Surgical Robot for Biopsy Using Stiubli 6 DOF Robot

Md. Kamrul Hasan
Fakrul Islam Tushar
kamruleeekuet@gmail.com
f.i.tushar.eee@gmail.com

Medical Imaging and Applications (MAIA)
University of Girona (UdG)

January 20, 2019

Contents

1 Project Proposal

1.1 Objectives

The objectives of this project is to design and implement a medical robot that will able to perform the surgical biopsy to remove specific pre-defined parts e.g. tumor from any parts of the body, calcified tissue in breast, cancerous tissue from any parts of the body etc.

1.2 Explanation of the project works

The generalized block diagram of the proposed project for the surgical biposy is shown in Fig. 1. To accomplish the objectives of the proposed project, end effector of the robot has to move from initial position (X_1, Y_1, Z_1) of the end effector to target position (X_4, Y_4, Z_4) of the tissue that has to be removed. To do so, there are some intermediate points (X,Y,Z) on the trajectory of the robot end effector path. One point (X_2, Y_2, Z_2) is vertical first point (see Fig. 1) and another one is trocer mouth (see Fig. 1). After reaching in the trocar mouth, end effector should move very precisely so that it does not press excess pressure on the specified organ. Surgical tool that can hold the object already mounted on the end effecter of the robot. Finally, after reaching to the target position (X_4, Y_4, Z_4), surgical tool holds the organ/ tissue and remove it from the body.

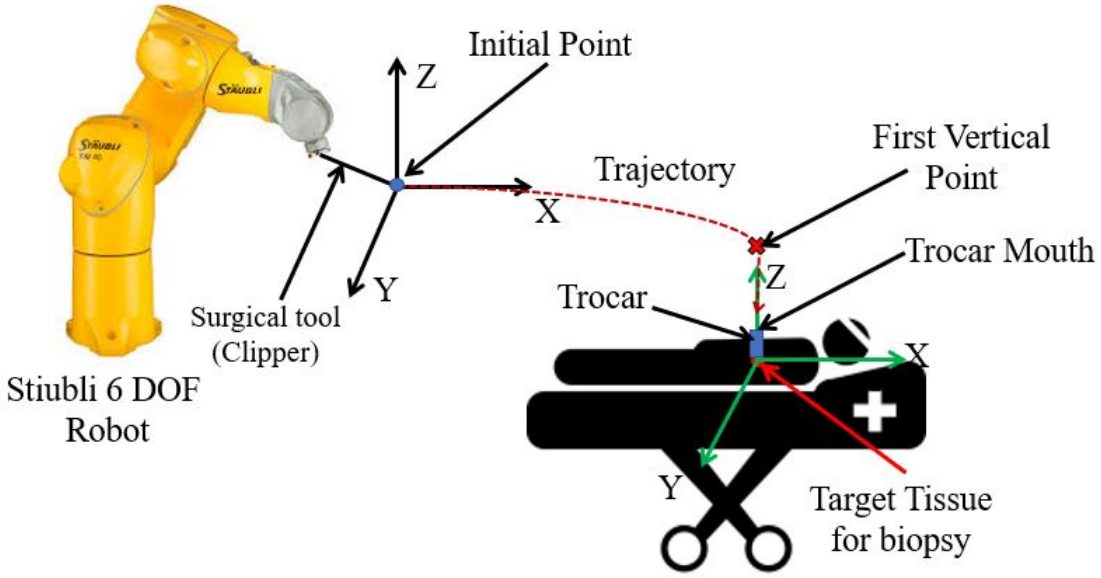


Figure 1: Generalized block diagram for the biopsy using stiubli 6 DOF robot

2 Introduction

A biopsy is a procedure to remove a piece of tissue or a sample of cells from a lump or mass of the body. Usually, a biopsy is performed to examine tissue for disease. Biopsies are frequently used to diagnose cancer, but they can help identify other conditions such as infections and inflammatory and autoimmune disorders. They may also be done to match organ tissue before a transplant and to look for signs of organ rejection following a transplant. In some cases, the amount of tissue obtained from a needle biopsy may not be sufficient and the biopsy may have to be repeated. To do the repeated biopsy by the surgeon is not always possible and less precise. To get the precise biopsy repeatedly, surgical robot is the one of the best choice now a days.

