Biomedical equipment management software for small and medium-sized medical facilities.

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Abstract It has been found that the medical facilities, up to and including those at level seven, under Resolution 267/2003, approved by the Ministry of Health of Argentina, lack a biomedical equipment management system. These systems are unavailable on the market and their high development costs can only be afforded by large hospitals. Consequently, there is an unsolved need for adequate records on the equipment at medical facilities, making management more difficult and creating unnecessary risks and expenses.In order to meet this need, a software program, called *Maguss*, has been developed for small and medium-sized medical facilities. It is a web-based software featuring low implementation costs, minimum hardware requirements, remote access from various mobile devices, and increased safety. The need for this type of systems was confirmed through its implementation and the excellent results obtained in two hospitals located in Córdoba city. At the same time, areas of improvement were pinpointed and steps are being taken, in collaboration with the Medical Informatics Department of the School of Exact, Physical and Natural Sciences, to remedy them.

1. Introduction

Maguss is an application software for managing medical equipment at healthcare facilities. This tool is designed to aid in the development of clinical engineering by making it possible to track the equipment within hospitals, clinics and other medical facilities in an orderly fashion. It is a free software product developed mainly with such tools as HTML, CSS, Java Script, IDE, MySQL databases, version 5.0, and a Linux server with PHP 5.3.

The main tasks performed by this software include:

- Keeping a record of all the biomedical equipment items at a medical facility through a customizable technical data sheet.
- Searching for equipment items by serial number.
- Displaying lists of equipment items by equipment and department through a filtering system.

- Tracking simple and complex maintenance work done on all equipment items through their Work History.
- Setting alarms as reminders of scheduled activities or tasks and assigning them a specific priority level.
- Listing spares and accessories indicating their availability and compatibility with the equipment.
- Listing suppliers along with the equipment provided and other relevant information.
- Keeping notes of the condition and movement of equipment on and off site.
- Viewing, printing and sending some of the above mentioned information via e-mail in Adobe Reader .pdf and Microsoft Office Excel .xlsx and .xls formats. Excel may also be used to filter and show information in statistical graphics.

In addition, it is a web-based application; therefore,

- It requires Internet access to operate.
- It may be remotely accessed from any device.
- Each facility is identified with a user name and a password.
- It may be customized and tailored to the specific requirements of each medical facility without altering its basic structure.

As regards access, the following points must be noted:

- Several users may be created for each facility.
- Users are assigned one of three different access levels, each of which is associated with particular ways of manipulating information:
  - Administrator: This user is granted full access and may view, enter, and modify information. He or she may also create new users of any of the three types mentioned in this section.
  - User: This user is allowed intermediate access and may view, enter, and modify information. However, he or she may not create other users.
  - Supervisor: This user is granted restricted access and may only view information. He or she may neither carry out any action that modifies the database nor create any new users.

2. About the software

2.1. Access to the software

To access the website at *http://www.magussingenieria.com.ar*, users must enter the user name and password provided by the software creators in the login window shown in Figure 1.

Figure 1: Login window to access the software at *http://www.magussingenieria.com.ar*

2.2. Home

To maintain consistency in user interfaces, the home page and all the other pages in this tool have a similar look and feel. They feature the Work Menu and the name of both the medical facility and the user, as shown in Figure 2.

In turn, the options on the Work Menu are "Manual" (Manual), "Contact" (Contacto), "Search" (Buscar), "Alarms" (Alarmas), "Add Equipment" (Registrar equipo), "Notes" (Notas), "Inoperative Equipment" (Equipos dados de baja), "Spares and Accessories" (Repuestos y accesorios) and "Suppliers" (Proveedores).

Figure 2: Home page. In this case no alarms were set; otherwise, they are displayed in this window.

2.3. Adding equipment

In order to add an equipment item to the database, a form must be filled in with some basic information. A distinctive feature of the software is that more specific information may be included through its customizable data sheet if the user considers it necessary, adding versatility to the software at this stage.

In addition, an image, such as a photograph, and a file, for example a manual, may be uploaded for each equipment item.

Once said form is filled in, if the user wishes to enter a similar item, he or she must click on the option "Duplicate" (Cargar y copiar). This opens a form containing the information on the item previously added, except for those details that are unique, such as the serial number and the internal code.

2.4. Alarm setting

Alarms are set on the data sheet page, where they are also deleted. When setting alarms, users must specify the reminder date, the frequency, the task, and the priority level as indicated by the colors red, orange, and blue. More than one alarm may be set per equipment item.

The alarms are displayed once the user signs in on the home page and are listed by date. They may be switched off by clicking on the button "Task performed" (Tarea realizada) on the same page.

2.5. Alarm entries on the home page

Alarm entries are listed chronologically on the home page, as shown in Figure 3, the one on top being for the current date, followed by those from previous days. If there are different alarm entries for the same day, these are listed in order of priority.

A tick is shown beside each alarm entry after clicking in the appropriate box to indicate the task is being carried out. Clicking on "Task performed" allows users to be notified of the completion of the task. The alarm is thus deactivated and the button now shows "Task performed by (user name)" [Tarea realizada por (nombre de usuario)]. This notification remains active throughout the day.

