ITE 3962 – Final Year Project

Project Proposal

Bionic Arm

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List of Abbreviations

Abbreviations	Description
EMG	Electromyography
IMU	Inertial Measurement Unit
DC	Direct Current
ADC	Analog To Digital Converter
PLA	Polylactic Acid
ABS	Acrylonitrile Butadiene Styrene

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1. Introduction

Sri Lanka endured a close to thirty years war, during which lots of people died and as the same many was injured. Apart from being injured in the war, many individuals have disabilities caused by accidents, diseases resulting from the normal activities of daily life. Consequently, a significant percentage of the people are left at a loss to cope with the loss of their arms and legs, thus finding it difficult to carry out basic tasks. For this chronic issue, taken a fundamental step in building a bionic arm that will help them regain functionality and improve their lifestyle.

While the person who loses a leg can employ temporary alternatives such as crutches or makeshift supports to do functions. But losing a hand is much harder. An idle plastic hand lacks any real usability, limiting the ability to do daily tasks necessary for survival. Advanced bionic prosthetics that can restore functionality and dexterity are available anywhere in the globe but at extremely high costs, at times in excess of a million Sri Lankan Rupees. The expenses involved in acquiring such a unit along with charges for installation make them out of reach for all disabled individuals within Sri Lanka.

The goal of this project is to develop an affordable and accessible bionic arm that restores essential hand functions for any people. By using cutting-edge technologies and necessary materials, the mission is to provide a realistic solution that allows the disabled upper limb patients to live independent lives with improved quality of life.

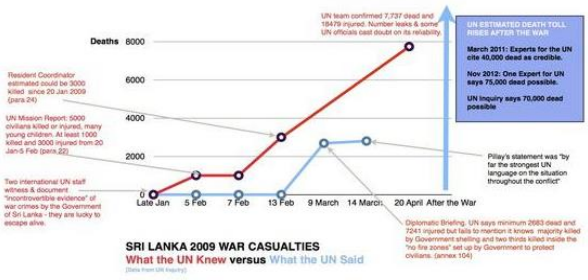

Figure 1 Sri Lanka 2009 War Casualties Chart [3]

Source: https://images.app.goo.gl/hhK25ohHWxJotPwXA

2. Background & Motivation

Due to war, claiming nearly 80,000 to 100,000 lives and causing tens of thousands to be seriously disabled. Beyond the war injury related injury, each day's accident also largely leads to loss of limb [1]. Approximately 3000 to 5000 persons lose an arm annually from accidents at work, on the road, other places and from a disease [2]. Among them, it is hard for many to do every day simple tasks, so prosthetic limbs are a matter of life and death. But the primary issue is availability. The extremely sophisticated bionic hands available in the international market cost between LKR 0.5 million to LKR 1 million [4], including base price, shipping and fitting. For the majority of the disabled population in Sri Lanka, this is too expensive that leaving them without an effective solution

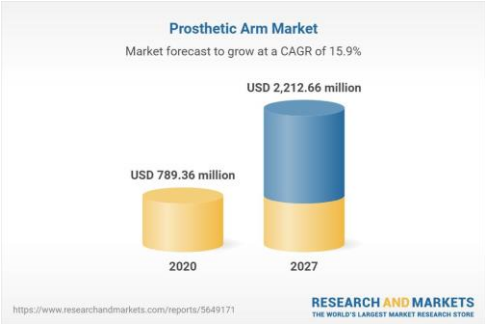

Figure 2 Prosthetic Arm Market-Forecasts from 2022 to 2027[4].

Source: https://images.app.goo.gl/FEAEe85t4wdc9quf8

Several international research institutions, such as MIT, Open Bionics and DARPA-sponsored projects, have developed highly advanced bionic hands with artificially intelligent motion, sensory feedback and grip force control. Such advances however come at high prices and are beyond the affordability of the majority in the developing world. This highlights the need for developing a bionic arm in the local context that is affordable and provides a functional level at much lower prices [3].

The motivation for the project is motivated by a wish to come up with an affordable, accessible, and practical bionic arm that restores independence, mobility and confidence in limb loss victims. Disabled persons in Sri Lanka cannot work, take care of their families or even conduct routine activities due to the lack of functional prosthetics. With a low-cost but good quality bionic arm, the project seeks to give power to individuals with disabilities, reduce reliance on expensive imports and stimulate local innovation in prosthetics. The two key imperatives are affordability and accessibility, and therefore individuals who require a bionic hand should be able to access it without necessitating a huge financial outlay. What the project seeks to do is enhance lives, enhance accessibility and provide a long-term solution to needy individuals.

