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TELMA: technology enhanced learning environment for Minimally Invasive Surgery

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Abstract

One of the most important revolutions in the past few decades in clinical practice has been motivated by the introduction of Minimally Invasive Surgery (MIS) techniques, which have spread amongst almost all surgical specialities. MIS training is a principal component of the education of new surgical residents, with an increasing demand for knowledge and skills for medical students and surgeons. Technology enhanced learning (TEL) solutions can deal with the growing need for MIS learning. This research work aims to develop a MIS learning environment based on web technologies, named TELMA, which will respond to the growing amount of information and multimedia surgical contents available (mainly intervention´s video recording libraries), in compliance with specific learning needs of surgical students and professionals, enhancing their competence on MIS cognitive skills. Furthermore, TELMA will support knowledge capturing, sharing and reuse, and effective management of didactic contents through personalised and collaborative services.

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Keywords: Minimally Invasive Surgery, training, technology enhanced learning, surgical videos, surgical network.

1. Introduction

One of the most important revolutions in the past few decades in clinical practice has been motivated by the introduction of Minimally Invasive Surgery (MIS) techniques, which have spread almost amongst all surgical specialties. These techniques help improve patient safety, favoring reduced tissue damage decreased morbidity and shorter duration of hospital stays for the patient. However, MIS techniques imply a different and limited interaction paradigm compared to the traditional open approach [1] [2].

This paradigm change has brought forth a necessary change in the formation programs for new surgeons. Traditional training methods, based on Halsted´s mentor-apprentice relationship [3] is gradually being replaced by

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new reproducible and flexible ones where active learning is encouraged. The development of standardized training processes is the key for success in the optimization of the trainee´s learning curve, whilst proper accreditation relies on developing objective curricula where personal bias can be reduced to a minimum.

There are a series of skills that a surgeon must master in order to achieve proficiency. These can generally be classified in cognitive (acquisition of the necessary theoretical knowledge), motor (mastering of the surgical gestures and processes), and judgment skills (knowing what to do and how to react when faced with different scenarios) [4] [5]. Cognitive knowledge can be obtained by different means, such as seminars and courses, or employing multimedia didactic materiel in the form of books, CD-ROMS, and specially, endoscopic videos, which are one of the most important sources of information present in this field [6].

Adoption of web technologies for cognitive on-line training can be a useful way of optimizing formation programs, allowing for anytime-anywhere training. Combined with the strengths provided by the laparoscopic videos, e-learning in surgery is an effective way of breaking time, space and cost barriers; offering online or blended formation alternatives that are always more viable and feasible than on-site courses.

Currently, there are several online repositories available, which characterize themselves for their low degree of interaction with the user. Such alternatives as WebSurg [7], WebOp [8], letsmedical [9], laptube [10] or hemostasia.com [11] among others; or the different sites provided by surgeon´s associations such as the Spanish Association of Surgeon´s (AEC), or the Fundamentals of Laparoscopic Surgery of the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES), compose different approaches and examples of enhanced medical learning environments.

However, expansion amongst the medical community of these sites is suffering undue hindrance. There are several causes identified behind this: (1) not all videos are properly documented and explained; (2) user interaction with the contents is at best reduced, limiting itself to simple navigation between sequential contents; (3) trainee evaluation is all but inexistent; and (4) contact between users is hardly encouraged.

We present TELMA as an alternative to existing web platforms, where didactic value of the surgical videos is exploited thanks to the possibility of edition. The user is also boosted, allowing a more active participation in his learning process, an objective surgical skills assessment and encouraging collaboration with other surgeons and trainees with different surgical expertise.

2. TELMA's MIS training environment

TELMA architecture is comprised by: (1) a multimedia didactic authoring tool, which allows to process and enhance didactically surgical videos for creating didactic units; (2) a Learning Content and Knowledge Management System (LCKMS), which monitors activities and efficiently personalizes contents to users' profiles; (3) an objective evaluation module; and (4) a surgical professional network which promotes users' collaboration.

2.1. Multimedia didactic authoring tool

Endoscopic videos are the main information source of MIS. Video sequences analysis can be used to extract the relevant information of the surgical scene such as objects position, anatomical and instrumental movements or depth. Therefore, the information extracted by endoscopic video processing plays a decisive role in the learning processes and can be used to limit the associated problems with this new training paradigm.