Surgical robotics are amongst the most important technologies to emerge over the last decade. Surgical robots may result in higher accuracy and precision than would otherwise be possible. The clinical corollary is that such robots may ultimately improve the safety and effectiveness of surgical interventions [1]. Robotic surgery, computer-assisted surgery, and robotically-assisted surgery are terms for technological developments that use robotic systems to aid in surgical procedures. Robotically-assisted surgery was developed to overcome the limitations of pre-existing minimally-invasive surgical procedures and to enhance the capabilities of surgeons performing open surgery. To design the surgical robot for the biopsy, we have used ***Staubli*** 6 Degree of Fredom (DOF) robot which is shown in 2.

3 Designing and Implementation

The overall workflow that was done for the controlling the robot end effector to do biopsy is shown in Fig. 3. From the Fig. 3, it is seen that the co-ordinates (as shown in Fig. 1) of the different points have been extracted using the CS8 console (which Stäubli calls MCP). Then those co-ordinates are transferred to the the computer processor to process as well as send back to the the CS8 console after processing.

To move end-effector of the surgical robot to the position of the target organ (to be removed), the following co-ordinates (as shown in Fig. 1) were taken as shown in table below.

Figure 2: Stiubli 6 DOF robot that has been used

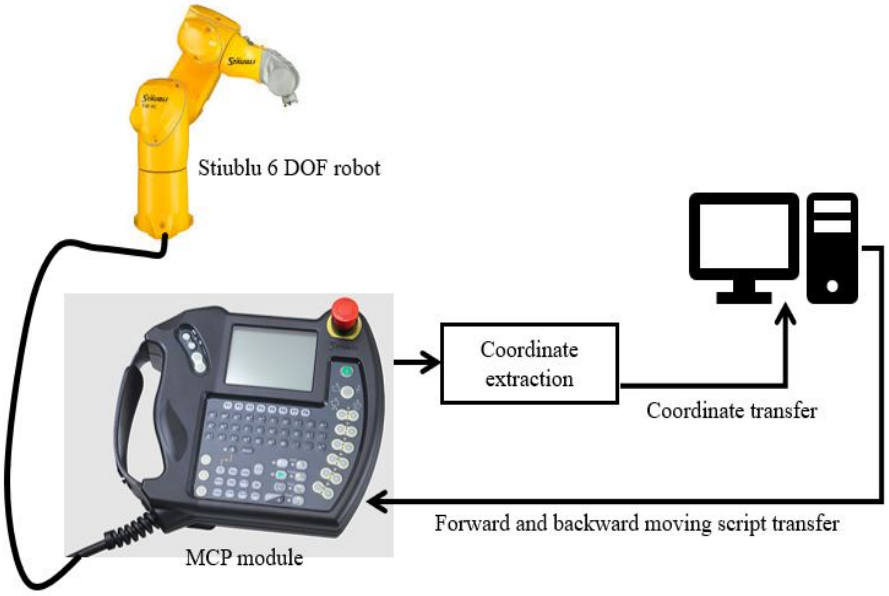


Figure 3: Generalized block diagram of the project work

Co-ordinates of the different positions	
Co-ordinate name	Position of the co-ordinate
Initial Co-ordinate	(X_1, Y_1, Z_1) = (505.35098, 0.201647, 440.283147)
First vertical point	(X_2, Y_2, Z_2) = (396.095915, -1.909677, 109.563785)
Troccar mouth	(X_3, Y_3, Z_3) = (396.095915, -4.035643, 46.710945)
Tissue point	(X_4, Y_4, Z_4) = (396.095888, -4.03564, -44.876421)

Using those co-ordinates, first of all, robot has been simulated in the simulation platform. The initial position of the robot end-effector in the simulation environment is shown in 4.

The first vertical point, troccar mouth and target postion of the end-effector in the simulation environment are shown in Fig. 5, Fig. 6, and Fig. 7 respectively.

After performing the simulation, the interface between the CS8 console (which Stäubli calls MCP) and stiubli robot has been established the following script as shown in Fig. 8 has been used.

