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RESEARCH PROJECT

Monitoring of hands movement trajectories in the field of laparoscopic and endoscopic surgeries and options in the clinical practice

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ABSTRACT

Within the project "Applied research trajectory hands in laparoscopic and endoscopic operations", ITMS Project code 26240220056, funded by the European Regional Development Fund and the state budget of the Slovak Republic, we created a technical background and algorithms for monitoring and evaluating the hand movements of the surgeon during laparoscopic and endoscopic operations. This is a unique idea and unique project transformed into clinical practice, which is promising to assist in laparoscopic training and inclusion of surgeon / endoscopist to "skilfulness" group on the evaluation of the effectiveness of movements of his hands *(Tab. 2, Ref. 11)*. Text in PDF *www.elis.sk.*

KEY WORDS: hands movement trajectories, laparoscopic surgery, endoscopic surgeries.

The recent research project took place on the Faculty of Medicine of Comenius University soil, where the participants' trajectories of hands movement of varied skill grades were studied. The aim of the research was the development of universal application, which could produce predictions about the surgeon's abilities and skills, based on the standardized curves of the surgeon's hands movement, applicable in laparoscopic and endoscopic surgeries, but also other diagnostic and therapeutic operations in wide spectrum of medicine. The main activity of the research task was to create a capturing system of the surgeons' hands trajectories in the space that could be used for more effective surgery procedures proposal. Given data should be used to be evaluated, partial exercises databases that are vital during the surgeries were created.

Research activities of the project were divided in three phases. The zero point was to equip the research workplace with the technical infrastructure, creating a suitable environment for the research. Within this stage, the advanced capturing, archiving and analyzing ICT technology took place, including new medical equipment and a laparoscopic trainer.

Within the first phase, an application for the surgeons' hands capturing during laparoscopic operations had been developed. In this phase the possible approaches to data collection were considered, choosing from the special sensor equipped gloves, wrist sensors or special sensor in the laparoscopic tools. These were so called direct methods. Another approach was to use indirect methods, i.e. hands capturing using the system of cameras installed in the research workplace. As the most suitable method for the purposes of the project, the combination of the camera system including the depth sensor camera with the combination of the specific parameter in the image – the gloves with the unique marker have been chosen. Using the special sensor equipped gloves seemed not to be suitable because of the noticeable discomfort of surgeons during the surgical procedures, the other mentioned methods were also not suitable because they could not detect reliably the movement from wrists down to the fingers.

In the second phase the database of the surgeons' hand movement trajectory has been created, used for the participants' knowledge classification development. This step had included the definition of the criteria for the participants' classification according to their gained skills.

In the last – third phase the testing of the surgeons according to the hands movement trajectories from the scope of the optimal movement was set. The database developed in the second phase had served as a benchmark value for the testing. Primary task in the third phase was to create predictions about the surgeons' abilities and skills, based on the standardized trajectories of the surgeon's hands movement, applicable in laparoscopic and endoscopic surgeries, and thus determining the optimal surgeons.

The task of the innovative approach to the surgeons' abilities evaluation was the replacement of the standardized lengthy system of the laparoscopic surgeons' preparation, usually directly in the operation room, when junior surgeons only assist passively during laparoscopic operations, gradually starting to actively assist the senior surgeons, and after a certain number of operations they are scheduled for the surgeries as main surgeons.

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Tab. 1. Specific research environmental conditions.

	Pros	Cons
Trainer	• Various cams placement • Various participant and trainer placement according to the cams • Repeat the record option when system fails • Non-sterile environment	• Light conditions (unstable light during the exercises)
Operation room	•Light conditions (relatively constant light after even several hours)	• Fixed cams standing • Unable to guarantee the unique surgeon in the image • Sterile environment • Restricted options of further cams positioning • Unique surgeries

Tab. 2. The character of the laparoscopic operation.

