Bi-Weekly Report

27 March 2015

Team Information

This document contains a summary of all that has been achieved over the last two weeks by team 19 on the CTSNet Robotics project as a part of the module Systems Engineering II of the University College London Computer Science course. Team 19 is formed of three students, Edward Collins (team leader), Kirthi Muralikrishnan (website and documentation lead) and Tom Page (research and programming lead).

Client Information

Team 19 has three clients:

~Dr Shabnam Parkar, paediatric surgeon at Great Ormond Street Hospital.
~Dr Joel Dunning, cardiothoracic surgeon at James Cook University Hospital.
~Dr Lourdes Agapito, computer graphics and vision expert at UCL and primary supervisor.

Summary of Progress

Six months later, and the team nears completion of the Systems Engineering Modules and our work on this project. We have arrived at the final bi-weekly report.

The past two weeks have been successful once again. The main achievement has been the construction of the final software of the system, which draws together all of the research and experimentation done by the team to create the first iteration of the DepthSensingSugricalSystem software. The application's user interface is not yet finalised and will be re-designed over the coming Easter break, but serves the purpose of exhibiting the various visual augmentations that we have designed and built.

The system currently consists of three augmentations:

- ToolProximity - the main augmentation of the project. This colours the surgical tool based on how close it is to the background of the image, which would be the body tissue in surgery. This algorithm is not yet optimised and still runs too slowly, so will be the focus of work over the Easter break.
- ColouredDepth - an augmentation that colours the whole image according to the depth information gathered by the Kinect. Specifically, this colours each pixel of the image based on its depth value, giving red for further away and green for closer to the Kinect.
- ColouredToolDepth - an augmentation that colours the surgical tool based on how far away it is from the Kinect. Specifically, this algorithm searches for green pixels in the image, measures the depth values of these pixels and then colours these based on what the depth value is.

Each of these augmentations can be applied by clicking a button. Currently only one augmentation can be applied at a time. In addition to this augmentation view are two views showing the depth and normal colour images received from the Kinect, which will provide a constant normal view of the operational area in the event of the augmentations failing. Screenshots of the system are shown below simply of a green bottle on a whiteboard background.

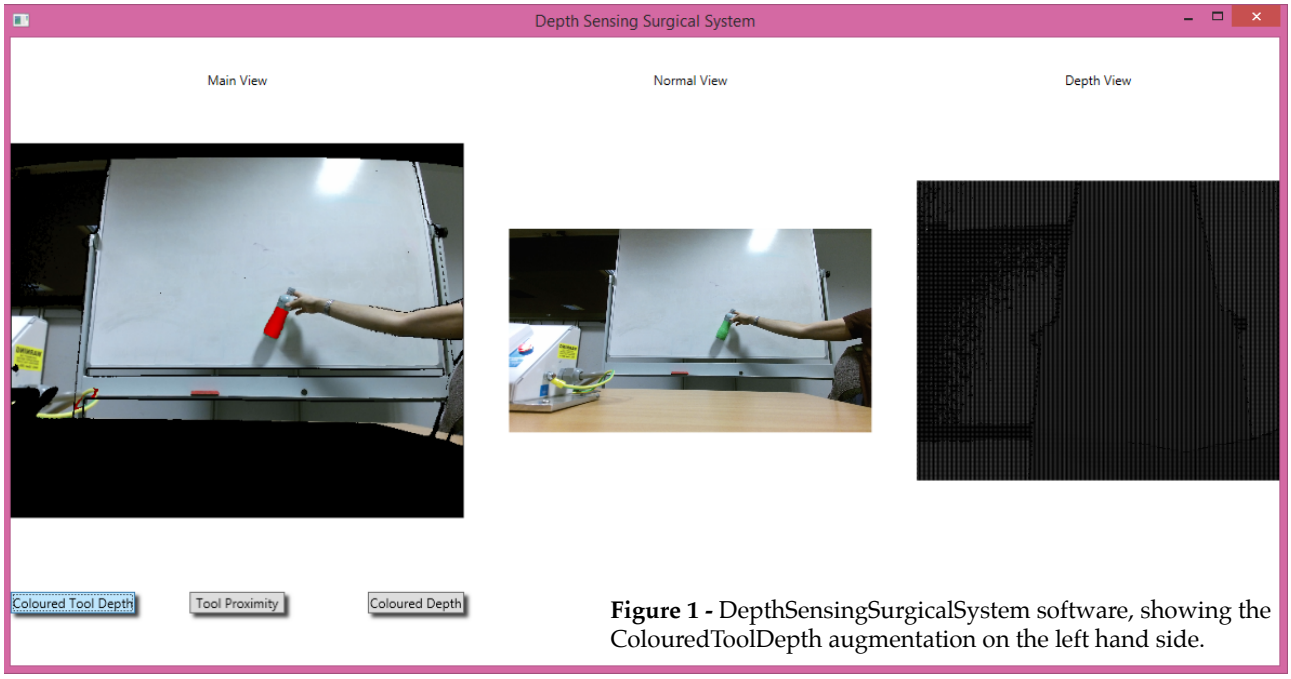

Figure 1 - DepthSensingSurgicalSystem software, showing the ColouredToolDepth augmentation on the left hand side.