TELMA provides an authoring tool which allows creating multimedia didactic contents based on surgical videos. Thus, relevant information in them is improved and resource sharing between TELMA users is encouraged (see Figure 1). Moreover, the authoring tool allows creating didactic units from several didactic contents, including new descriptive elements (images, textual documentation, etc.) in order to enhance its didactic value.

Figure 1: Didactic multimedia authoring tool

The functionality of the authoring tool can be grouped into the following categories: archive operations (open, save and close videos), image processing operations (segmentation of structures, tracking of structures, etc.), enhancement operations (insertion of a voice recording and insertion of textual information), interactive operations (insertion of didactic exercises), interoperability operations (insertion and search of tags), content visualization operations (reproduction control of the laparoscopic videos and tracking of a ROI) and others operations (clipping, insertion of medical images, insertion of documents, etc.). Through the combined use of all functionalities, the user can open, edit and/or reproduce the video and save the changes performed in the didactic resource.

An important issue of the authoring tool is its user simplicity. It is assumed that surgeons have not a great informatics experience, nor many time to spend. For this reason, the authoring tool incorporates an easy interface, and an interactive help, which indicates the sequence of the steps to perform a determinate operation. Finally, the authoring tool supports of reusable learning objects (endoscopic videos, medical images, etc) for creation of new didactic units. Thus, contents sharing and collaboration between TELMA´s users are encouraged.

2.2. Learning Content and Knowledge Management System (LCKMS)

TELMA includes a Learning Content and Knowledge Management System (LCKMS). In comparison to existing LMS and LCMS systems, LCKMS allows: (1) Monitoring the activities of TELMA's users, (2) Interpreting these activities to update trainees' learning curve, (3) Automatically inferring special user requirements, (4) Representing these preferences and requirements in pedagogical models and (5) Acting upon the available knowledge.

The LCKMS consists of a content manager, a knowledge management system and an adaptation engine supporting a recommendation layer, which efficiently personalizes contents to users' profiles.

2.2.1. Knowledge management system

The Knowledge Management System monitors all interactions and processes within the TELMA environment, allowing the creation, capture, storage, sharing and distribution of the information, and turning it into knowledge which can then also be shared by TELMA users.

By monitoring the user´s learning process, the KMS is able to acquire and register trainees input referenced to their learning evolution and behaviors. This way users' learning evolution is identified and training is adapted accordingly to them. Adaptation comes in two possible forms: 1) adaptation of the contents (through a recommendation process, see 2.2.3), and 2) adaptation of the interactivity. Furthermore, formative feedback is provided to users.

With all functionalities implemented in the KMS, users will be able to more rapidly and effectively acquire MIS cognitive skills. The KMS will thus serve as an aid for skills retention.

2.2.2. Adaptation engine

One of TELMA´s main objectives is to provide users with a personalized training experience according to each trainee’s evolution. Personalization systems are still confined to research labs, and most of the current e-learning

platforms are still delivering the same educational resources in the same way to learners with different profiles and needs.

TELMA has an adaptation engine which considers (1) initial users' data (for instance profile, preferences, and objectives), (2) interactions information and (3) performance; and provides personalized recommendation centered on formative paths. Likewise, the recommendation layer will make possible lifelong learning, where formative and evaluation stages follow each other continuously with the system able to track the learner's evolution and adapt accordingly.

Closely related to the adaptation engine, a dynamic user model is developed, which gathers users' skills and data. As preferences and requirements differ from each user and vary during the use of the TELMA environment, the model must change and adapt to them, guiding users through a innovative training process. The result is a model that stores all users' information, whether it would be static (personal or professional data) or dynamic (interests, preferences, and concerns) and their associations.

The recommendation agent uses the user model in order to generate a real-time personalized recommendation, providing users with didactic contents suitable for their own learning requirements. This layer processes all data using a rules' engine that establishes rules for tracking and debugging the inference process.

2.2.3. Content management system

Contents management is a crucial issue in a web-based learning environment for efficient storage and retrieval. TELMA has a CMS, responsible of efficiently managing all multimedia contents (i.e. endoscopic surgical videos, medical images, auxiliary documents) generated by TELMA users.

TELMA´s CMS has a modular architecture based on different components, in order to improve its performance. Finally, the TELMA MIS knowledge base will be comprised by the learning objects and units' repositories and the learning methods.