3. Problem in Brief

Loss of the hand is not just a disability of the physical kind; it is a grievous disruption of a person's life, independence and self-respect. In Sri Lanka, hundreds of individuals lose hands due to Sri Lanka's long civil war, work accidents, road traffic crashes, diseases and other unforeseen mishaps like from birth. Thousands of soldiers and civilians have become victims of war's destruction and thousands are hurt as a result of common accidents in Sri Lanka. More than 3,000 people lose a hand each year in Sri Lanka due to accidents, and it is growing, it is estimated [2].

For the individual who loses a hand, the impact extends far beyond the immediate physical loss. Simple activities that most people do not even think about feeding oneself, writing, dressing or even the mere act of holding a tool become major obstacles. For others, this loss is a sudden plunge in the capacity to feed themselves or their families. The inability to utilize a hand handicap one's mobility, autonomy and ability to engage in work or social activities, thus financial insecurity and emotional trauma.

Without access to functioning prosthetics, the victims must make do with crude or malfunctioning prosthetic devices that provide little or nothing towards a normal return to the functions of daily life. The devices, which are typically made of plastic, lack dexterity or movement necessary for use in performing basic tasks. It leaves the victims helpless and many cannot resume work or resume their occupations. This not only results in economic hardship but also brings about social loneliness, stress and irritability.

Even though very advanced bionic prosthetics are impressively functional, with capabilities for precision grip and natural movement, they are commonly too expensive, with the importation of a bionic hand to Sri Lanka being nearly LKR 0.5 million to LKR 1 million [4]. These prices, along with shipping and fitting, are out of reach for most individuals who could use them. This lack of solutions makes it a tremendous health care access gap and deprives the majority of Sri Lankans of the equipment they need to be independent.

This project will cater to a critical need by creating an affordable, locally made bionic arm that restores mobility and independence to those who lost their hands due to war, accident or similar unfortunate events. With the development of an affordable counterpart with similar functionality to high-tech prosthetics, hope to restore individuals' ability to regain control of their day-to-day living, be active in their communities and return to work. With this project, the envision reducing the social, economic, and emotional burdens of those who have lost a hand so that they can resume their lives with increased confidence, autonomy and dignity.

4. Aim & Objectives

4.1 Aim

The aim of this project is to develop a bionic arm that facilitates the coordinated movement of the thumb and other four fingers together which enables natural gripping functionality.

The bionic arm is designed to assist individuals who have lost their wrist to helping them to perform everyday tasks such as holding a glass.

4.2 Objectives

- To design a bionic arm that replicates the natural gripping action of the thumb and other four fingers together.
- To integrate a control system that enables the user to perform various tasks from the above part of the wrist, such as gripping and holding objects, through intuitive movements.
- To create an intuitive control system that allows users to perform tasks like holding a glass, grasping objects and performing other essential activities.
- To ensure that the bionic arm closely resembles the natural structure and movement of a human hand, offering some functionality for essential daily activities.
- To implement safety mechanisms and reliability features, ensuring optimal performance and user safety in daily use.

5. Proposed Solution – Bionic Arm

This project involves making locally manufactured bionic arm in a quest to match the natural agility of the human hand from above the wrist. Designed for war injury or disease victims who have lost hand from the wrist, the arm assists in the coordinated movement of the thumb and the remaining four fingers as a group, which is beneficial in gripping a glass along with other forms of grasping activities.

The cost of developing this bionic arm is estimated to be approximately LKR 1.5 lakhs, covering the materials, integrating technology and manufacturing processes. This amount of investment ensures the functionality, safety features and durability over time of the arm, providing a superior-quality solution for individuals in need of a quality assistive tool. The current available advanced bionic hands, such as the Michelangelo Hand, can cost close to LKR 1 million, which places them clearly out of reach of most people. This bionic arm, by the use of electromechanical actuators, offers an affordable answer without compromising on any functionality.

Built using necessary materials, the bionic arm is stable and long-lasting, ensuring more extended use. Designed to be comfortable and wearability for extended durations, it ensures an ergonomic design that is stress-reducing on the residual limb. Internal safety mechanisms ensure safe application during everyday use, enhancing user confidence and independence.

By fabricating the bionic arm locally using necessary materials and processes, the project aims to make the device significantly affordable and thus, more accessible to all individuals in all socioeconomic levels. The proposal addresses the pressing need for affordable and functional prosthetic devices in Sri Lanka, where pricey bionic hands are usually outside the economic means of most individuals. The extent extends beyond physical rehabilitation; it provides people with the resilience to relearn autonomy, get back to work, lead ordinary lives and be productive members of society. Encouraging increased independence, self-worth and mental health, this initiative also facilitates the creation of assistive technology solutions locally, weaning us off costly foreign prosthetics and stimulating local research and innovation. Ultimately, this bionic arm will improve mobility, restore dignity and generally enhance the quality of life for individuals suffering from upper-wrist disability, enabling them to lead independent, productive and productive lives.