The application is written according to the "strategy" design pattern, with each augmentation as a strategy as well as tool identification and system controller strategies in their own separate folders within the project. This means that strategies can be easily added to by future developers to give other visual augmentations, methods of tool identification or system control, for example adding a strategy so that the system gives haptic feedback.

Significant development occurred in the fields of ColouredDepth and ColouredToolDepth, where rather than having hard thresholds for changing the colour as we previously had, a mathematical function is now applied to the depth values of each pixels to determine what colour they should be set to. The issue of two objects sometimes appearing in the camera view was also solved - it turned out that this occurred whenever objects were too close to the Kinect giving inaccurate depth readings.

Furthermore, the team has discussed with Max Allen from the Surgical Vision group at UCL about methods of identifying surgical tools without the need for green tape, and briefly with Dan Stoyanov of the same group about the construction of test scenarios for the system which will take place over the Easter break.

Summary of Team Meetings

Date	Topics Discussed	Time
17 March 2015	Meeting with Dr Agapito. Discussed doubling issue.	30 minutes
20 March 2015	Demonstration of final system to Dr Agapito and Aron Monszpart.	1 hour 30 minutes
27 March 2015	Lab session. Discussion of methods of speeding up algorithms with Aron Monszpart.	1 hour 30 minutes

Difficulties Encountered

The primary difficulty encountered was the sluggishness of the ToolProximity augmentation. While this does colour the edges of the tool based on how close they are to the background, it runs extremely slowly and is by no means ready for deployment. To be deployment-ready, it will need to be significantly speeded up. Furthermore, it currently only colours

the edges of the tool based on how far away they are from the background, not the whole tool. The team has several ideas about how to fix this issue and speed it up which will be implemented over the Easter break. The second main problem was that the augmentations were found to run at vastly different speeds depending on what machine they were running on, most likely meaning the algorithms need to be optimised slightly more than they currently are, and employ multi-threading.

Progress Target

By the end of the Easter break, the team will:

- Speed up the ToolProximity algorithm.
- Re-design the graphical user interface to make it more attractive.
- Experiment with making the system voice controllable.
- Add augmentations to give explicit depth feedback through colour, giving exact measurements of the distance of objects from the camera.
- Make the system multi-threaded so that it runs more smoothly.
- Build the test scenarios for the system.
- Complete documentation on the website.
- Make the final system video and plan our technical presentation.

Soon after returning from the Easter break the team will be giving a technical demonstration of the system to a panel of examiners, which will conclude our work on the project.

Individual Descriptions of Tasks

Ed Collins

The main task I have completed in the last two weeks is the building of the final system framework. I created the skeleton classes of the final system, as well as a main class and the user interface to display the visual augmentation being implemented. My teammates and I then added the various visual augmentations used by the system to this framework which abides by the strategy design pattern to make the final system. I have also corresponded with the Surgical Vision group to develop ideas to improve the project. Our work on this project nears its end now, but there is so much potential with this project that I sincerely hope that we will not be the last to work on it.

Kirthi Muralikrishnan

Over the last two weeks I have worked on creating a heat map algorithm. It shows a progressive change in the colour of the feed depending on its distance from the camera. This works fairly well and does it efficiently. I had also integrated the heat map with the ColouredToolDepth that identifies the tool due to its green colour and then changes its colour depending on its distance from the camera.

Over the next few weeks I will try to come up with methods to make our system to run faster and more efficiently. If I have time, I will try to include voice control in the system. Improvements have to be made on the tool proximity algorithm. I will also update the website and help with the documentation.

Tom Page

Over the past couple of weeks I have managed to develop a working version of the ToolProximity program. In addition we have transferred the program over to an object oriented approach in order to allow our system to be more understandable for future development and also to implement the “strategy” design pattern.

Our final few weeks will focus on improving the speed of the algorithms in order to allow the program to run more quickly as at present the ToolProximity feed runs at around 1 frame per second. In addition we aim to make our system multithreaded, again in order to improve efficiency.