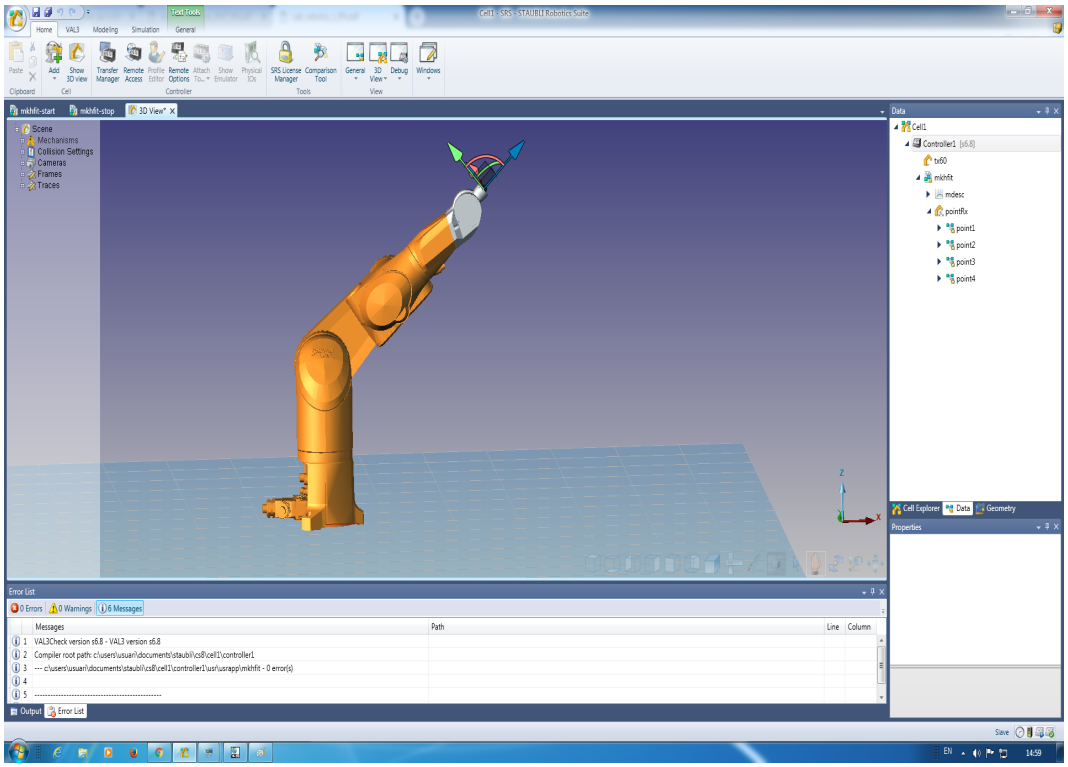


Figure 4: End effector initial position at (X_1, Y_1, Z_1) = (505.35098, 0.201647, 440.283147)

