

FEASIBILITY OF A COST-EFFECTIVE TELECONSULT PLATFORM FOR MINOR AMBULATORY SURGERY

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Abstract: This paper reports a cost-efficient solution for the classification of patients eligible for treatment with minor ambulatory surgery in the modality of unique act. The teleconsult is based on the transmission of digital images, acquired with a webcam, from a primary healthcare center to a specialized service of burn patients and plastic surgery. Client applications have been designed for all the scenarios, with particular emphasis on the use of multiplatform, open-source development tools and compliance with medical standards. This proposal reduces transit time of the patient along the health system by removing unnecessary consults, and saves costs when compared with other possible commercial solutions.

Introduction

It is widely accepted that the telemedicine paradigm is playing a major role to strengthen health services when the need to provide pervasive access to hospital care has to match cost-saving solutions [1-2]. Despite the large number of telemedicine projects and patent applications that have been developed during the last years [3], there are still important issues which hinder the success: work overload of medical staff, legal barriers, data security and privacy, diversity of standards, etc. We present a case study which shows that it is possible to build cost-effective services over existing infrastructure, following an open-source philosophy and improving the quality of medical assistance with a very low economical investment. The case study is a consult managed by a service of burns and plastic surgery (BPS), located in the health area covered by the University Hospital Virgen del Rocío (UHVR, Seville, Spain), and aimed at the triage of patients eligible for minor ambulatory surgery (mAS).

mAS is a simple surgical procedure, practised with local anaesthesia, aimed at the treatment of cutaneous pathologies that not require a complex reconstruction procedure. In most cases, it is related to the extirpation of a skin injury and the simple closing of the wound. In general the satisfaction of patients with these procedures is high provided that the delay is low. Both the location and size of the injury are important factors that determine whether a mAS procedure can be practised or not. Several properties favour the application of mAS:

- injuries with small diameter,
- with benign aetiology in most cases, since this allows small margins of extirpation,
- that not require complex reconstruction procedures,
- located in parts like face, head, hands and extremities.

Examples for which mAS is indicated range from cutaneous nevus, keratosis, to small sequels of scars, etc. On the other hand, mAS is not recommended in situations in which:

- the patient requires hospitalization due to intercurrent pathologies,
- there is some risk for the patient, due to potentially dangerous pathologies, which suggest the collaboration of an anaesthetist in the operation,
- lesions that require complex reconstruction procedures, like plastias or graftings, being recommended in these cases major ambulatory procedures,
- patients who are psychologically immature or unstable.

Patients eligible for mAS in a highly resolute consult present benign cutaneous pathologies, with some of the signs referred above and none of the negative symptoms.

The current procedure followed by the patients in the health area covered by UHVR starts with a first evaluation by the general practitioner at a peripheral or primary healthcare center. The patient is then transferred to the center of specialties, where a second consult takes place. If the expert considers that the patient can be treated by mAS, he/she will enter the UHVR BPS unit. From this stage, the communication with the patient is managed by the hospital user agency (UA), which serves as a customer/patient assistance department. Based on the eligibility report of the expert physician, the UA, in close contact with the doctor in charge of the BPS unit, and depending on the citation book of the service, schedules a new consult for the plastic surgery service of the UHVR. In spite of the data which the patient has generated through this process, the surgeon has not explored the patient yet. In case the patient is eligible for mAS as a result of the consult, the

date of the operation is scheduled and some recommendations to be followed before the operation are given to the patient.

A high percentage of these patients could be tributary of a treatment with mAS in the modality of unique act, if the lesion was correctly classified before his/her admission to the hospital. Precisely because of that, the objective of this paper is to provide a teleconsult tool which allows the accomplishment of this triage with maximum guarantees, reducing the number of patients who have to be redirected to conventional mAS. This way, the aim is to reduce delays and unnecessary visits, integrating within a unique act two of the episodes: the consult in the hospital and the surgical procedure, so that the process started at the primary healthcare center leads directly to the surgical resolution. Considering that between 1500 and 2000 patients are treated every year with mAS in the service of plastic surgery of the UHVR, and that nearly 50 % of the cases use to be eligible for mAS, the quality perceived by the patient treated with this highly resolute process would be significantly improved.