Functionalities incorporated in the CMS include:

- Content ingest: including encoding and automatic transcodification into different qualities. For instance, there exist a master quality for authoring purposes, and a low quality for attached videos to newsletters. This leads to a multi-format learning environment, where quality is automatically chosen according to network capacities and users' requirements.
- Multilanguage: all contents managed by the CMS are provided in two languages, English and Spanish.
- Surgical thesaurus: this functionality facilitates a guided documentation, based on a thesaurus previously defined. It simplifies both the guided documentation, and the search engine, and achieving a much more efficient management of didactic resources. Guided documentation is complemented by free documentation introduced manually by the user, allowing the description of didactic contents (author, brief description, etc.).

2.3. Objective evaluation module

One of the pillars on which the proposed training model relies is on providing, whenever the user asks for it, immediate and objective feedback on the exercises completed that accurately reflect their learning curve´s progression within TELMA. Results for the exercises, comprised of a series of correct and failed answers, will be (1) processed by the KMS to determine the degree and level of the acquired cognitive knowledge; and (2) used by the adaptation engine to suggest new contents to the user according his current aptitudes.

When a trainee completes an exercise, results are sent to the evaluation module from the content repository, which then grades performance and sends that information to the user history- and level-update modules. The first one recalculates the learning curve based on his recent performance, which reflects on his profile and thus is always available for consultation (external update). Level update implies reconfiguring the User´s Model via the KMS so that TELMA´s adaptation engine can adjust future content´s for the user based on his current skills (internal update).

Grading information, along with the updated learning curve, moves then onto the dossier generation unity, where the evaluation module sends the information for textual and graphical data formatting. Finally, a full customizable report is presented onscreen to the user, which will be able to save, discard or print it.

2.4. Surgical professional network

E-learning processes are more effective when trainee interaction is promoted, whether with the system itself or with other users. TELMA strengthens this trainees' collaboration and their coaching by subject matter experts by means of the creation of a surgical professional network. This MIS network supports synchronous and asynchronous communication between users within the learning environment, so as to encourage informal learning (see Figure 2). Therefore, the activity and the collaboration in the learning processes are improved, as users share their medical knowledge and experiences through individual and group interactivity, as well as useful information, doubts or opinions, amongst other things.

Figure 2: Surgical Professional Network

3. Conclusions

Cognitive skills´ training is a vital part on a surgeon´s formation. This work presents a collaborative web-based environment which will permit trainees to improve their knowledge and skills anytime and anywhere. Training with TELMA will be fully supported by automatic and immediate skill assessment and learning curve monitoring; and by a professional network of surgeon´s with different experience, to ensure a holistic and complete learning experience. TELMA is comprised by: (1) a multimedia didactic authoring tool, (2) a Learning Content and Knowledge Management System (LCKMS), (3) an objective evaluation module, and (4) a surgical professional network.

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References

1. Cuschieri A. Laparoscopic surgery: current status, issues and future developments. Surgeon, 3(3), 2005, pp125-138.
2. Aggarwal A., Moorthy K. and Darzi A. Laparoscopic skills training and assessment, Br J Surg, 91(12), 2004, pp 1549-1558.
3. Halsted, W.S. The training of the surgeon. Bulletin of the Johns Hopkins Hospital 15, 1904, pp. 267-275
4. Park A., Witzke D., Donnelly M. Ongoing Deficits in Resident Training for Minimally Invasive Surgery. Journal of Gastrointestinal Surgery, Vol 6, num 3, 2002, pp. 501-509(9).
5. Moore R.G., Loening S., Bishoff J.T., Docimo S.G., Bonnett R.. Minimally Invasive Urologic Surgery. Chapter 11. 2005

6. Rosser JC, Herman B, Risucci DA., M. M. , Rosser L, and Merrell RC, "Effectiveness of a CD-ROM multimedia tutorial in transferring cognitive knowledge essential for laparoscopic skill training.," The American journal of surgery, vol. 179, no4, 2000, pp. 320-324.
7. Web of World Electrnic Book of Surgery (WebSurg) http://websurg.com (Last access: July 2010).
8. Web of WebOp http://www.webop.de/ (Last access: July 2010).
9. Web of Letsmedical http://www.letsmedical.com/ (Last access: July 2010).
10. Web of Laptube http://laptube.net/ (Last access: July 2010).
11. Web of Videohemostasia http://www.videohemostasia.com/ (Last access: July 2010).