Optical Instrument Tracking for the Training of Navigated Surgery Procedure

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Introduction

The aim of this project is to create a low-cost optical tracking system using Microsoft Kinect. Previous study has created algorithms that can detect the markers and recreate the surgical tools.

Figure1 Kinect v2[3]

This study verified the accuracy of both colour and infrared detection. On the basis of this, an user interface was also created to make it easier to use these functions. In the UI, the tracking method was further optimized to make it possible to match the position of the box with the surgical tool.

Also, in order to put this system into real training use, a series of exercises were created by other study where a specific designed box was used to represent the patient . And this study combined it with the UI created by importing a STL file to represent the box used in the exercise.

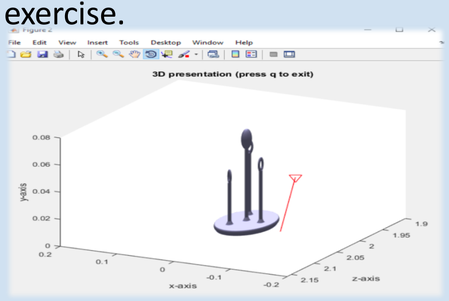
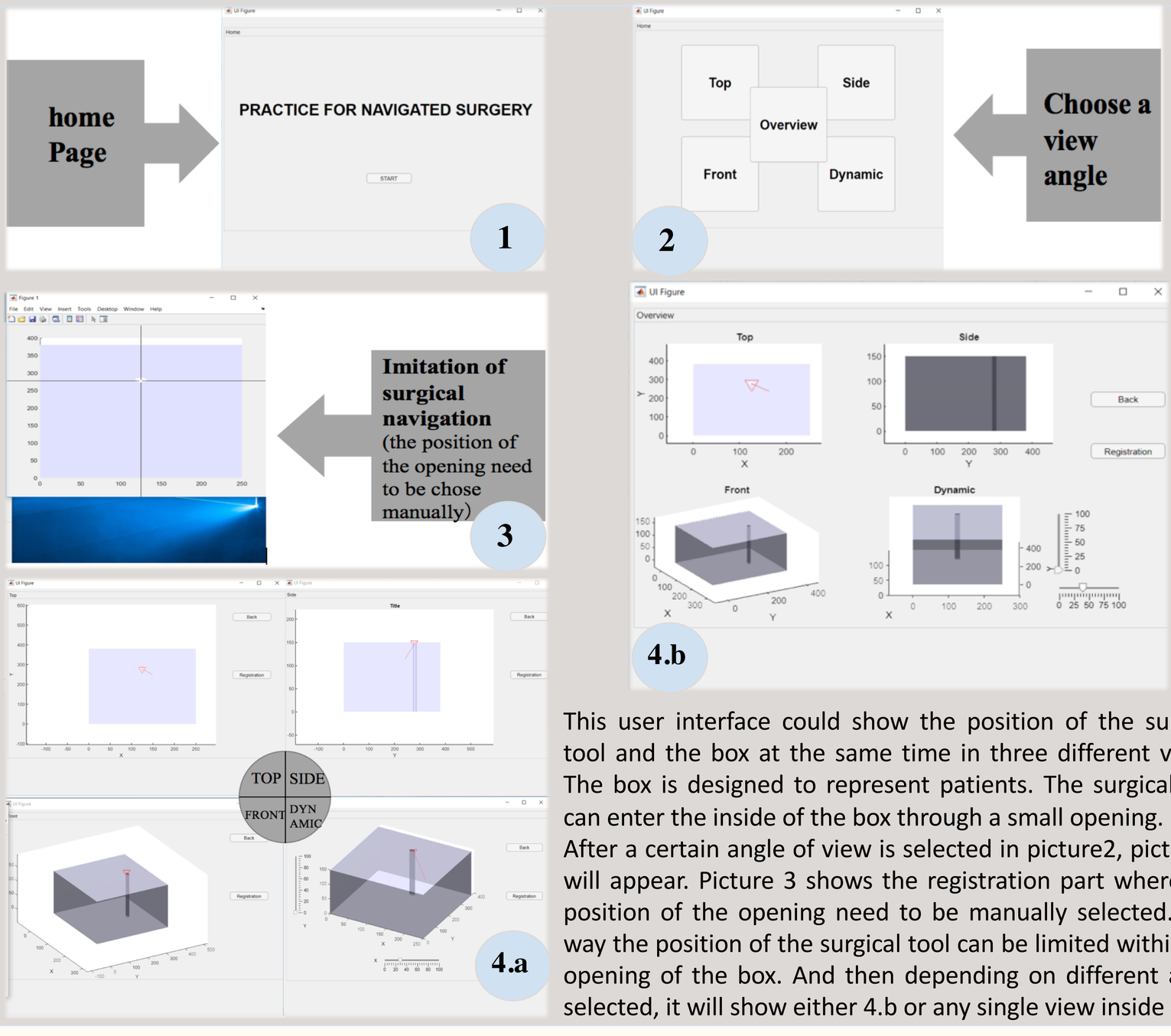


