Virtual Environment for the Training of the Hands in Minimally Invasive Thoracic Surgery

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***Abstract*—The hand and eye coordination of the surgeon is one of the most important factor minimally invasive thoracic surgery. Virtual Simulation is a powerful training tool in surgery. At present, the main problems of the learning process are to reduce the learning time and to improve specific skills by the simulation. There are different options to perform tests: working with animals, with artificial tissues to simulate the pressure, and even simulators through joystick. The main disadvantage is the high cost of this systems and the complexity to replicate the situation during a real operations. In this paper, a virtual reality system is presented. This system allows to reduce the learning time and to improve the hand and eye coodination of the surgeon. Moreover, it is a low cost, portable and easy-to-use solution for future surgeons.**

1. Introduction

In the world of minimally invasive thoracic surgery the hand and eye coordination of the surgeon is one of the most important skill. The virtual simulation is a powerful training tool [1]. It allows to reduce the learning time and to improve specific skills repeating the simulation. The main challenge now is to apply minimally invasive techniques using low cost systems. The most problem is also to replicate the appearance and functions of the human body. The thoracoscopy requires a different skills than open surgery. The thoracoscopic camera is inserted and the surgeons see patients from the inside out. The virtual simulator allows surgeons to practice their skills in a non-clinical environment.

Actually, there are different commercial approach. The commercial systems are dedicated to helping the future surgeons to understand each step of an operation by simulation exercises. The expensive systems provide a training solution to learners.

The da Vinci Simulator [2] is a expensive and full system designed to give users the opportunity to improve their skill with the da Vinci surgeon console controls. Its not only a simulator, it can use a specific machine for surgery purpose. The main advantage of simulation include the ability to measure progress and also increase the familiarity with the da Vinci System. One of the main problem is that the exercises are thinking for its specific console controls.

The LapSim Haptic System [3] is a new generation of tactile feedback for surgical education. It includes a haptic hardware platform with LapCam.

Immersion Medical introduces LaparoscopyVR Surgical Simulation System [4]. It is the laparoscopy surgical simulator designed as a complete system with tightly integrated TouchSense-enabled haptic hardware and software.

The Simbionix LAP Mentor [5] stands out amongst available laparoscopic surgical simulators by providing a complete training solution to learners in gynecology, urology and general surgery.

Surgeon Simulator [6] is a video game that it allows to perform a heart transplant, using any tools available. The goal is to complete the operation in the quickest time possible, with minimal blood loss. the user interaction is using a finger manipulation control system.

In the previous systems and video games, the main disadvantage are the expensive, non-portable system, and the difficult to use a real surgical instrument. Our virtual simulator allows to improve the hand and eye coordination of the surgeon, to use a surgical instrument, to replicate the operations. Moreover, it is a low cost system and portable solution.

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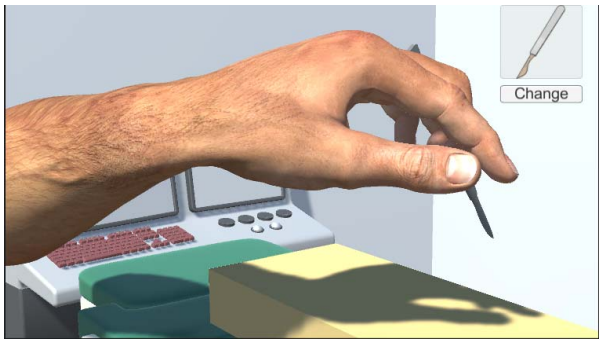
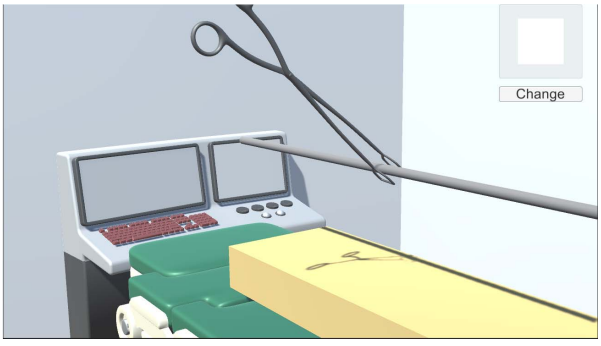
2. Game system

According to the features of the project, natural interaction has been chosen as the best option to make it easy to use for users. The most suitable devices for the needs of the simulator were Leap Motion [7] and Intel Real Sense because they were the only devices capable of using fine motor skills and a recognition of the hands. Between these two devices finally Leap Motion was opted to integrate it, since it is cheaper than Intel Real Sense and the precision that offers in hand tracking is acceptable to develop a surgery simulator.

The user can have a surgery tool on the hands (see Figure 1a) to make the simulation more realistic and will be reflected in the virtual environment. The tool, displayed in the virtual hand, is selected in the tools panel of the interface and is possible move this tool (see Figure 1) with the tracking hand.



(a) Scalpel Tool



(b) Surgycal Forceps Tool

Figure 1. Surgery Tools in action.