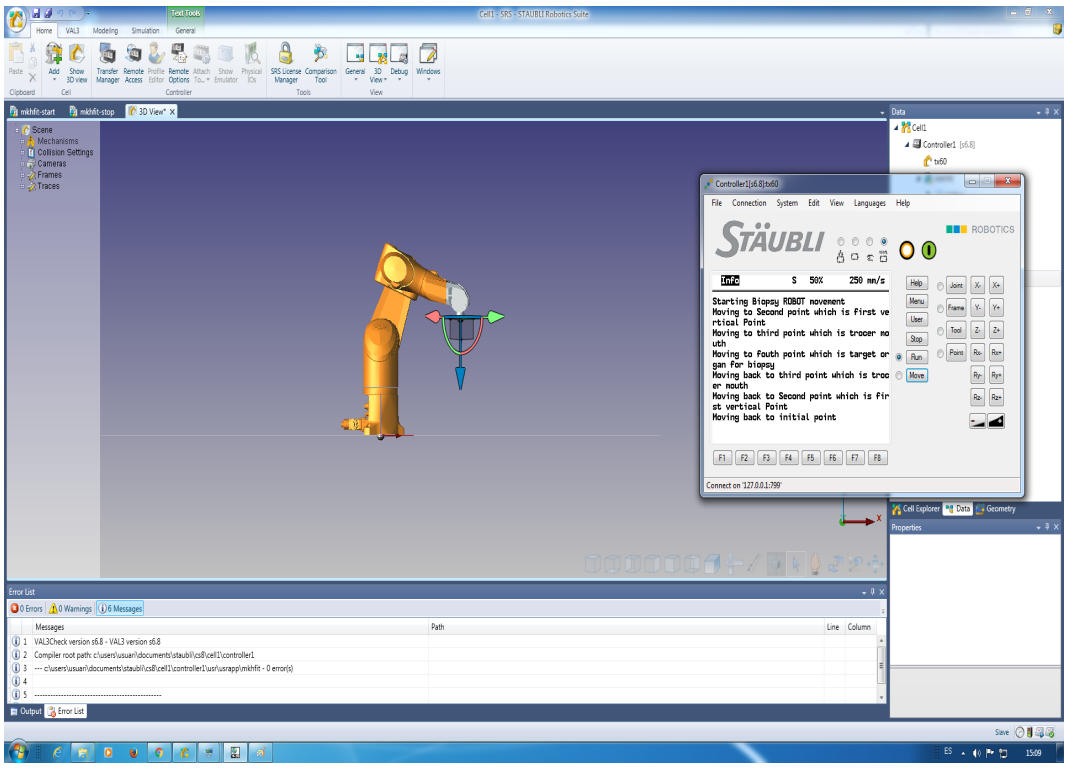


Figure 5: End effector first vertical position at (X_2, Y_2, Z_2) = (396.095915, -1.909677, 109.563785)

The different positions in the real case of the end effector of the stiubli robot for the biopsy is shown in the Fig. 9.

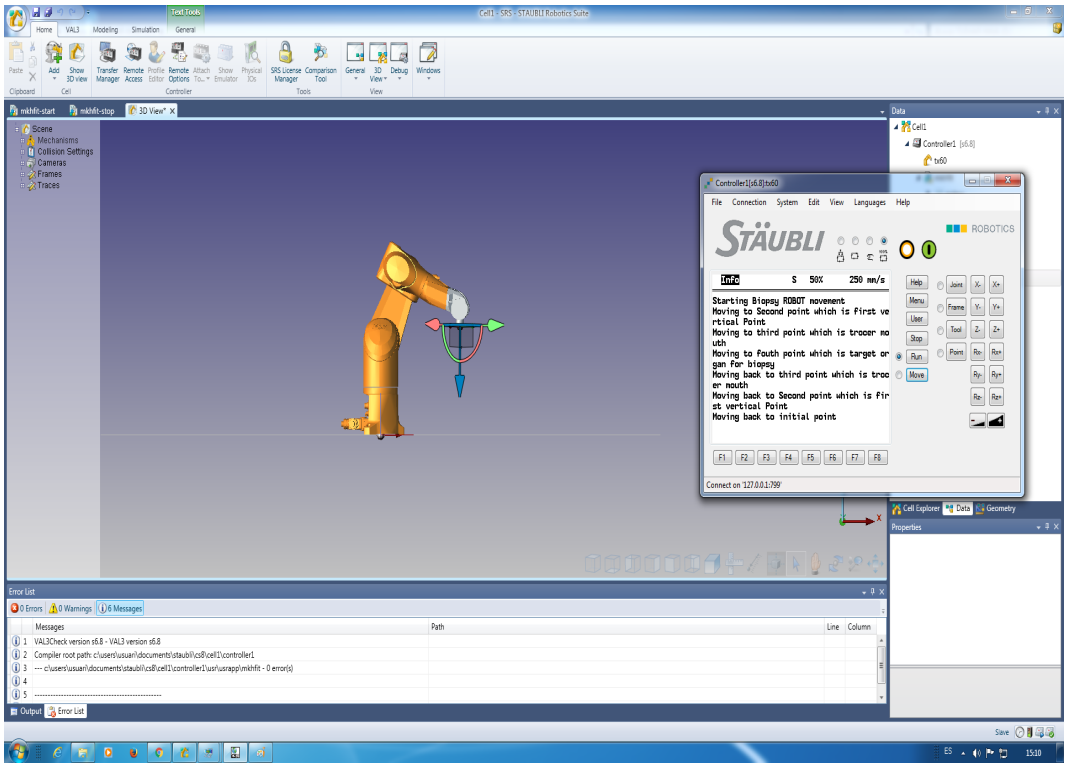


Figure 6: End effector troccar mouth position at (X_3, Y_3, Z_3) = (396.095915, -4.035643, 46.710945)

