A PROSTHESIS CONTROL APPROACH USING MOBILE PHONES AND ITS IMPLEMENTATION ON A BIONIC ARM

ATHESIS SUBMITTED TO THE GRADUATE SCHOOL OF APPLIED SCIENCE OF NEAR EAST UNIVERSITY

By
EHSAN FARAMARZI ASLI

In Partial Fulfillment of the Requirements for the Degree of Master of Science in Biomedical Engineering

NICOSIA, 2019

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Approval of Director Of Graduate School Of Applied Science

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I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that I have fully cited and referenced all material and results that are not original to this work, as required by these rules and conduct.

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ACKNOWLEDGEMENT

This thesis would not have been possible without the help, support and patience of my principal supervisor, my deepest gratitude goes to Asist. Prof. Dr. Elburus IMANOV. for her constant encouragement and giudance. He has walked me through all the stages of the writing of my thesis. without her consistent and illuminating instruction, this thesis could not have reached its present from.

I would like to thank Prof. Dr. Ayse Gunay Kibarer who has been very helpful through the duration of my thesis

Above all, my unlimited thanks and heartfelt love would be dedicated to my dearest family for their loyalty and their great confidence in me. I'm greatly indebted to my father Vahab FARAMARZI ASLI who is indeed my inspiration and man who led me to the treasures of life. I would like to thank my mother Nasim ESHAGHI FARAHMAND for giving me a support, encouragement and constant love have sustained me throughout my life. I would like to thank my girlfriend Dilan BALIK for her personal support and great patience at all times.

Eventually, there is a long list of friends that I would like to thank.

To My Parents…

ABSTRACT

Nowadays, by new technology and increasing the knowledge of producing information more and more, human begins have been faced with the new methods and technologies in various fields of trade, industry, medicine, etc. One of the important technologies is biomedical engineering. Biomedical engineering is the use of engineering principles to reduce the gap between engineering and medical, to further the goals of health care, including diagnosis, monitoring and treatment that has become to a very strong assistant for doctors. One of the important fields of it is Orthopedic Prosthesis and Orthotics. Many researchers are working in this field and many hardware and software equipment's are designed and built now. Prosthetics has developed in the recent years to the extent that give their users the ability to replicate natural human motion on certain limb disorders. These ‘smart’ limbs require the use of multiple technologies and knowledge from a broad field of areas including biomechanics, biomedical, electronics, mechanics, mechatronics and software engineering. In these bionic limb applications, a multitude of sensors are required to measure and predict the user intent and then a set of mechatronic actuators are utilized to conduct the resulting motion or the gesture. However, for severely injured or disabled patients that can only move their finger or one hand, The use of such control techniques is very limited due to the restricted muscle movement of the users. In this study, The propose is a new command and control approach for bionic limbs based on a mobile phone platform. Todays’ mobile phones contains a number of inertial sensors such as accelerometers, angular speed sensors and magnetic field detectors. The implementation and demonstration have used inertial sensors of mobile phones to detect the gesture of the user to control prototype robotic arm prosthesis.

