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Management information system of medical equipment using mobile devices

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Abstract. The large numbers of technologies currently incorporated into mobile devices transform them into excellent tools for capture and to manage the information, because of the increasing computing power and storage that allow to add many miscellaneous applications. In order to obtain benefits of these technologies, in the biomedical engineering field, it was developed a mobile information system for medical equipment management. The central platform for the system it's a mobile phone, which by a connection with a web server, it's capable to send and receive information relative to any medical equipment. Decoding a type of barcodes, known as QR-Codes, the management process is simplified and improved. These barcodes identified the medical equipments in a database, when these codes are photographed and decoded with the mobile device, you can access to relevant information about the medical equipment in question. This Project in it's actual state is a basic support tool for the maintenance of medical equipment. It is also a modern alternative, competitive and economic in the actual market.

1. Introduction

In the last years there has been the phenomenon of global massification of mobile telephony. In South America the mobile telephony market it's in a continuous grow. Particularly in Chile the statistics indicates that nine of ten persons have a mobile device [1].

By increasing the supply in the market, the available technologies in this field are getting better, the mobile devices have greater capabilities and consequently it's possible to implement better applications in the devices. According to this, it raises the following question: How obtain benefits from these technologies in the biomedical engineering field?

Is in this context that the project is developed. Currently there are several management softwares for the medical equipment [2]. Unfortunately the current systems are expensive and inefficient in some cases.

In order to take advantage of current technologies and optimize the existing systems, from the point of view of work and cost, this project proposes to use mobile devices as a platform for a management information system of the medical equipment. The system manages to converge and to coexist: the information and communications technologies (through transmission), the digital image processing (by decoding barcodes with mobile devices), the programming languages and clinical engineering. All new and effective way.

2. Design

The system was designed as a mobile tool for managing information relevant to the departments of medical equipment.

Using a mobile phone, qr-codes [3] (2D barcodes) are decoded, which are associated with a medical equipment. The purpose of this decoding is to receive on the mobile device critical information (contained in a database) for the equipment in question (quick guide or checklists for example).

The use of qr-codes intended to facilitate the process of entering information on the mobile platform and make it more dynamic. Similarly, using the information associated with bar codes, the mobile platform is use to generate service orders related to the maintenance of biomedical equipment.

In this way then, the mobile device has the role of central axis of the system and through a Web server connectivity allows to obtain the requested information in all places. Figure 1 outlines the complete system and associated information flows.

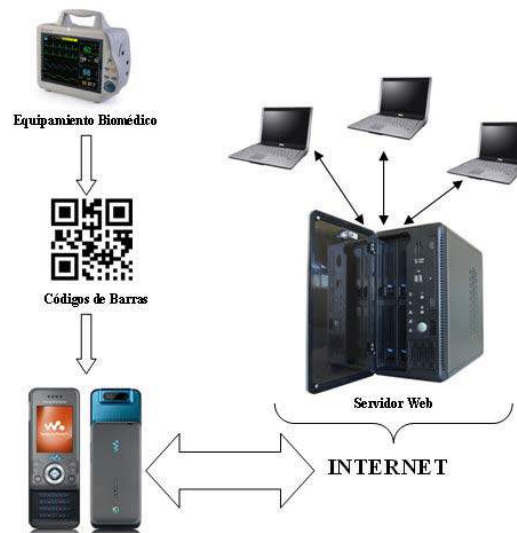


Figure 1. Schematic of the system.

3. Development and Operation

In the development of the system, the main tools used and their characteristics are:

- Mobile Phone with Java support, 2.0 MP integrated camera and GPRS/EDGE connectivity.
- Apache Web server, with PHP and MySQL.

The system is based on the interaction between the software installed on the mobile phone and the managing databases from the Web Server.

The mobile device software was developed in Java for cell phones, better known as J2ME. The choice of this language is mainly due to high compatibility presenting with these devices.

The whole system, as shown in Figure 2, can be divided into the following stages:

a) 2D bar codes decode

This step involves accessing the mobile phone's integrated camera in order to photograph a qr-code and then decode it to obtain the associated information.

The data associated with the code mentioned may be the brand, model or service where is operating the medical equipment, among others. This decoding it simplifies the introduction of several parameters to the user, which are already in a database associated with the decoded barcode.

b) Send or request information

Once the qr-code it's decoded, is possible to perform various operations related to the maintenance of medical equipment. These options include:

- Generate and send a service order.
- Request for preventive maintenance checklist.
- Request for information relating to medical equipment in question (basic information, operation, last maintenance, photography, etc.).

c) Web Server Response

Depending on the code associated with the medical equip and the action required from the mobile device will be the answer that will run the Web server.

This response can be summarized as sending information from the system database or the inclusion of information in the database.

d) Reception of Information

Once is processed the response in the Web server, the information according to the action required by the mobile phone will be received and displayed.

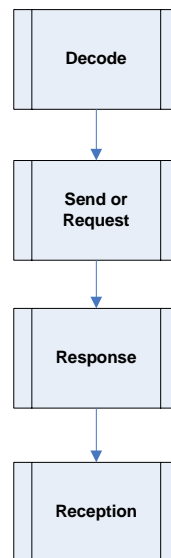


Figure 2. System stages.

4. Experimentation

The resulting product is a management tool based on the various stages that interact with each other, making a high-mobility system, easy access and easy use.

To determine the decoding capability of the system, using a medium category of mobile phone, several operational tests (called decoding tests) were conducted. In Figure 3 we can appreciate the mobile device photographing a QR-Code for further decoding.