Figure 3: Alarm entries displayed on the home page.

2.6. Search page

Two search types are offered by the software, as shown in Figure 4.

On the one hand, an equipment item may be searched for by its serial number or internal code.

On the other hand, the software offers equipment lists filtered by equipment items and departments. Therefore, lists may be filtered by the following parameters:

- All the equipment at the medical facility.
- All the equipment in a department.
- All the equipment of the same type at the medical facility.
- All the equipment of the same type in a department.

Figure 6 shows a list of all the equipment at a medical facility.

If the user clicks on an equipment item on the resulting lists, its data sheet is displayed, as illustrated in Figure 5.

Figure 4: Search systems.

2.7. Data sheets

Figure 5 shows the data sheet of an equipment item with its photograph and all the relevant information about it. For further details, a file, like a manual, may be uploaded in this window.

Data sheets also include the Work History, showing the maintenance work done on the equipment.

This type of record presents the date and type of work performed on each item as well as a description of and the person responsible for it, making it possible to track repair and maintenance in an orderly fashion.

If the user wishes to enter an equipment item with features common to items already in the system, the shared information can be copied by clicking on the "Copy" (Copiar) button. In this way, entering several similar items becomes a user-friendly task.

Equipment with an inoperative status is deleted from the database of functional equipment and recorded separately.

It is possible to open the data sheet in Adobe Reader .pdf and Microsoft Office Excel .xlsx or .xls formats to print it and send it via e-mail.

Figure 5: Data sheet. The figure above shows the data sheet of an anesthesia ventilator including the product details and its Work History.

2.8. Lists

The different software lists, such as that of equipment, suppliers, spares and accessories, and inoperative equipment, may be exported to Microsoft Office Excel .xls or .xlsx formats, allowing users to filter and present information, for instance, on a pie chart showing the functional equipment and that under repair. In turn, lists in said formats may be printed and sent via e-mail.

Figure 6: Software list. All the equipment at a medical facility.

2.9. Inoperative equipment

The software allows users to track inoperative equipment. The inoperative equipment list is ordered chronologically.

The reason for taking equipment out of service may be indicated in the Work History, where it is kept regardless of the equipment status.

When the equipment is back in running order, its status may be changed by accessing its data sheet.

More than one equipment item may be deleted at a time from the database.

The list may be opened in Microsoft Office Excel .xls or .xlsx formats to filter, print, and send the information via e-mail.

2.10. Spares and accessories

To add spares or accessories to the database, a form must be filled in by clicking on the "New" (Nuevo) button. These are then ordered alphabetically.

The list of spares and accessories also indicates the equipment with which they are compatible.

More than one spare or accessory may be deleted at a time from the database.

The list may be opened in Microsoft Office Excel .xls or .xlsx formats to filter, print, and send the information via e-mail.

2.11. Suppliers

To add a supplier to the database, a form must be filled in by clicking on the "New" button. Suppliers are then ordered alphabetically by name or department. To do this, the user must click on the "Name" (Nombre) or "Department" (Especialidad) buttons, respectively.

More than one supplier may be deleted at a time from the database.

The list may be opened in Microsoft Office Excel .xls or .xlsx formats to filter, print, and send the information via e-mail.

2.12. Notes

The software features three types of notes to record and notify users of the condition and movement of the equipment. These include Service Requests (Solicitud de servicio), Removal of Equipment Notes (Salida de equipamiento) and Maintenance Reports (Informe de servicio). They are designed to record the work cycle.

They contain fields for the user to complete and present a similar layout. They may be exported to Adobe Reader .pdf format by clicking on the "Print" (Imprimir) button. The printed version will display the letterhead of the organization.

2.12.1. Service Request. By this type of note, also called 'Work Order', the personnel of any department may inform the biomedical engineering department about the condition of an equipment item.

2.12.2. Removal of Equipment Note. This type of note records the removal of equipment for different reasons, including repair, service, and relocation, among others. The same note may be used to record the removal of more than one equipment item.

2.12.3. Maintenance Report. It is a technical report describing the maintenance work performed on the equipment by both staff members and third parties.

3. Implementation

In order to evaluate the software performance and obtain some feedback about it, it was implemented at a typical medical facility in Córdoba, Argentina. An agreement was reached with the Hospital de Niños de la Santísima Trinidad, a children's hospital located in Córdoba city, to implement the software in its Department of Surgery.

Currently, this tool is in operation both at said hospital and the Hospital Municipal de Urgencias, another local medical facility.

4. Results

The objectives pursued in developing the software were as follows: to improve equipment management, organize maintenance work, schedule tasks of different priority for specific dates and with a certain frequency, reduce corrective maintenance work, and build an inventory. Taking these into account, and after its implementation, the software was found a suitable tool.

5. Conclusion

In the course of this work, numerous ideas as to the design and the functionalities of a biomedical equipment management software were considered. However, the goal established was to design a user-friendly tool that would help manage equipment at medical facilities and, once its development was complete, make it available for use.

Although the software is currently being improved to some extent, it already fulfills the authors' expectations in the sense that it serves as the basis for a full-featured management software as it enables the creation of a database of the equipment including its Work History, movement, and spares and accessories, among others.