Keywords: Prosthetics; control systems; mobile platforms; bionics; robotic arm

ÖZET

Günümüzde, yeni teknoloji ve daha fazla bilgi üretme bilgisinin artmasıyla insan ticareti, ticaret, sanayi, tıp vb. Gibi çeşitli alanlarda yeni yöntem ve teknolojilerle karşı karşıya kalmaktadır. Önemli teknolojilerden biri biyomedikal mühendisliğidir. Biyomedikal mühendislik, mühendislik ve tıp arasındaki boşluğu azaltmak, doktorlar için çok güçlü bir asistan haline gelen teşhis, izleme ve tedavi de dahil olmak üzere sağlık hizmetinin amaçlarını ilerletmek için mühendislik ilkelerinin kullanılmasıdır. Önemli alanlarından biri de Ortopedik Protez ve Ortez. Bu alanda birçok araştırmacı çalışıyor ve birçok donanım ve yazılım ekipmanı şimdi tasarlandı ve üretildi. Protez, kullanıcılarına belirli insanlarda doğal insan hareketini çoğaltma becerisi kazandırabilecek ölçüde geliştirmiştir. Bu 'akıllı' uzuvlar, biyomekanik, biyomedikal, elektronik, mekanik, mekatronik ve yazılım mühendisliği gibi geniş bir alandan çok sayıda teknoloji ve bilginin kullanılmasını gerektirir. Bu biyonik uzuv uygulamalarında, kullanıcının amacını ölçmek ve tahmin etmek için çok sayıda sensör gerekir ve daha sonra ortaya çıkan hareketi veya hareketi yapmak için bir dizi mekatronik aktüatör kullanılır. Bununla birlikte, sadece parmaklarını veya bir elini hareket ettirebilen ağır yaralı veya engelli hastalar için, bu gibi kontrol tekniklerinin kullanımı, kullanıcıların sınırlı kas hareketleri nedeniyle çok sınırlıdır. Bu çalışmada, teklif, bir cep telefonu platformuna dayanan biyonik uzuvlar için yeni bir komut ve kontrol yaklaşımıdır. Bugünün cep telefonları ivmeölçerler, açısal hız sensörleri ve manyetik alan dedektörleri gibi bir dizi atalet sensörüne sahiptir. Uygulama ve tanıtım, kullanıcının prototipli robotik kol protezini kontrol etme hareketini saptamak için ataletsel mobil telefon sensörlerini kullandı.

Anahtar Kelimeler: Protez; kontrol sistemleri; mobil platformlar; biyonik; robotik kol

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LIST OF ABBREVIATION

FAT: Frenchay Arm Test

BBT: Box and Block Test

DIP: Distal Interphalangeal

PIP: Proximal Interphalangeal

IP: Interphalangeal

MP: Metacarpophalangeal

DOF: Degree Of Freedom

IDE: Integrated Development Environment

DIP: Dual Inline Package

EMG: Electromyography

CHAPTER 1

INTRODUCTION

1. Overview

Natural causes, Diseases, Nutrition, Environmental causes, accidents and even hereditary limb or organ loss are very common today. Scientists want to copy human organs and limbs from the past to the present and to increase the quality of life of the person. Many projects, experiments and researches have been done about artificial organs and artificial limbs. Many world famous medical device companies have artificially developed the internal organs and limbs of the human body. These devices can never be used for definitive treatment. These artificial organs are only applied to the patient for the purpose of performing the functions of other organs of the body until the organ transplantation is performed for a certain period. Today, artificial limbs are implanted in many amputated patients. Most important of all is that these artificial limbs are biocompatible with the human body. One of the reasons why these prostheses are not widely used is the high price. Researchers have attempted many articles to solve this problem and have examined implantable prostheses in terms of materials, mechanisms and structures. Titanium (T) is the only metal that presents no problems when implanted in the human body. For many years, human beings have been able to solve the amputee barrier, but as technology advances, human comfort and health have a different importance. Today, with the help of electrical signals, these studies are developing and growing. The electrically powered prosthetic limbs replacing the human natural ones has always been a futuristic view of the future biomedical application. These limbs have been introduced since 1954 (Alderson, 1954). The high production costs and the lack of powerful control platforms have led to the slow realization of these limbs. Recently the powered prosthetic limbs industry has been flourished. The availability of low-cost 3D printing technology enables the production of special prosthetic limbs for different structures and purposes (pirian and petrosanu, 2013), helped greatly in this direction. Also, powerful and cheap microcontroller boards have been introduced with friendly environments to program and control. There are many such projects introduced various methods to control powered limbs. Its worked on the Electromyography (EMG) signal generated from neural system were used for the first time to activate the arms (Kato et al, 1967). This method requires special electronics to perform, which increases the cost of the device. The image processing has been used to estimate the movement of skin thus introducing signal which can be used for controlling the limbs (Martin et al, 1967). The upper limbs are more challenging to control unlike the lower limbs. Since the lower limps has less complex movement comparing to upper limbs which perform multi-joints accurate movements (Aprile et al, 1967). Mobile smart phones are becoming an essential device in our daily life. It is a normal development that these devices would take more tasks related to mental and physical performance (Tezel et al, 1967). Capability of controlling the hand by this method was impractical. The use of touch screen of the mobile phone to takes more time to handle. Using sensors such as flex sensors to control the prosthetic hand (Ozkan et al, 1967) . Also motion sensors have been introduced as new controlling method of prosthetic limbs in the tork (Kybred and Poulton, 2017). These sensors are embedded in almost all the currently used mobile phones. In order to minimize the cost of manufacturing a new control joystick or glove the smart phone can be used. By using simple programming app which name is “MIT appinventor2” can be able to designed to analyse the sensors data equipped with the phone. Creating smart mobile phone application has been simplified and introduced to public especially in the android operating system. The “MIT appinventor 2” which is a visual programming environment has been used to create productive applications with a simple knowledge of software engineering (Xie and Abelson, 2016).

