CALIFORNIA SCIENCE & ENGINEERING FAIR
2019 PROJECT SUMMARY

Name(s)

Christopher Caligiuri

Project Number

S1005

Project Title

BrainBot: Multielectrode Data Modeling and Stem-Cell Derived Brain Stimulation through a Real Time Robotics Platform

Abstract

Objectives

Human iPSC-derived brain organoids are human "mini-brains," consisting primarily of the cortex area of the brain and are similar to those of premature babies. As the organoids currently cease development after nine months, this project aims to develop a robust robotic system for interpreting, modeling, and interacting with these brain organoids via a multielectrode array for more mature development of the brain organoid. These combined features constitute a research mechanism that will further scientific studies into developmental biology and critical neurodevelopmental treatment and prevention.

Methods

A quadruped base containing 12 Servos, 3 Arduino-based microcontrollers, an Ultrasonic and IMU sensor, Bluetooth Bee, and Bluetooth Module were used in the design of the BrainBot. A custom C++ based application was developed and used with an Arduino board for interpreting high level commands from the computer and calculating Servo positions through inverse kinematic equations. A custom Python-based application (running on a local computer) is used for interpreting the multielectrode neural data and sending the commands to the quadruped via a Bluetooth channel.

Results

The initial design used hard-coded Servo positions sent by a Python application directly to the Servo controller for static robotic movement. A neural interpretation application was developed to allow the initial design to receive commands from the organoid. After integrating each respective aspect, the robot's movement varied based on changes in neural activity. A significant redesign was required for more natural movement by introducing a microprocessor that calculates effective positions that simultaneously move all 12 Servos with the center of gravity taken into account. Two additional sensors were also integrated through simultaneous processing, allowing for a closed-loop system for stimulation of the organoid.

Conclusions

The final design of the system met all the specified requirements as it effectively interpreted, modeled, and interacted with the organoid. This integrated platform, alongside the brain organoids, allow for an improved disease modeling and treatment testing system. Indeed, organoids currently used to model disease are limited as the disease pathways are not complex enough. These pathways, however, will be improved through the robotics platform as it will induce a more complex organoid.

Summary Statement

An integrated real time robotics platform that incorporates external stimulus and fluid movements for stem-cell derived brain stimulation and multielectrode data modeling, thereby acting as an artificial body for these brains.

Help Received

The multielectrode data used to develop the BrainBot was collected by the Muotri laboratory, specifically Dr. Alysson Muotri; all other aspects of the project were researched and conducted independently.