This application aims to train professionals who are dedicated to surgery and develop skills that will serve them in their profession. This serious game has a training mode thus is necessary to adapt to this type of devices that are not normally used and require some practice to use them. This mode of training included two types of gestures: pinch gesture and swipe gesture. When these gestures are made correctly will give feedback to warn that the gesture has been recognized by gesture recognition module. Training shall be considered overcome when the user is able to make the moves a certain number of times. This game mode is optional and the intention is to make it easier for the user to complete various activities of the game.

The flow of interaction of the game begins with the activation of the service of the Leap Motion device. This service communicates with the application to be able to use the features of this device in the game and to do hand tracking and gesture recognition. The mouse is used to interact with screens that have menu or user have to make decisions as for example hand that you want to use in the game. When the user has to perform activity disables the use of the mouse and keyboard to enable interaction with the Leap Motion sensor and activates the module corresponding to the tracking of the hand. This module collects at all times the position in x, y, z of the hand so that it can be moved by the virtual environment and can interact with other objects. There is also a module for the recognition of gesture, which has a series of gestures implemented by default for use in the activity. Each of these gestures will have a set of associated, being the main States States: the initial state and final. The user will have to go the initial state of the gesture to the final State in a period of time so that it is recognized by the system and do the corresponding action. The application also has a module of evaluation provided an assessment the user depending on their behavior in the activity.

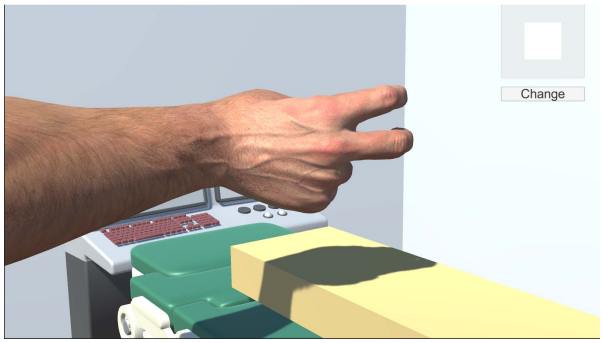
2.1. Activities

These activities have been developed for user acquire a set of skills in the field of surgery through the game. The game is composed of three activities:

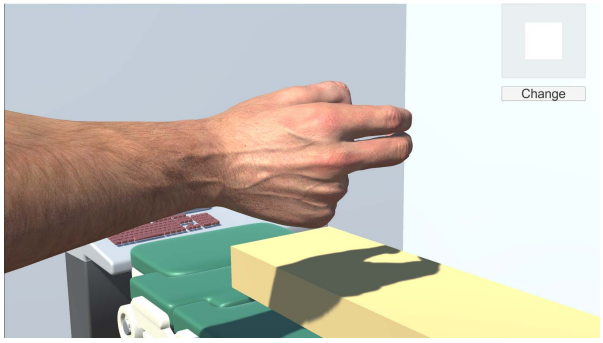
The first activity aims how to use clamps. First the user will have to select which hand you want to work or if you want to work with both hands equally. The possibility of working with one hand makes that it is to improve the skill in hand that the gamer has less skill. Below is a series of objects on display and a box. At all times will be shown a counter to find out how much time has elapsed and the number of objects that the user has inserted in the box. The user will have to pick up objects that will appear on screen and place them in a box. The size of objects depends on the chosen for the game difficulty, if the easy difficulty is chosen the objects will be large, while if it is difficult objects will be smaller. When the user put in the box all objects activity will be completed. Activity you can do with the hand right, left hand or both hands depending on the option chosen previously. When the user has finished the activity will be changed to the evaluation screen, where you will be informed the user of his/her score depending on the time of the exercise.

The second activity involves cutting a cable, two instruments will be used for this purpose: tweezers and scissors. Clips are used to hold the cord and scissors to cut it. First the user can choose previously if he/she wants to make the action from the clamps with the right or left hand and also the action of the scissors. After taking this decision appears a cable that will have a thickness determined depending on the chosen difficulty, in easy mode the cable is thick and hard cable will be fine. The user will need to fasten the cable

with the hand that has clips, being useless cut the cable if the user has not caught the cable previously. When the user has picked up with tweezers cable, you can then cut the cable. To cut the cable, the user has to repeat the associated gesture to be cut about 5 times. If the cable doesn't keep him subject and falling, the user will have to repeat the gesture until the 5 repetitions needed to cut the cable. Evaluation will consist of time which the gamer has taken to cut the cable and as a result you will get a score based on this time.