Materials and Methods

The adequacy of mAS is assessed by analyzing different properties of the cutaneous lesion, including its location. We hypothesize that the utilization of a clinical protocol including a digital image is enough to perform a triage of patients eligible for mAS in the modality of unique act [4]. The applied methodology is based on a multidisciplinary team, including experts in plastic surgery and biomedical engineers. It is necessary to define a clinical protocol to establish distances and illumination conditions of the patient with respect to the acquisition device. Likewise the design of communications protocols and electronic health records must be compliant with existing infrastructure. As a second hypothesis the introduction of an open-source philosophy will improve the cost-effectiveness of the product, while ensuring the compliance with standards, usability and maintenance requirements. As a final remark, the adoption of medical standards is the only means to save costs in the process of integration with heterogeneous systems like a large-scale hospital information system (HIS), as that operating in the UHVR health area.

From the clinical point of view, the following requirements are needed:

- Low-cost materials must be used, so that it is possible to install them in several health centers. Installation should not require reforms in those locations.
- The system must be user-friendly. Any authorised person should retrieve patient data in a time no longer than required to handle paper-based records. It is not possible to count on a technician in every center.
- The features of the lesion must be preserved, so that the expert in the BPS unit can make a decision with the highest reliability.

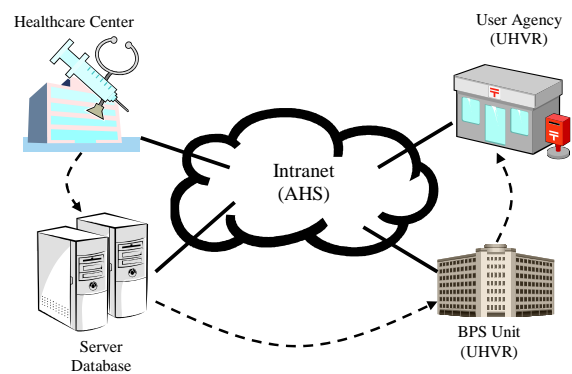


Figure 1: Scenarios involved in the teleconsult system

- The psychological impact over the patient must be minimized.

With regard to the information system, two objectives are pursued. First, to provide a digital version of the normalized form model that is currently filled-up in every health center. This form, which will be referred to as basic form, will be complemented with other fields that could be of some interest to the physicians. This extended record includes a digital image of the lesion. Second, it is desirable to provide a computer desktop, as intuitive as possible, which does not require more knowledge than that needed to fill-in the form in paper format.

Medical data are considered by the applicable legislation as one of the classes of personal data that require the uppermost protection and the highest level of security requirements. This implies that appropriate technical and organizational measures have to be undertaken, including: user identification and authentication, control of access to installations and computers, control of mass-storage hardware, control of memory, communications and electronic transactions, control of use, protection against data loss, backup systems for data recovery, audit of data access and insertion.

In summary, from the technical point of view, this paper provides solutions for each of the scenarios identified in this previous analysis:

- Primary or peripheral healthcare centers, where image acquisition is performed and patient forms are filled-in.
- User agency, from which citations are issued to the patients for consults in the BPS unit.
- BPS unit, with access to the image server and patients' database.

The relations among all these scenarios are depicted in Figure 1.

Results

As a response to the requirements identified in the previous section, technical solutions have been proposed in the field of medical image acquisition and the development of a clinical information system to

perform the triage of patients eligible for mAS in the modality of unique act has been done.

With regard to the acquisition of images, a study has been performed to compare images acquired with a digital photograph camera and a webcam, and their capabilities, so that a panel of expert physicians can classify a series of images of medical injuries, obtained from patients treated in the service, subject to informed consent, and analyzing the rate enough-quality / cost-effectiveness. The evaluation was accomplished through a survey which analyzed the aptitude of the digital image to provide a correct classification of a patient as eligible or non-eligible for mAS in the modality of unique act. The survey was prepared following the guidelines of the medical experts, and their results were an invaluable feedback to validate the image acquisition protocol.

The best score in terms of cost-effectiveness was obtained with the webcam, although this device presented worse results in terms of focus, illumination and resolution of the injury borders. These issues were accounted for in order to design the definitive technical acquisition protocol.

With regard to the architecture of the proposed system, we have selected the client-server model, developing independent client applications for the primary healthcare centers and the BPS unit, and a server based on DICOM standard to store the images and associated information.