Figure2 Previously established tracking system based on infrared detection[4]

User-Interface Design



This user interface could show the position of the surgical tool and the box at the same time in three different views. The box is designed to represent patients. The surgical tool can enter the inside of the box through a small opening.

After a certain angle of view is selected in picture2, picture 3 will appear. Picture 3 shows the registration part where the position of the opening need to be manually selected. This way the position of the surgical tool can be limited within the opening of the box. And then depending on different angle selected, it will show either 4.b or any single view inside 4.a.

Background

Navigated Surgery is a surgical process which can detect certain markers placed on the patients and the surgical instruments and combine it with the preoperative CT or MRI, helping the doctor better locate and perform on the lesion.[1]

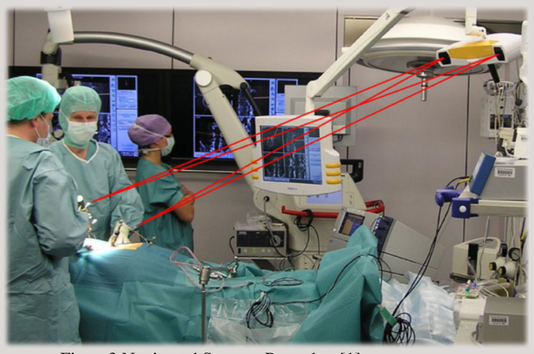


Figure3 Navigated Surgery Procedure[1]

The optical tracking system (OTS) is a device that can locate the position of some specific landmarks by stereoscopic cameras collecting infrared spectrum. The current one has a high accuracy ranging from 0.1nm to 1.4nm but the cost is also very high due the application of sophisticated scope. Due to the high cost, it is not easy for medical students to gain accesses to this kind of device and practice on it.[2]

Previous studies have shown that the Microsoft Sensor V2 has a potential in simulated the OTS system. It is also low-cost and easy to get. So , this was chosen to create the OTS.

Methods: Object Tracking

First thing this study done is to optimize the detection algorithm. Previous study used the coordinates of three markers arranged in triangle to calculate the position of the tool's tip. But the coordinates of the STL file is random when imported into MATLAB. So this study add another marker on the opening of the box. Then the length of the tool inside the box can be calculated. With the combination of the 3D formula of the original tool. The computer will be able to draw a new line going through the opening to represent the tool.

This study also verified the accuracies and stabilities for both detection method. Previous study has found out the best distance between the camera and marker is 2m. From the table bellow, it can be seen that color detection shows better performance in both x, y and z measurements. Though when it comes to stability the infrared is better, variances for both method is less than e-07 which can be ignored.

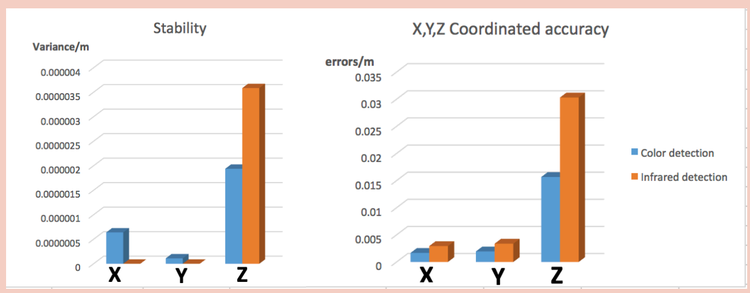


Table 1 xyz coordinates accuracy test

Table 2 stability test with time changing

Conclusion and Discussion

- This study verified the accuracy and stability of both color and infrared detection. After analyses and comparison, color detection was chosen for further study.
- A user-interface was designed, with ability to show the position of the surgical tool and the box at three different views. Also the interface provide a function similar to the surgical navigation system. This will make the practice more like a real navigated surgery procedure.
- Further study needs to increase the accuracy of the whole detection process. This will make sure during the exercise people can see clearly whether the tip of the box has reached wanted area with sensors. Then the box will send back signal to the computer

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References:

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[4] Ilias Velmachos, "Optical tracking device based on Kinetic sensor for navigated surgery procedures,"