The decoding tests consist in photographing bar codes by varying the size of the code (in [cm²]) and the distance from the camera to the code (in [cm]). 5 series are realized for each size and distance, thus quantifies the number of attempts required for a successful decoding. Finally is calculated the percentage of successful decoding for each series, according to equation (1):

$$\%Successful_Decode = \frac{Successful_attempts}{Attempts_total} \cdot 100 \quad (1)$$

From the results of tests of decoding, is possible to infer minimum requirements for optimal system performance. The size of the qr-code must be at least 3.5 [cm] x 3.5 [cm] and the resolution of the integrated camera 1.3 MP or more. The above test results are presented in Table I:

Table I. Decoding tests results.

Format	Size [cms x cms]	Distance [cms]	Successful decode [%]
LCD Display	3,5 x 3,5	20	100
		20	100
Printed	6,5 x 6,5	10	100
		20	100
Printed	3,5 x 3,5	10	100
		20	60
Printed	2,2 x 2,2	10	80

Table II. Communication tests results.

Protocol	Decode time [seg]	Reception time [seg]	Total time [seg]
GPRS	2	20	22
Wi-fi	2	10	12
Wi-fi (emulated)	--	5	5

Whereas most stages of the system are directly related to the exchange of data between the mobile device and the Web server, communication tests were realized to the system. These communication tests consist in measuring the time it takes to get the information to the mobile device since the sending of a query.

The measured time considers the entire consultation process, since it decodes a qr-code until it reaches the requested information. The average size of information sent in these tests is 525 [bytes] and the server used is physically located in the United States (the mobile device was located in Chile). The test results are listed in Table II.

The results of both tests allow to state that from the point of view of time and cost, the system is fast and economical, making it highly competitive with any existing management software.

The estimated time it takes to the user to perform a query (according to the results of tests of communication) is about 25 seconds.

The associated cost is low because the system does not require of expensive platforms for operate. As demonstrated by tests carried out, a mid-class mobile device that meets the minimum requirements is enough to make the system work.

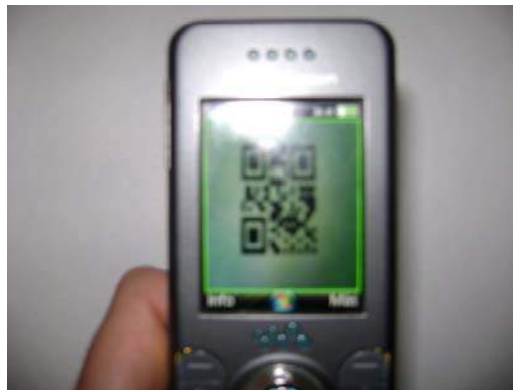


Figure 3. Mobile device capturing a barcode.

5. Discussion

The system is strongly influenced by the technology of mobile equipment used as a platform. The points where greater dependence was detected are those directly related to the technological features necessary for the application. These are the decoding of bar codes and data transmission.

Referring to the decoding, this depends directly on the resolution of the camera integrated into the mobile equipment. As shown by the results in Table I, with a mid-class mobile, the qr-codes are decoded without problems. With high-class mobile devices with integrated cameras of highest resolution (5MP for example) the decoding is optimized.

Relating to communication, the tests were realized using two different methods of data transmission, GPRS and Wi-Fi. Today mostly of the mobiles of medium category have the ability to communicate data through the GPRS protocol. This is an important factor to consider when implementing the system, since the mentioned protocol has some inherent limitations, for example the speed of transmission. For the project in its current state, the limitations of GPRS are not a problem, but are considerable to contemplate in a future evolution of the system.

On the other hand there is the use of Wi-Fi as data transmission protocol. The mobile devices with Wi-Fi are considered high-class and therefore its cost is higher, but the trend indicates that most mobile devices will have this technology in the near future [4], which will make more accessible to users.

Using Wi-Fi as a data transmission method brings many benefits compared to GPRS, mainly due to their speed of transmission. Yet, Wi-fi implies an investment cost when deploying the system in the sector (clinic or hospital) due to technological tools that are necessary (modems, routers, cabling, etc.) to allow connectivity.

In summary, the importance of mobile phone specifications are considerable, since items like a high quality camera, the connectivity or a high performance processor allows better use of the system.

Another relevant aspect of the project is related to its safety, here are two angles, the safe use of mobile devices in hospitals and safe handling of information.

About the use of mobile devices in hospital compounds, exist a controversy about this subject. There are studies that claim that cell phones generate significant electromagnetic interference on some medical equipment [5], and there are many others who deny this information [6]. But there are not conclusive studies about any of these two statements.

In order to reconcile any position regarding the above, a guideline for a safe use is considered, which is *"not using the application in medical devices that are connected directly or indirectly to a*

patient." Compliance with this guideline does not generate conflict for the system, because the focus of this project is the maintenance management and, by definition, medical equipment in maintenance must be disconnected from any patient.

As regards to the safe handling of information, to have a reliable system, it is necessary to restrict the access to the database (for example: using passwords) and back up the information continuously. It is also necessary to identify the mobile phone from which is requesting or sending information, in order to restrict access only to authorized persons.

6. Conclusion

The department of medical equipment from any health institution, public or private, plays a critical and important role, because they are responsible for ensuring that all medical equipment from the organization will have a correct and efficient performance and provide a quality service.

To assist the staff of the medical equipments departments, there are management or administration softwares, which facilitate the several tasks.

The implemented system emerges as an alternative to the existing management softwares, this system optimizes the processes related to the maintenance of medical equipment. Using the mobile devices as a platform, the application becomes versatile, dynamic, universal and flexible.

Adding new functions to the system is a real possibility and that is already developing thanks to the continued advancement of mobile technologies and the great potential that shows the application.

The project in its current state is the foundation of a complete management application, competitive and affordable for the departments of medical equipment of any health institution (public or private). It is also an alternative for the assets control of the maintenance enterprises of medical equipment.

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