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

In this section there are fifteen significant relative research fields which are main categories in the field of prosthetics organ;

2.2 Development of an anthropomorphic hand for a mobile assistive robot

The mechanism, design and control framework of a modern human hand-type with control capacities similar to human function are examined. The hand is outlined for the humanoid robot which has to work independently or intelligence in participation with people. Such an effective result would be the ability to use individually employed devices and objects while working in the same field. In this manner, a new design is made for a prosthetic hand is designed one to one in accordance with the normal hand. This includes the number of fingers and the position and movement of the thumb, the extension of the connecting lengths, and the palm shape.While this hand is considered specifically for human beings to handle most sports, it is committed to research, special features and functionality of the hand model. Moreover, to begin with experience picked up from utilizing hand models on a humanoid robot is sketched out (Kargov et al, 2005).

2.3 Low-price wearable multichannel surface EMG acquisition for prosthetic hand control

Physiological withdrawal forms of one or more muscles evoke electrical possibilities to be utilized as a consequence of a well-described strategy for prosthetic hand control with the acquisition and preparation of sEMG. Moreover brilliantly mobile medical devices are on the brink of presenting safe and exceedingly modern frameworks to assist a wide patient community to recapture a significant sum of life quality. The main difficulties that cannot be transferred in such a coordinated system plan are primarily faced when getting a compact framework via a long versatile independence.This framework is expected to be competent of conveying the specified signal requirements up to 32 simultaneously operating channels behaving as a small device preventing any possible disorder for EMG based prosthetic control. Hence, agreeing to these requirements show a remote, mobile stage for acquiring and communicating sEMG signals implanted into a total mobile control system. These factors involve a convenient device such as a laptop which provides a basic computıng access for the control of a commercially available mechanical hand-prosthesis. Bluetooth standard is a basis for communication among those devices. It appears that an economic mobile device can be created to be utilized for legitimate prosthesis control where the daily life of patients depends on the gadget for a continuous operation (Brunelli et al, 2015).

2.4 Single channel surface EMG control of a high-level prosthetic hands: An economic, simple, and efficient approach

sEMG is a principal source enabling the control of prosthetic hands with regard to their expectation and comfort. It is a driving force for the improvement of prosthetic hands with various degrees of mobility opportunity, requiring many EMG channels to receive the total outcome of the integrated prosthetic terminals. Several EMG wearable instruments were produced late, to distinguish several signals. In any case, the most handicaps of these frameworks are the cost, the estimate and the framework complexity.

A simple, fast and cost-effective framework capable of recognizing up to 4 signals with a single channel sEMG signal has been proposed. Signals include hand closure and opening, wrist flexion and double wrist flexion.These motions can be utilized to control a prosthetic terminal that includes predefined grasp stances. It appears that by employing a high-dimensional feature space, in conjunction with a back vector machine calculation, it is conceivable to classify these four motions. Overall, the framework appeared palatable comes about in terms of classification exactness, real time motion acknowledgment, and resilience to hand developments via integration of a lock motion.

Calibration lasted 30 seconds and session independence was performed by highly classified perfection on individual test sessions with no need for the repetition of calibration. This framework is employed control a previous prototype soft prosthetic hand. Generally, a basic equipment with a single-channel EMG is thought to be capable of controlling multi-DOF prosthetic hands. In expansion, this framework can be used as a common cause of the Human Machine Interface to play games, control interactive media tools, or control robots. (Tavakoli et al, 2017).

