office, Washington, DC, USA, 2009.
- [11] K. Lorincz, B. Chen, G. Challen et al., "Mercury: a wearable sensor network platform for high-fidelity motion analysis," in *Proceedings of the 7th ACM Conference on Embedded Networked Sensor Systems*, pp. 183–196, ACM Press, Berkeley, Calif, USA, November 2009.





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