Figure 2 shows the structure of the implemented DICOM server, which is based on [5]. To accomplish the development, we have used DCMTK libraries from Offis for Visual C++. In order to store the information managed by the system, a PostgreSQL database has been defined with an entity-relation model, since this approach fits better the information model defined in DICOM. Connection with the PostgreSQL server is performed through libpq libraries, which contain all the necessary functions to make SQL queries over the database. The skeleton of the proposed database is detailed in Figure 3.

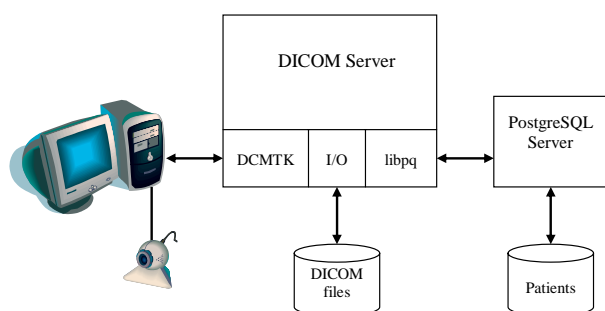


Figure 2: Structure of the DICOM server

The access to the DICOM server from the BPS unit is performed through a web interface programmed with PHP script language. Our choice for the web server was Apache, due to its availability in heterogeneous platforms. Different classes have been developed to

provide the required functionality in order to generate the pages and methods needed to access the database.

The client application for the primary and peripheral healthcare centers has been developed in Java under the JBuilder programming suite, and with support of SDK 1.4.2 libraries and Java DICOM Toolkit (JDT). The graphical user interface includes sections and tabs for the patient's personal data, clinical and complementary data, the physician making the petition, destination center of the query, mode of notification, intercurrent pathologies and image of the injury. By means of the JDT libraries the client application makes use of two DICOM Message Exchange (DIMSE) services: connection check and acknowledgment, C-ECHO, and request to store in the server, C-STORE. All the user interfaces have been validated by the medical team. For instance, Figure 4 shows a sample screen of the client user interface, with the detail of the different sections and tabs, and an image selected for transmission.

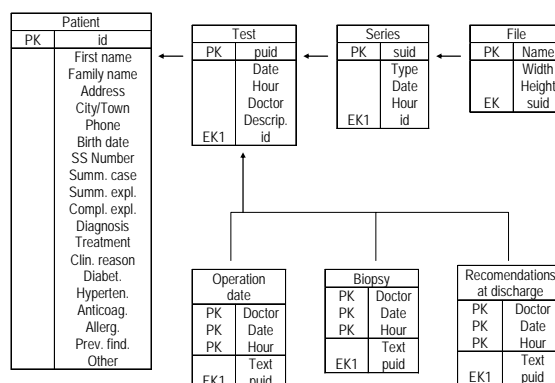


Figure 3: Structure of the proposed database. Principal key for each table is denoted as PK; relation to other tables is established by means of external keys (EK)

Client application in each healthcare center creates a file from patient's personal and clinical data, together with a digital image of the lesion which motivated the consult. This file is stored in the computer from which the teleconsult is started, and transmitted to the DICOM server through the intranet of the UHVR health area. DICOM files cannot be displayed with the majority of applications that are usually found in a user desktop PC. Considering that the web interface is indicated for the BPS unit, it is desirable to provide general practitioners and expert physicians with a tool that allows viewing the images stored in the local site. For this reason a DICOM file viewer has been developed as a stand-alone application. This tool, like the primary healthcare center client, has been programmed in Java with the Jbuilder development suite, and JDT libraries to manage DICOM classes and data types.

Finally, we have developed an application that allows the transmission of the eligibility report from the BPS unit to the User Agency of the UHVR. The proposed solution is compliant with the present applicable procedure, according to which the doctor in charge of the BPS unit must communicate to the User Agency whether the patient can be treated with mAS,

and in positive case, the date and time scheduled for the operation. This information is transmitted using the ftp protocol, as an unformatted text file. This application has also been developed in Java, although in this case additional libraries are not required, since all the functions are included in SDK 1.4.2.