2.5 A prosthetic hand control interface via Android application and ESP8266 Wi-Fi module

Upper limb amputees regularly suffer from mental and physical difficulties as they cannot use their farthest foci.To assist such clients in obtaining a hand achieving an attainable benefit, a 3D printed prosthesis was created with the ESP8266 wireless module. Significant distance can be kept up from the costly and complicated control procedures using a simple Android application which allows the amputees to select a motion that one desires the hand to achieve. The application of mobile transmits this information to the Wi-Fi module and independently controls the activation of each finger in turn.The basic plan allows customers to quickly adapt to technology (Pakalapati et al, 2017).

2.6 Real-time machine learning applicationfor myoelectric prosthesis control: A case arrangement in versatile switching

Foundation: Myoelectric prostheses as of presently utilized via amputees may be troublesome to control. Machine learning, and particularly learned desires around client point, might offer assistance to diminish thecognitive and time stack needed by amputees whereas working their prosthetic device.

Goals: The aim of this idea is to analyze two switching-based methodologies to control a myoelectric arm: incompatible (or schedule) control and flexible control(counting real-time figure learning).

Consider Arrange: Consider the case action plan. Strategies: In this context, incompatible and inflexible control was compared in two different tests.Initially, an amputated and a non-amputated subject controlled a mechanical arm tocarried out a basic task.

Conclusion: A real-time desire learning has been successfully utilized to maintain the control interface of a myoelectric mechanical arm in the midst of nonstop utilize through an amputee subject and able-bodied subjects.

Clinical Importance: Real-time prediction learning is used byflexible control to reduce both the cognitive and the timestack essential via amputees in real-world valuable circumstances when utilizing myoelectric prostheses species (Dward et al, 2016).

2.7 Prosthetic Arm Control via Human Brain

The human brain is the most crucial organ in the human body, consisting of various hundred million neurons.EEG signalsare utilized to discover issues pertaining to electrical action of the brain. EEG based Brain-Computer Interface (BCI) prosthetic arm can offer assistance as an effectivegadget for extremely disabled individuals in their normal exercises, particularly to help them to provide mobility their arm deliberately. The brain waves are detected by sensors within the Emotiv EPOC headset. At that point EEG signal is handled through a microcontroller to control servo engines and move an manufactured hand. Case that endures from amputee underneath the prosthetic arm is advantages for the elbow. The main objective of this study is to allow the physically impaired individual ended up autonomous on others in their standard of living time for their purposes (Chinbat and Lin, 2018).

2.8 Fabrication and design of prosthetic human hand viaEEG and force sensor with Arduino micro controller

This venture bargains with the plan and improvement of a 5 fingered prosthetic hand for excised people. The plan of the framework represents a basic, adaptable and ideal control technique that empowers the individual to utilize the gadget as typical arm. The framework of hand has free commands to mobility the appendage down and up and position of the fingers absolutely. Usage of the mechanical equipment plan of the biological hand is founded on associated twofold revolute joint instrument. The ligament framework of the twofold revolute joint component and input arrange provides capacity denying topology and thus enabling the advantage of employing a basic control calculation. The show is have to be manufactured with Servo engines and drive sensors for fingers activation. Inputs for the engines can be produced with EEG signals created from brain, which is capable of taking the lead from the client to reflect on the objects correctly. (Mohan and Purushothman, 2017).

2.9 For Bilateral Rehabilitation using EMG-Controlled Robotic Hand Exoskeleton

In this research, a new EMG-driven hand exoskeleton is handled in stroke for bilateral rehabilitation. The created hand exoskeleton was planned with two unmistakable highlights: (a) kinematics with inherent flexibility to patient hand estimate, and (b) free-palm and fingertip plan, protecting the remaining tangible cognitive ability of touch amid help in getting a handle on of genuine objects. Within the conceived reciprocal preparing procedure, the patient non paretic hand behaved as direction for the paretic hand in getting a handle on assignments. Getting a handle on drive applied with the non-paretic hand was assessed in real-time from EMG signals, and after that imitated as mechanical help for the paretic hand by implies the exoskeleton of hand. Evaluation of the getting a handle on constrain through EMG permitted to perform restoration works out with any graspable and non-sensitive objects.