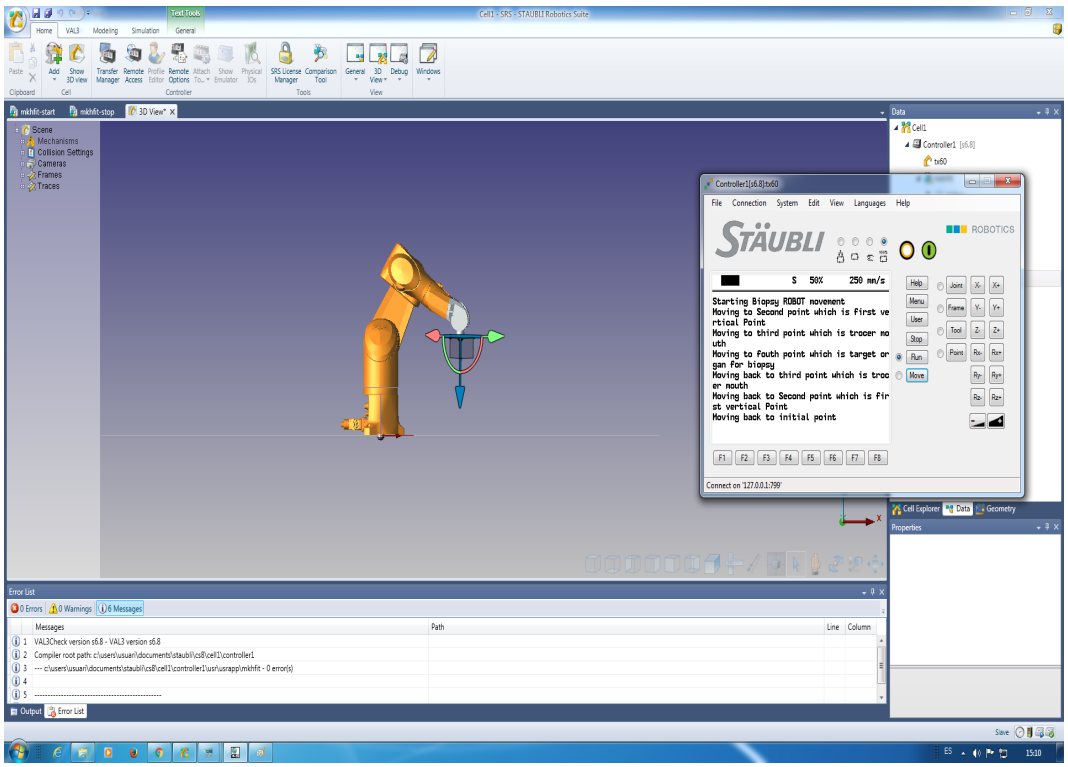
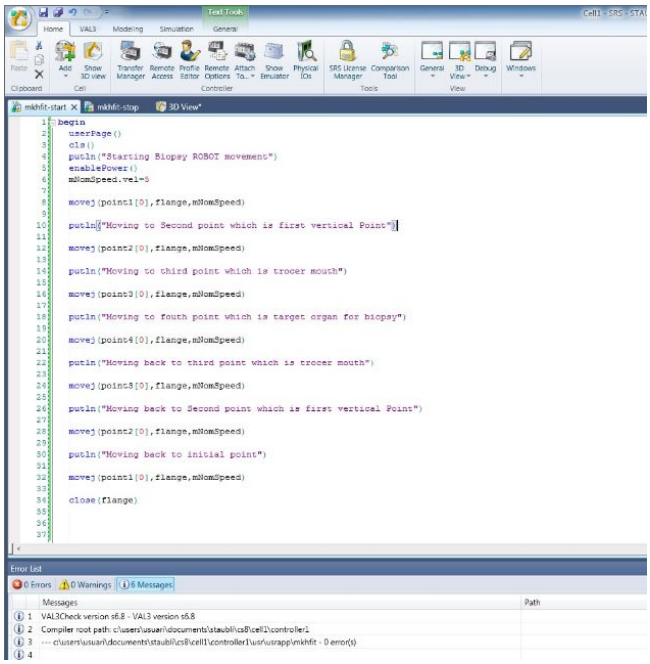