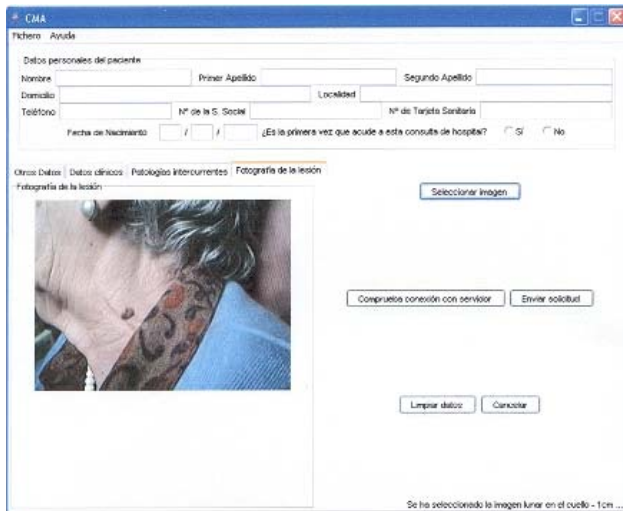


Figure 4: Graphical user interface of the client application for the primary healthcare center

Discussion and conclusions

In this work we propose a low-cost and multiplatform system that allows a teleconsult aimed at the assessment of eligibility for treatment with mAS in the modality of unique act, for patients who arrive at a primary or peripheral healthcare center. The devised solution can be easily integrated in the present infrastructure of the BPS unit, and the applied methodology can be exported to other services and medical units. As an added value, the proposed system can be applied to ease the follow-up of the patient, given the amount of information that is stored in the service, not only at the disposal of the BPS unit, but also to be consulted by the general practitioner.

Among the advantages that derive from the use of the proposed system, we emphasize an improvement of the quality of service perceived by the patient, since it accomplishes a reduction of the delay between the first consult and the surgical treatment, and because the flux of the patients through the health system is optimized. A direct consequence of this optimization is that the productivity of the service can be improved, since unnecessary consults are removed and the medical staff can spend more time in other tasks.

From the point of view of the costs, it is important to emphasize the savings that are derived from the adoption of a design philosophy based on open-source, since the investments in software licenses contribute to raise the public health expenditure. Results reported in this paper show that it is possible to design applications with a lower cost while maintaining the same levels of quality, security and reliability, by utilizing open-source development tools. Indeed, JDT libraries used for the

client application at the primary healthcare center are not freeware. The reason for this choice is motivated because, as they are fully implemented in Java, they allowed a reduction of development time. However, at this moment we are designing the same applications with DCMTK (C++) through Java Native Interface (JNI) using open-source programming tools.

Another important issue is the development of tools that allow networking with the HIS of the Andalusian Health Service (AHS), based in a proprietary HL7 version. In a first stage, the teleconsult system has been regarded as an independent application accessible from primary healthcare centers and the UHVR service of BPS, through the intranet of the AHS. However, the possibilities that are offered by currently available open-source HL7 parsers, would allow a higher degree on integration with the HIS of the AHS. A direct consequence of a design methodology based on the application of medical standards is that the cost of integration with other systems is always lower.

Acknowledgement

This work has been partially supported by the Regional Ministry of Health, Andalusian Government, under grant number 98/03 of (motion of May 28, 2003).

References

- [1] TULU B., CHATTERJEE S., and LAXMINARAYAN S. (2005): 'A Taxonomy of Telemedicine Efforts with Respect to Applications, Infrastructure, Delivery Tools, Type of Setting and Purpose', Proc. 38th Ann. Intl. Conf. System Sciences. 3-6 Jan. 2005, p. 147b.
- [2] PAL A., MBARIKA V.W.A., COBB-PAYTON F., DATTA P., MCCOY S. (2005): 'Telemedicine Diffusion in a Developing Country: The Case of India', *IEEE Trans. Inf. Tech. Biomed.*, **9**(1), pp. 59-65.
- [3] TOMIOKA Y., AIDA N., KAKEHI K., and NAKAJIMA I. (2004): 'Survey on patent applications for medical communications and telemedicine in Japan', Proc. 6th Intl. Workshop Enterprise Networking and Computing in Healthcare Industry, Santa Clara, USA, 28-29 June 2004, pp. 121-124.
- [4] KARIM R.B., HAGE J.J., et al. (2002): 'A digital photography as a means of enhancing interconsultant communication in oncological cutaneous surgery', *Ann. Plast. Surg.*, **48**(2), pp. 180-183.
- [5] PAYO-OLLERO J. (2002): 'Design and implementation of a DICOM image server with web interface', MSc Thesis (in Spanish). University of Seville, Spain.