This study demonstrates the framework plan, improvement, and test assessment. Tests were achieved within a gather of 6 sound subjects and 2 constant stroke patients, executing robotic-assisted getting a handle on assignments. Comes about pertaining to execution in evaluation and balance of the automated help, and to the results of the pilot recovery sessions via stroke patients, emphatically back legitimacy of the suggested strategy for the clinical health services of stroke rehabilitation(Leonardis et al, 2015).

2.10 Design of an Arduino-based platform interfaced via Bluetooth low energy using Myo armband for the control of under-actuated transradial prosthesis

In this study, a diagram of the recent developments in upper limb prosthesis innovation is shown; these are determined primarily from points of interest, which are nowadays commercially available for exceptionally low price, dealing with the advertising of advanced sharp and high-performance electronic modules and devices .At that point the hardware of Adam's Hand, a transradial myoelectric prosthesis for upper-limb amputees, is portrayed. The gadget is prepared with actuators and sensors that streamline and help the hand developments; in specific, the instrument on that can activate 15 degrees of flexibility through fair one engine (rather than the five/six engines expectedly utilized in another commercially accessible prosthetic gadgets). Two servomotors are utilized to activate the wrist developments. The myoelectric signals utilized to control the prosthesis are recognized with the Myo armband, that coordinating 8 EMG terminals and an Inertial Estimation Unit (IMU) founded on InvenSense MPU-9150 IC; these information are sent throughMyo armband via BLE convention to the recognized control gadgets that incites the utilized engines (Gaetani et al, 2018).

2.11 Mobile Quad-Controlled wireless Robotic Arm

In this study, Its created a remotely controlled mechanical arm with 4 degree of flexibility (D.O.F) that's wirelessly controlled utilizing four control instruments, i.e, Voice Control, Savvy Phone-Tilt Control, Inaccessible control and Hand Motion Control. Remote innovations such as Bluetooth and Wi-Fi are utilized to get to the Quad-Controlled Mechanical Arm (QCRA). A model QCRA is created. The QCRA can be utilized to choose and put objects from one put to another on getting the commands from remove, in this manner decreasing the human exertion. An Android application is created for comfort of the client in working this QCRA, utilizing diverse control components. Execution assessment comes about are empowering. Potential applications of the QCRA in homes, businesses and for physically challenged/aged individuals are moreover examined (Reganti et al, 2016).

2.12 Gesture Controlled Prosthetic Arm with Sensation Sensors

The significance of a Prosthetic Arm can as it were be realized by a disabled individual. But these arms are not simple to create., commonly do not have different degree of flexibility., complex to utilize and expensive. That's why this venture aiming to form a prosthetic arm that can be made effectively with degree of flexibility near to genuine hand., client inviting and taken a toll effective. Here., Degree of Flexibility is the number of autonomous parameters in a mechanical framework. It characterizes the opportunity of development in framework. The chassis of the hand was made by 3D printing innovation which evacuated complexity of generation. Chassis was made mirroring an genuine hand to allow greatest degree of flexibility. The hand can be worked by flex sensor which can imitate the development of other useful hand.

The sensor will send information to the servo engines that will be moving the fingers of the prosthetic arm as like as the useful arm., which makes it client inviting. Once more., an LM35 sensor was utilized within the hand which can send warm sensation input to a Peltier plate that produces client to feel the warm sensation like an real arm. The total venture was made with locally and commonly accessible materials which made effectively a fetched effective one (Saqib et al, 2018).

2.13 Design of a Controlled Robotic Arm

This research presents a plan of controlled mechanical arm with myoelectric and body activity signals. The execution employments the detected signals, through the signal preparing of ARDUINO UNO R3 improvement board and NUC140VE3CN improvement board (ARM processor), to control the automated arm wirelessly. The proposed plan can be utilized within the unsafe operation environment. The clients can contactlessly control the mechanical arm securely. And it can work indicated activity more than once and precisely for manufacturing plant fabricate. The rotative point of mechanical arm controlled by Servomotor is chosen by beat width balance signal gotten from microcontroller by means of BlueTooth 4.0 remote innovation. The beat width balance signal gotten from microcontroller is chosen by the sensors found on the human's arm or sensor glove (Chen et al, 2016).

