Virtual reality applied to the management, planning and optimization of surgical interventions.

CRISTINA SUÁREZ-MEJÍAS, ARMANDO CABRAL-CAMACHO, DANIEL DERLINCHAN-GONZÁLEZ, TOMÁS GÓMEZ-CÍA, PURIFICACIÓN GACTO-SÁNCHEZ, MANUEL PÉREZ-LORENTE, CARLOS PARRA-CALDERÓN, JOSE MARÍA DE LA HIGUERA-GONZÁLEZ.

Virgen del Rocío University Hospitals
Sevilla University
Avd/Manuel Siurot s/n. 41013 Sevilla
SPAIN

e-mail: cristina.suarez.exts@juntadeandalucia.es

Abstract:- In the present paper we present the knowledge Management System based on Virtual Reality developed in our hospital, which allow surgeons to plan the virtual surgical intervention by means of VirSSPA, to store and share the generated knowledge. This system is very important for the sanitary organization since the surgeons are helped in decision taking. The system has been made with Java language and it is composed by two equipments: REGSSPA Server and REGSSPA Client. Also, it interacts with other systems as PACS Server, Data Base Server, FTP Server, LDAP Server and VirSSPA. In this system the interoperability, security and accessibility are insured.

Key-Words:- Knowledge Management, Computer assisted surgery, virtual reality, surgical simulation.

1. Introduction

The classic knowledge management distinguishes two kinds of knowledge: explicit knowledge, which can be articulated in a formal language and transmitted among individuals and the tacit knowledge, [1] which corresponds to the personal knowledge rooted on the experiences of individuals and refers to the assessment of individual and combined experience of people as an intellectual asset. Get capture, transfer and implementation of these assets is still a goal in health organizations such as in others [2]. Systems to aid decision making are the most effective way of narrowing the gap between knowledge and medical practice, providing the necessary information "just in time" and "just in case" [3]. The current system designed aims to resolve these issues in the surgical field, by creating 3D virtual models in which physicians can transfer their experience and expertise in search for optimal solutions, applied to the planning and optimization of operations. As a stating point the “Virgen del Rocío” University Hospitals have a virtual reality tool called VirSSPA. The VirSSPA project began in 2005. It is a virtual reality tool for surgical planning and training which has been developed in our hospitals. It was piloted in the Clinical Management Unit on Major Burns and Plastic Surgery, Clinical Management Unit on Maxillofacial Surgery, Clinical Management Unit on Urology and Nephrology, Medical Surgical Unit of Respiratory Diseases and Clinical Management Unit on Traumatology. VirSSPA is nowadays used in more than 150 cases successfully [4-5] and surgeons declare their satisfaction with the results. VirSSPA gives physicians a tool to assist decision making, allowing the anticipation to some complication of the real surgical intervention by means of the virtual simulate. Moreover, surgeons have more knowledge of the patient's pathology. The virtual intervention is done by taking the information of its own conventional imaging studies (CT, MRI, PET) of patients in standard DICOM format. This tool does not require additional radiological images. Images which used VirSSPA are the same images which surgeons request for the
diagnosis of pathology. For 3D model generation, the surgeon selects in a first phase the tissue of interest using different segmentation methods based on semiautomatic thresholding, region growing from seed and bubbles [6-7] designed by researchers for the project. Then reconstruction technique using Marching Cubes [8] reconstructs the 3D model. The next step is to perform surgery with the tools of VirSSPA. As an extension to this VirSSPA project, we propose the design and development of Integrated Knowledge System. This system permit to share the knowledge generated in VirSSPA among all surgeons of our Hospitals. Thus surgeons will have cases of similar surgical interventions which allow surgeons choose the most appropriate option based on the experience. Furthermore, this system allows the digitization of surgical information not available until now in the health field. In addition, it could become the first step before the clinical history in the surgical field, since it can store the simulation of surgery and assess the patient's progress through image comparison tools.

2. Problem Formulation
Surgical planning information which is obtained from 3D model grows with the use of VirSSPA by surgeons.

This fact poses a problem of information management that is generated. The models were stored in the PC where they were created and the exchange of information between surgeons had to perform manually.

Another problem that surgeons had to plan the interventions was access to conventional radiological images. These tests had to follow a protocol that in most of cases made slowed the virtual planning process and thus the real surgery. The protocol was based on requests from surgeons to technical manager via email or phone call. Upon receiving the request, the technical manager must establish a criterion of priority according to the urgency in performing surgery. Then, the radiology supervisor received a list of requests for studies with priorities. After receiving the list, the radiologist stored radiological images in DICOM format. Once the images are stored the technical manager sends the images to surgeons involved. The automatic access to the radiological images will ensure the interoperability and security between systems would be a solution for this problem.

Also the development of VirSSPA is continually updated, incorporating new functions. The installation of new version software was made manually so far. Automatic software updates allow surgeons to have the latest version of VirSSPA easily.

To solve all these problems, The Integrated System for Knowledge Management is developed. Its design and implementation are detailed in the following session.

3. Problem Solution
The growing of information need for information exchange and knowledge transfer in health care systems require interactive systems with characteristics of reliability, security and interoperability. On this basis, the Integrated System for Knowledge Management has been developed. The language designed is based on JAVA and its architecture is composed of two machine, REGSSPA Server and Client REGSSPA. Moreover, different applications involved in the system. This section will detail the system architecture, functional description and mechanism to ensure compliance with the Patient Data Protection Laws.

3.1 System architecture
The Integral System of knowledge management is composed by the following components:

PACS Server (Picture Archiving and Communication System): Server where imaging studies are stored in DICOM format. The system should consult the server to enlist a new case of a patient plan.