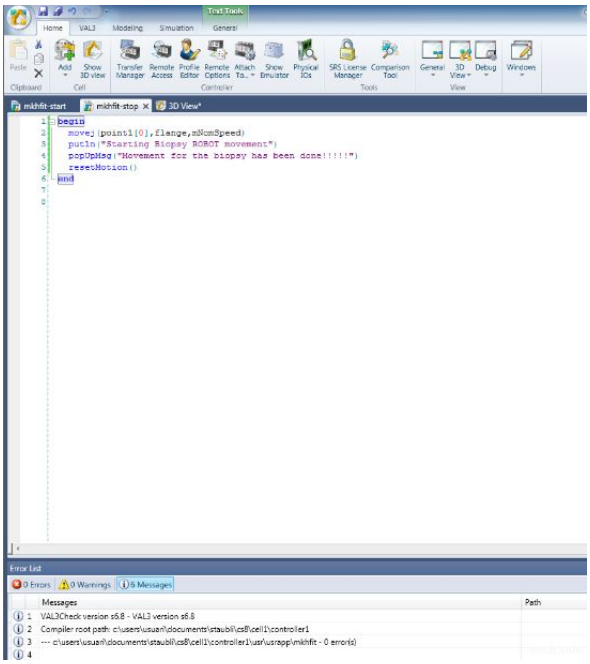
Figure 7: End effector final target position at (X_4, Y_4, Z_4) = (396.095888, -4.03564, -44.876421)

4 Discussion

The designing and implementation of surgical robot has been done in this project. The movements of each joint of the stiubli robot to bring the end effector to the target position was precise and accurate. During the forward and backward movement of the end effector, video was captured



(a) For the forward movement



(b) For the backward movement

Figure 8: The source script to control forward and backward movement

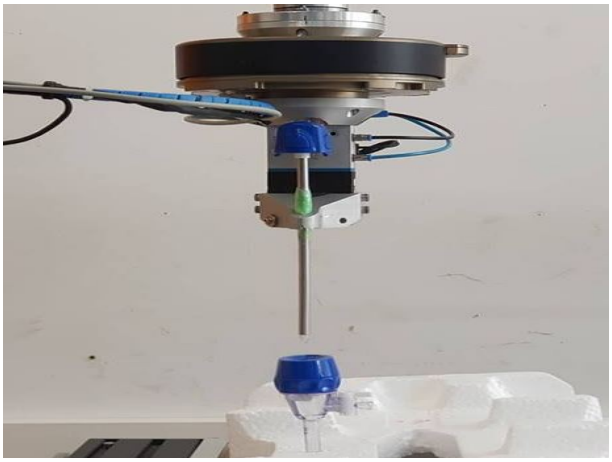
which has been added with this report. From the video, it is seen that after reaching to the troccar mouth, the end effector moves slowly and very precisely so that surgical tool dose not pressurize excessively to the tissue.

References

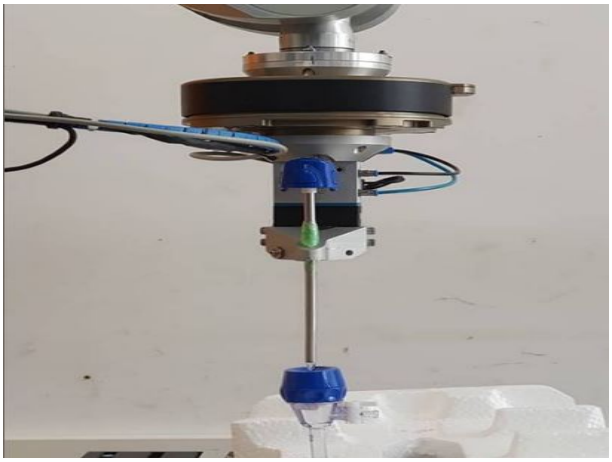
[1] Hughes-Hallett A, Mayer EK, Marcus HJ, Cundy TP, Pratt PJ, Parston G, Vale JA, Darzi AW, "Quantifying innovation in surgery," *Ann Surg.*, vol. 260, pp. 205-211, 2014.

(a) Fixation of the troccar mouth

(b) Initial position of the end effector



(c) First vertical point



(d) End effector at Troccar mouth

Figure 9: Different positions of end effector of the stiubli robot in the real case