2.14 Survey of robotic arm and parameters

This can be a study on a mechanical arm and their improvement. It provides a specialized presentation to a few of the current research study in this field. This could be an area with a series of extraordinarily open problems and a research area. These days, a diverse assortment of automated arms are commercially accessible. A few of them are great in precision and reproducibility. In this study, we get it the advancement of automated arm in last 20 years and depicted distinctive parameters of an arm. Sort of automated arm as it were depends on these parameters. This overview may be utilized for information and rules for future work. The paper finalized with investigate crevices and proposed work. Mechanical arm employments within the distinctive areas like a family, working environment, and working station (Patidar and Tiwari, 2016).

2.15 Design, Analysis and Implementation of a Robotic Arm- The Animator

A humanoid mechanical technology could be a modern challenging field. To co-operate with human creatures, humanoid robots not as it were need to include human like shape and structure, but more critically, they must arranged human like behavior with respect to the movement, communication and insights. The show Number of this tenderfoot is ASR K-250. This study we consider the instrument and mechanical structure of ASR K-250 (Tenderfoot) and it is usage (Rahman et al, 2013).

CHAPTER 3

MATERIALS ANDMETHODOLOGY

3.1 Introduction

Orthopedic and prosthetic (O&P) care and rehabilitation for amputation or injury for more than 43 million disabled American citizens and also for millions of other patients around the world is a health care solution that helps with increased access to health care costs and limited access to quality service. As a result of research, it has been observed that for every dollar spent for rehabilitation, disabled patients can save much more money by maintaining their daily lifes after an injury occurs. The cost of long-term care, compared with the savings made bylong-term care and patient rehabilitation; institutionalization may include adult day and home care. Rehabilitation means income generation, so that rehabilitated patients can start working and continue to pay taxes, as well as ending wage claims.It is very difficult for rehabilitation patients to receive medical care for a long time.

As of late, the plausibility of combining mechanical and rehabilitative advances has been communicated with extraordinary intrigued in rehabilitative applications. Amid the final fifteen a long time, multi-degree of flexibility robot arms and able automated hands have been built to perform independently fine and sensitive assignments. Based on this innovation, analysts have begun testing on the EMG control of multi-fingered hands, tele-operation of complicated robotic prosthetic hands, usage of drive tangible criticism on myoelectrical controlled lower arm prostheses and plan of multifunctional robot prosthetic hand mechanisms.

Currently, the effective controlled prosthesis may have one or two controlled degrees of freedom driven via moo control motors. The currently used limit prostheses are either an end assembly (such as hand or snare drum) controlled by the movements of a bearish stem transmitted by a cable (e.g., body fuel) or by, for example, fuel-powered body myoelectric control (i.e., motors driven by compression of the engine). muscles in the remaining limb).Within the last mentioned control strategy, terminals implanted within the socket of a prosthesis distinguish EMG signals produced by withdrawal of the leftover muscles of an removed limb.These signals give a trigger for battery-powered DC motors that enable the prosthesis to move the hand, elbow and / or wrist.

