Optical Tracking System for Focused Ultrasound Neuronavigated Procedures

Cole Barraclough, Alliana Dela Pena, Zain Jelani, Denise Kenny, Nika Magadia, Melanie Nguyen
Schulich School of Engineering, University of Calgary

Abstract

- NovusTX Devices is a biomedical company that seeks to treat neurological disorders non-invasively. Ultrasound technology is used to achieve this. In order to accurately determine the location of the focal point to be targeted within a patient's head, a method of tracking the patient's head is required.
- The objective of our project was to create a tracking system to the determine the 3D position of a target (the focal point). We implemented a camera system with a UDP server to stream the images to the host computer. The images are processed through our tracking software where markers are detected and their location is determined. Finally, the 3D locations are displayed in real time in a visualization application, 3D Slicer.

Introduction

- The company sponsoring this project is NovusTX Devices. They have created a medical device that treats psychological and neurological disorders in a non-invasive way. Their technology targets ultrasound waves at a focal point in the brain to treat patients.
- To accurately aim the ultrasound waves at the focal point in the brain, the procedure requires a method to track the location of the patient's head and the position of the focal point.
- This project entails creating a 3D tracking system to determine the 3D position of the focal point. For our tracking system we used a multi-camera system, image processing software for detecting and locating ArUco markers, and 3D slicer for visualization.

Methods and Materials

Here are the various components we used to create our tracking system:

- **Arducam Quadrascopic Camera** - This camera is composed of four cameras that take images simultaneously. The benefit of having a quadrascopic camera is that 2 of the 4 cameras can be placed at angle relative to the others, giving a more precise z dimension value for 3D positions.
- **Raspberry Pi UDP Server** - The quadrascopic camera is attached to a Raspberry Pi to read and stream images from the camera. This will allow the images to be streamed to a host computer. Since the images taken by our camera are too large to be sent over a single UDP packet, the image is split up, sent over many packets, and reconstructed on the host computer.
- **Tracking Module** - The first step that must be done before tracking is camera calibration. The purpose of this step is to create a matrix for removing camera distortion. Calibration only needs to be done once. The second step is tracking ArUco markers. Each camera pair can use triangulation to determine the 3D position of an ArUco marker. The x and y coordinates for the position are accurate for a single pair of cameras. The second pair of cameras, which is at an angle relative to the first pair, is used for improving the z coordinate.

An Example ArUco Marker

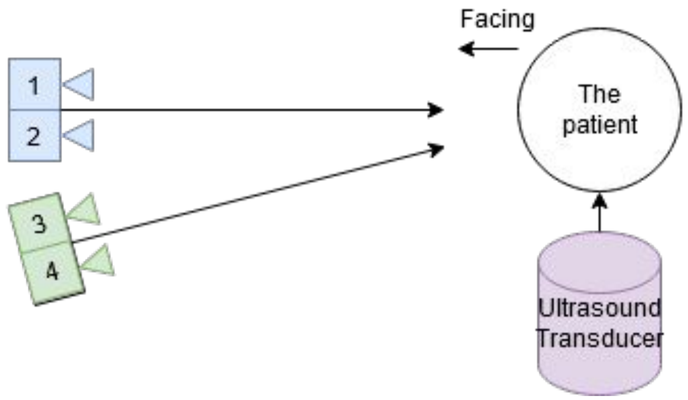
- **Plus Toolkit** - Plus Toolkit is an open source toolkit used for streaming position data in real time to 3D Slicer. 3D Slicer has an interface that follows the OpenIGTLink protocol. Plus Toolkit also implements that protocol, which allows for a communication between the two.
- **3D Slicer** - Once the 3D positions are sent to 3D Slicer, they are visually displayed on the application

Results and Discussion

- ArUco markers can be placed on tools such as styluses of known length. By pointing those tools at different features of the face, and determining the location of the ArUco markers, the location of the facial features can be calculated.
- Using MRI data and the location of the facial features, the location of the focal point can be calculated.

Conclusions

- The smaller the focal point being targeted is, the more precise results the tracking must have. The benefit of our solution is that each component is very customizable and extendable.
- This project provides an extendable platform for future tracking development for NovusTX Devices to get the sub millimeter precision that they require.



Top view diagram of the full system

CONTACT
Nika Magadia | Team Lead | Email: thessalonika.magadia@ucalgary.ca