5.1 Technologies Used

Sensors for Control

- Electromyography (EMG) Sensors
- Force & Pressure Sensors
- Inertial Measurement Unit (IMU)
- Touch Sensors (for advanced models)

Actuation & Control

- Servo Motors (for precise movement)
- DC Motors & Gear Systems (for joint movements)
- Pneumatic Actuators (for soft robotics)

Processing & Communication

- Arduino (for basic models)
- ESP32 (for wireless capability)

5.2 Hardware Requirements

Mechanical Structure

- Materials: Aluminum, Carbon Fiber, 3D-printed PLA/ABS plastic
- Joints & Actuators: Servos, Stepper Motors, Linear Actuators
- Prosthetic Hand Design: 3D-printed Fingers or Robotic Grippers

Electronics & Components

- Microcontroller (Arduino/ESP32)
- Sensors (EMG, Force, IMU, Touch)
- Motors (Servo, DC, Pneumatic Actuators)

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Appendix A: Plan of Action

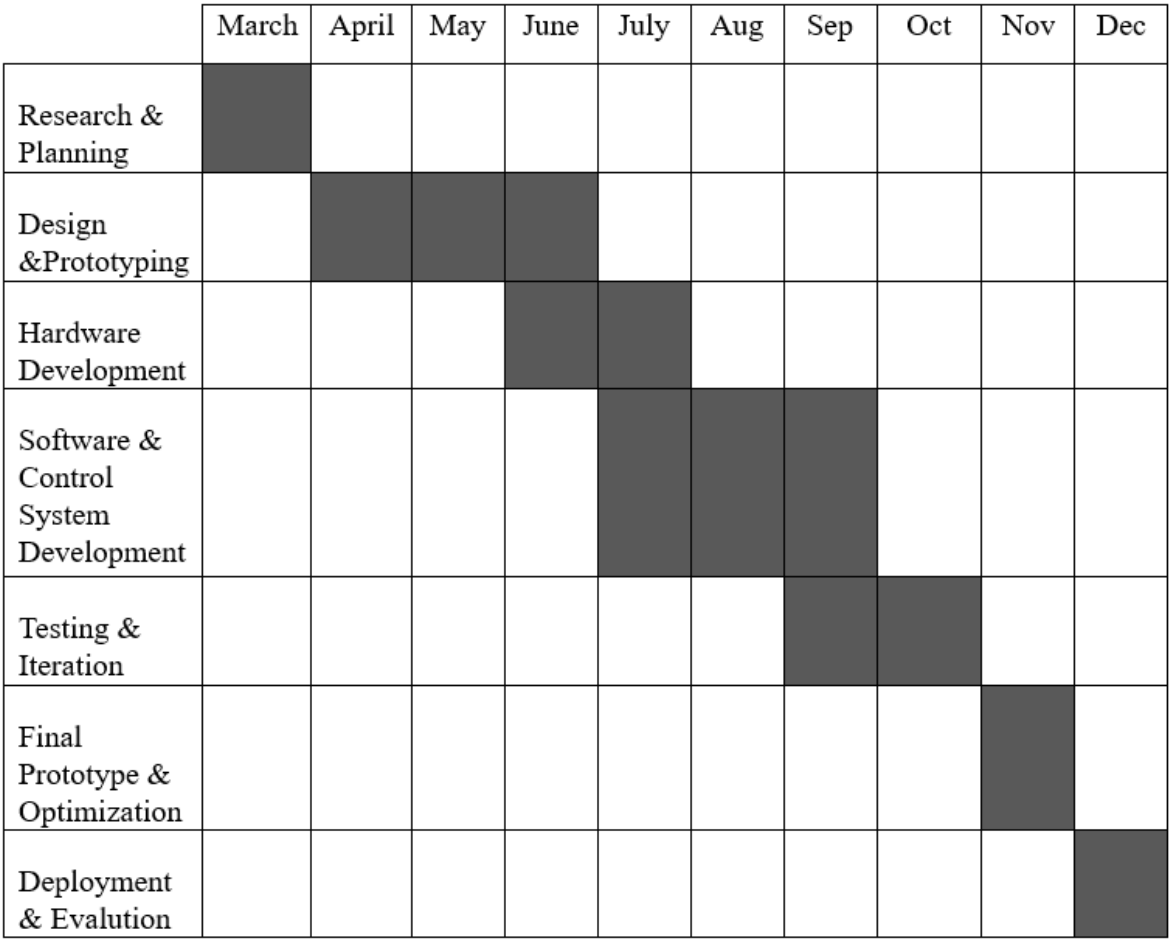

Figure 3 Gantt Chart