# Proposal Name：

Bridging Communication through Gesture-Based Robotics

# Purpose：

To develop a novel gesture tracking system using mechanomyography (MMG) for controlling robots, aimed at improving the quality of life for disabled individuals and amputees.

# Background and Challenges:

At present, touchscreen, joystick, mouse and keyboard are the main input electronic devices. However, these traditional input devices may not be suitable for some disabled individuals and amputees. The project focuses on the development of recognizing simple hand gestures based on MMG technology by interpreting muscle movement in the arm. The system will enable users to control and command a mobile robot, thereby enhancing their independence and daily functionality.

# Literature Review:

Apart from the traditional input devices (e.g. mouse and keyboard, touchscreen, and joystick), new methods are investigated and studied to fit the new requirements of input wearable devices. In real-time human-computer interaction, hand gesture has considerable potential uses (Nooruddin, Dembani & Maitlo, 2020).

Generally, there are two major approaches to hand gesture recognition (HGR), the outside-in tracking system and the inside-out tracking system. According to Angelov (2020), in the outside-in system, extra sensors are placed around the tracked device in fixed positions, they continuously scan the whole area and detect the position and orientation of the tracked object. For the inside-out system, sensors are placed inside the tracked object, and positions and orientations are determined by processing and calculating through the feedback provided by sensors.

Tracking by applying infrared cameras (Nooruddin, Dembani & Maitlo, 2020) is an example of using the outside-in tracking system, while the HGR Glove with shaped memory alloy strain gauges (Kim, Gu, and Kim, 2022) is an example of using inside-out tracking system. However, these two methods of tracking hand directly are sometimes not applicable to disabled individuals and amputees.

To overcome this challenge, electromyography (EMG) and mechanomyography (MMG) have been widely used in terms of detecting hand gestures through muscle activity, and they have the advantages of being non-invasive, having real-time feedback, and supporting dynamic measurements. (Castillo et al., 2021). In Liu and his team’s study (2020), he illustrated the types of sensors detecting EMG and MMG in previous studies, which are accelerometers, microphones, IMU sensors, and piezoelectric films. Liu further studied the way of using accelerometers to distinguish eight hand gestures, including wrist extension, wrist flexion, and fist-making that are potentially used in helping disabled individuals and amputees, and an overall accuracy reached more than 90%. In Castillo’s team’s study (2021), microphone MMG sensors were designed and tested among disabled individuals and amputees. The research also studied the relationship between the normal pressure exerted on the skin surface and the conductivity of the mechanical waves, and six hand gestures were recognized, including flexion, extension, pronation, supination, adduction, and abduction. Castillo’s team also mentioned that skin condition (sweating) and sensor position could have a significant effect on the accuracy of detection.

Apart from detecting mechanical muscle movement, a novel method of using radiomyography (RMG) has been developed (Zhang and Kan, 2023). In this method, sensing antennas are used to measure muscle activity in both superficial and deep muscle groups, and it reached an overall accuracy of around 99%.

Among those 3 methods of detecting muscle movements, machine learning is also used to improve the accuracy of the sensing system. In hand gesture recognition, machine learning is a vital technique, and it enables developers to classify hand gestures and convert the raw data from sensors into meaningful instructions. (Lyons et al., 2007). With the aid of machine learning techniques, such as Support Vector Machine (SVM), Backpropagation (BP), Convolutional Neural Networks (CNN), and Deep Neural Network (DNN), the accuracy of HGR is further improved. (Nooruddin, Dembani & Maitlo, 2020) In addition, the Vision Transformer (ViT) Deep learning network is used in Zhang and Ken’s study (2023).

# Product Features and Solutions:

**Mechanomyography-Based Gesture Detection:**

A system that detects hand gestures (Fist, Rest, and Grasp) by using an MMG sensor aided by an IMU sensor. Translating them into robot control commands. The MMG sensor will detect the muscle movement in the arm, and the IMU sensor will detect the displacement and orientation of the arm.

**Application in Robotics:**

Use of this technology for remote control of a mobile robot, providing a tangible demonstration of its potential. The remote control of the mobile robot will include but not be limited to the basic ability to navigate the room, avoid detected obstacles, and grab items.

**Innovative Learning and Control Algorithm:**

Development of an algorithm to accurately interpret hand gestures and execute corresponding actions in the robot.

# Anticipated Outcomes:

The project expects to yield a user-friendly, efficient, and innovative solution to aid those with disabilities, revolutionizing how they interact with technology and perform daily tasks. It will also provide invaluable insights into the integration of MMG technology in practical applications.

# List of References

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