REGSSPA Server: Project’s main server, which supports the following two systems. 1) REGSSPA Web: J2EE Web application made in accordance with the framework of project. It is responsible for managing patient cases retrieved from the PACS and of their virtual planning versions by means of VirSSPA. Contains a
comprehensive management of users in the system that is configurable.

![Image](image_url)

**Figure 1.** REGSSPA Web

2) **Dicom Server:** Asynchronous server for reception of DICOM by the PACS. The server made in java can operate independently to perform C-STORE operation of the PACS, or implant in the REGSSPA system. It permits easy configuration allowing among other options encrypt the DICOM.

**REGSSPA Client:** It is made in Java to ensure compliance with the Patient Data Protection Laws in the system

**FTP Server:** This is a file storage server used to build the library of studies and their corresponding versions. Thanks to this store, all studies generated during the virtual planning will be available for surgeons in the future.

**Management System Database:** The database manager ensures consistency between the computer studies of the physician and the server. It contains all the information necessary to ensure that planning cases have been requested and have been stored on the FTP server.

**LDAP Server:** LDAP Server using Active Directory tool enables central storage of information about users, network resources, security policies, and so on. This system will validate the user access the application, preventing unauthorized access.

**VIRSSPA:** VirSSPA is a Tool for planning and optimization of surgical procedures in a virtual reality environment. This is developed in C++, and uses a graphics engine designed by means of OpenGL for 3D reconstruction from radiological studies. VirSSPA has advanced image segmentation algorithms that analyze the different tissues and to extract relevant information. From 2D segmented images, and using the 3D reconstruction algorithm Marching Cubes, the 3D models are necessary for surgical planning. Thanks to the graphics engine built into the application, surgeon can navigate inside the model as if it were a virtual tour, in addition to make distance, generate implants, performing extractions, and so on.

![Image](image_url)

**Figure 2.** 3D model made with VirSSPA

**REGSSPA Client** shall be responsible for storing the studies of virtual surgical planning of patients in REGSSPA Server. Other users of the system will download that information with this option.

![Image](image_url)

**Figure 3.** Global Architecture of Integrated System of Knowledge Management
3.3 System Features

The main functions performed by the server are the following as:

1. **Control Panel**: the system requires authentication for user access. The system has two types of profiles called user or administrator. The main functions of user are management of the planned studies and the administrator functions are the management of user and results.

2. **User Management**: The main actions of the user management are register, drop, change and consulting users. The system will access to the Active Directory to authenticate and to register a new user. Date are stored in the application to ensure security.

3. **Management Studies**: The studies are the cases of patients planning and virtual surgical interventions through VirSSPA. Each user will have its own studios and of other users. The actions can be performed on a study are: 1) high of studies, involving the application and import of a patient radiology images in DICOM format to the PACS server. To ensure standardization of the integration between servers is implemented IHE profiles of ARI (Access to Radiology Information) [8]. The Access to Radiology Information Integration Profile specifies a number of query transactions providing access to radiology information, including images and related reports, in a DICOM format as they were acquired or created. Such access is useful both to the radiology department and to other departments such as pathology, surgery and oncology. Non-radiology information (such as lab reports) may also be accessed if made available in DICOM format. For this purpose, HL7 messages are sender between present systems in the communication (Figure 4), 2) the change of study generates a new version, 3) visualization of studies and 4) import the study of another user.

![Figure 4. ARI Access to Radiology Information Integration Profile to request and import of PACS radiological images.](image)

4. **Usage Statistics Management**: The user must complete a questionnaire InfoPath form [9] when ending a virtual surgical planning of the patient. This will be stored for future statistical studies of the operation of the system. Moreover, surgeons can storage new change proposal to improve the system because the code of system is open to new development.

5. **Log Management**: The system will track all transactions performed by the physician during the virtual planning of the intervention. This is to ensure the Patient Data Protection Laws.

The functions performed by REGSSPA Client listed below:

1. **Synchronization**: This allows the matching of patient studies stored on the PC with the studies associated with that user on the server. In this process, new studies are imported to the PC through REGSSPA Server and planning studies with evaluation questionnaires and log files are exported of VirSSPA to REGSSPA Server. The import / export of studies are made by sending / receiving a single compressed file.

2. **Control of Licenses**: These checks whether the user has enabled the VirSSPA license, updated or may refuse it if appropriate.

3. **Update components** and other necessary elements VIRSSPA
4. Patient Data Protection
Validation of users accessing the system will be made by LDAP servers to ensure compliance with the Patient Data Protection Laws. Thus, the system administrator of the hospital network will have control at all times of the physicians who access the application, and therefore the data it. The actions taken by users during the virtual planning will be recorded in log files that are stored on the server every day. With regard to patient data, radiologic studies are encrypted using the Advanced Encryption Standard AES [10-12]. It is an encryption standard adopted by the U.S. government. Also to secure encryption, whichever is the generation of several keys that are generated automatically after new software version. The software update also VirSSPA is automatic, allowing doctors once they connect to the corporate network have the software with new features and improvements suggested by the clinical team and the research project. REGSSPA Server perform the encryption operation during import of a new study from the PACS DICOM.

5. Conclusion
The developed knowledge management system will enable to improve various aspects in the health field below:

1) The quality of care, because the surgeon will have a support system for decision making in the surgical field based on actual patient cases that contribute to the “improvement of clinical practice”.
2) The personal intervention planning for each patient, decrease the time of it and potential risks, opting for less invasive and aggressive solutions to the patient.
3) Share and store the information of surgeries so far not available, contribute to the digitization of information in hospitals, as well as optimize the use of available information, promoting the export of knowledge between professionals.
4) Assess the patient’s progress through the automatic comparison of 3D images by colour codes.

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References:
[10] Infopath