(a) Scissors Gesture Open

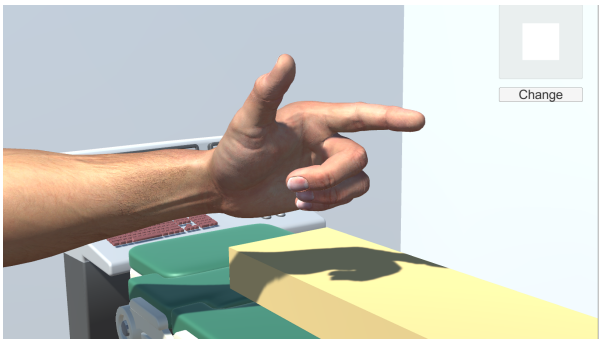


(b) Scissors Gesture Closed

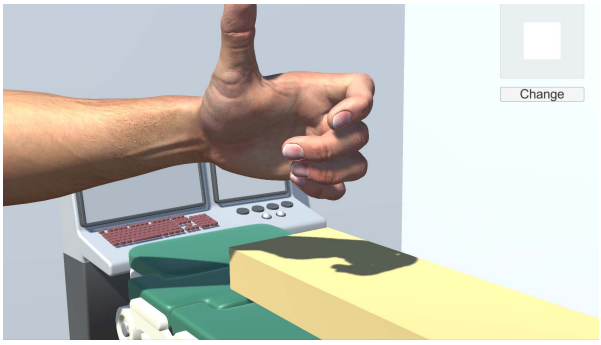
Figure 2. Type of scissors gestures.

The third activity will appear a series of spheres around the cable, the objective will be to join each of the spheres making a similar gesture to the movement that you make when using an electric scalpel. First the user must choose which hand you want to use for the activity. Then appears a cable with a number of areas in a particular area to join them. The number of spheres depend on the chosen difficulty, if you choose the easy way to create less areas but on the other hand if the user chooses hard many areas are created. There is a counter as in other activities to control how long the user is able to unite all areas. The user will get a score according to the elapsed time, to more quickly will be the score.

In each of the activities will be assigned a score depending on the user's action. In the first activity will be evaluated time activity, carried out to greater time will be the score. In the second activity will be assessed the time and the number of repetitions. The number of repetitions must be equal to 5 to get the cable to be cut. The third activity is taken into account the time to complete the activity. When the activity



(a) Scalpel Gesture Open



(b) Scalpel Gesture Closed

Figure 3. Type of scalpel gestures.

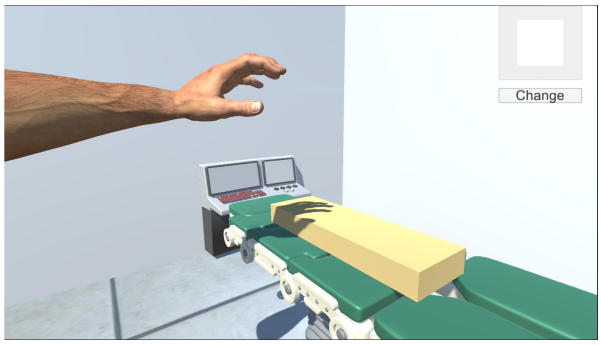
is completed is loaded a screen showing the result of his action in said activity. To assess how has made it a series of stars, will be displayed on screen a star is the lowest score and will be qualified as a beginner, while four stars is the highest rating and the user will be considered an expert.

A ranking was created to motivate the user and get a competitive environment with the aim that users have an incentive and work when they do various activities. Depending on the score obtained in the test user will be in a position in the list, with the consequence that the user wants to repeat the activity in a better position to overcome fellow.

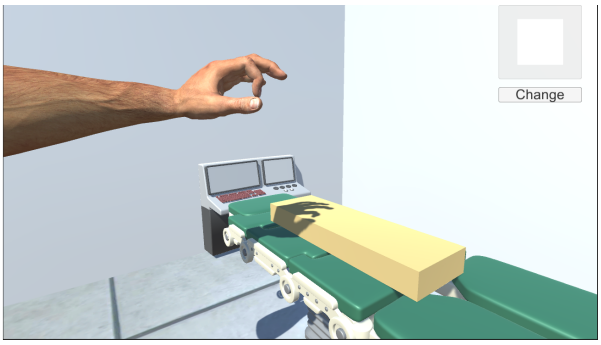
For each of the activities there will be three levels of difficulty: easy, medium and difficult. The chosen difficulty level will determine the size of the objects; a higher level of difficulty, the objects will be smaller or finer (such as cable), being more difficult to catch them. In the case of the third activity the level of difficulty is also determined by the number of areas that the user has to unite, to greater number of major areas will be difficult to complete the exercise.

3. Conclusion and Future Work

The virtual simulator allows to improve the hand and eye coordination of the surgeon in minimally invasive thoracic surgery. It includes different exercise with surgical instruments to evaluate the specifics skills. The system has been implemented using a leap motion device. It is a low cost system and portable solution.



(a) Pinch Gesture Open



(b) Pinch Gesture Closed

Figure 4. Type of pitch gestures.

Intended future work is to that when the user to work with the tools of surgery you can feel the pressure and the texture of the object with which it is working. Thus when cutting a fabric it will exert a degree of pressure corresponding to the tissue being cut. Tissues will behave in a different way to make more realistic the experience of surgery.

In future developments is intended to include more tools of surgery to enlarge the actions that the user can do. Include more gestures depending on the tools used. Create a multiplayer mode so that multiple users can be in the same operating room and each is responsible for a specific task and see skills that has each of the participants, as well as the coordination and work in team between them.

Acknowledgments

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