	Pros	Cons
Laparoscopy	• The tool is held permanently by hand. The method is changed only in the specific action executed by the tool (e.g. cutting), resp. when changed to different tool. No necessity to analyse the hand gestures. • Laparoscopic tool action is commonly not perceptible to the eye • Standardized shape of the tool	• The surgical glove colour is not unique in the image, can be changed during the surgery (i.e. covered by blood)

Project realization

The given aims of the particular phases were needed to achieve the final result positive evaluation. Based on the chosen methodical approach it was possible to evaluate the research. Within the first phase, application development, the approach under the four defined steps was necessary. One of the external factors that was taken into account, was the specific character of the environment of the Faculty of Medicine of the Comenius University, i.e. various conditions in the case of the tasks executed on the laparoscopic trainer and real surgery (Tab. 1), as the character of the surgery (Tab. 2).

System of the data collection and analysis had to be developed while considering these factors and to enable the ex post semi-automatic processing of the experimental data.

Based on the available input information and limitations, within the first phase, after the technical infrastructure installation, the application had been developed, based on principles of the image data capturing, data reconstruction, selection of the surgeons' hands in the image, identification of the hands position and further dimensional time stamped hands movement monitoring. Based on this procedure, an application has been developed, that monitors, captures and evaluates the hands movements during the exercise. The application had been then installed in the Faculty of Medicine of Comenius University's dedicated places and took an inherent part in next phases of the research.

In the second stage, using the application and the chosen procedure the database of the laparoscopic trainer exercises was created. There were three main categories of the participants defined.

Student has theoretical knowledge of the laparoscopic operations, but has no practical experience. Advanced user have strong theoretical knowledge of laparoscopic surgeries, have assisted the laparoscopical surgeries, though have never operated. Expert has excellent theoretical knowledge and has led number of surgeries. Definition of the categories was proposed according to the classification of some hands movement characteristics. Categories were defined on the basis of the quality of the exercised predefined tasks, as the benchmark value the results of the most skilled category of the participants – the experts were used. Analyzing the results with the benchmark the database of the exercises was created and participants were classified into three categories. Experiment on the laparoscopic trainer consisted of four exercises, two in virtual environment and two on the laparoscopic trainer. According to the experts hands movement trajectories the scatters of the participant movements were defined and then classified into the categories.

The third stage, the experiment, consisted of the participants testing within the predefined exercises and their classification based on the database created in the previous phase. Participants were told to execute one of the exercises, their operation was captured with the same method, evaluated and the participants were assigned to the categories according to their results.

Output of the first phase have been the mechanism of capturing and recording the surgeons hands movement using the technical equipment – cam system capturing the hands movement within the laparoscopic trainer manipulation. In the second phase the surgeons hands movement database has been developed, allowing to create the predictions about surgeons abilities. Application enabling surgeon testing according to the hands movement trajectories in terms of the optimal movements has been developed in phase three.

Results given by the categorization function had brought the conclusion that practically in all exercises it was possible to observe an improvement among the defined categories, confirming the presumptions, standing as the background in their defining process. Subsequently, the possibility of grouping the participants according to the results has been verified. In exercise 1, categorization function correctly defined new participants into existing categories, comparing their abilities with the database benchmark. The characteristics selection itself seemed to be correct and the assumption of improvement/deterioration of values in means of the skills categories as legitimate.

The research was held on the laparoscopic trainer, in virtual environment, respectively, where the chosen participants were asked to practice even moves that were evaluated by the application according to a set benchmark. In case of real surgery is the system using this method usable in a very limited extent however, since each surgery is unique, it needs a unique approach to the patient and to the surgical intervention. For these reasons it is not possible to use the principle of the hands movement based on the database in the clinical practice.

To evaluate the possibility ofof using the system in clinical practice the further research is required, which should be focused on the search for more accurate characteristics of the surgeon work categorization, alternatively would be concerned for other aims than determining the skills category, for instance: wrist strain as the outcome of multiple hands rotations, unworthiness of the laparoscopic tools and further research.

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