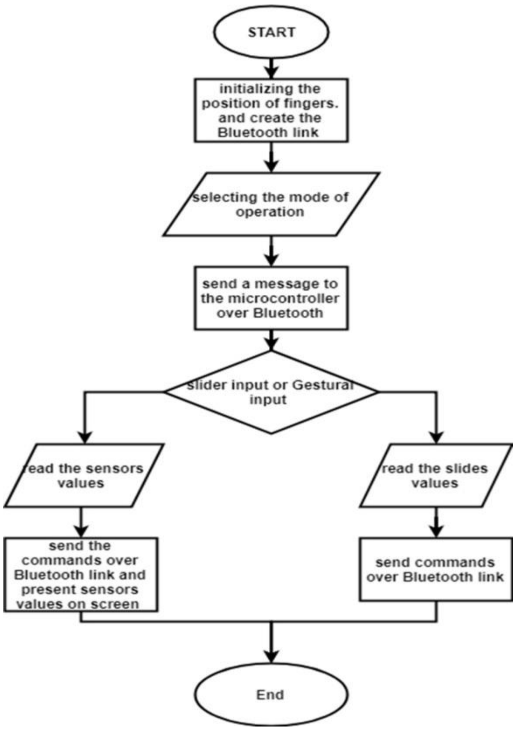


Figure 3.1: Mobile phone application flow chart

However, these types of prostheses support restrictedcapability to manipulate small objects. The control of the holding force is not strong as there is no sensory feedback. In addition, the support structures and gear systems that provide the weight of the motors enable the prosthesis to increase its weight. It also eliminates the significant aesthetic qualities of a device with excessive system noise. Improved control of multiple degrees of freedom and sensory feedback will greatly improve the operation of these prostheses.

Robotic systems have been suggested to perform largely tasks in non-medical procedures where anthropometric movement is selected but human intervention creates natural risks. Such activities involve the removal of hazardous waste and non-use of nuclear sites. Since these tasks are performed in an environment with high radioactivity, robotic and automated systems are needed to decrease the exposure of workers to radiation. Robots operating in such dangerous conditions must be capable of lifting high weights and can create a large working area. At the same time, they must be soft enough to move in a light, scattered plane for easy transport. However, existing robotic systems for macro processes are formed with a low load capacity / weight ratio and are generally bulky and voluminous.

Traditional systems utilized to provide the aforementioned robotic applications have many restrictions. Heavy, weak, and bulky actuators are generally not suitable for human anatomy.However, the lack of advanced sensory interfaces and traditional control approaches cannot ensure the interaction between human and artificial members. The tactile sensation of the human lower and upper limbs develops, changes in temperature and can be detected when a force is applied to the limb, and may also decide to use a force appropriately. Existing prosthetic and manipulative articulation devices do not have these features.

A complex and subtle living organ, such as the human hand, makes it suitable over a long period of time to carry out an almost impossible process, to fully insert it into an adequate place. Therefore, those who design hand prostheses should immediately acknowledge the fact that in any model production, the natural hand is confronted with simulation of infinite movement, as well as the natural deficiency of power mechanisms, nerve sensitivity and subconscious reflexes. Although "hand innovations" have some anthropomorphic properties, they are, in fact, counted as a substitute, and are naturally produced so as to have the features of tools designed to increase the usefulness of an armlet.

In the case of technical studies, it is very important and guided by limb designers to choose these features from all normal hand characteristics, since it is very difficult to include a hand limb in a hand prosthesis that is more than a very limited number of qualities of a normal limb designer. Thus, the loss is most commonly felt by the arm amputee. These include pre-tension function, sensory and perceptual ability, cosmetic appearance of the hand itself, and mostly cases under one-sided elbow, in order of importance in both men and women.

Generally, in all cases of upper extremity amputation, the inability to grasp objects is one of the most noticeable deficiencies, and in bilateral situations the patient is desperate when looking at other parts of the anatomy only the lower limb can adapt to some of the old hand functions.Except in extreme cases, it is simple and easy to apply replacement preventive. According to some model appearance of the normal grip, there is a variety of essential clamp movements. This allows it to be supported by a variety of design examples, scapular abduction, arm flexion, non-elastic muscle motors or other sources of force that work in accordance with the springs, as well as the distinctive hook development and prominence. Adaptable as a means for many different types of activities such as rubber bands, hook prostheses and the like, there has been a long yeoman ship in the health service of thousands of arms amputees, without significant limitation in shape and appearance (Mavroidis et al, 2002).

3.1.1 Hand movements

The hand of human could be a complicated mechanical construction contains tendons, bones freely interfacing bones, muscles providing as pressure engines, ligaments performing as cables joining muscles to bone, and a covering of defensive delicate skin and tissue. The bones are connected to the joints and do not alter in measure. Muscles can make joint movements or torque via weight, and for each muscle there are one or more muscles which provide opposite via counter-torque or restricting movement. In Figure 3.1 shows the skeleton of the left hand from the palmarside and dorsalside.

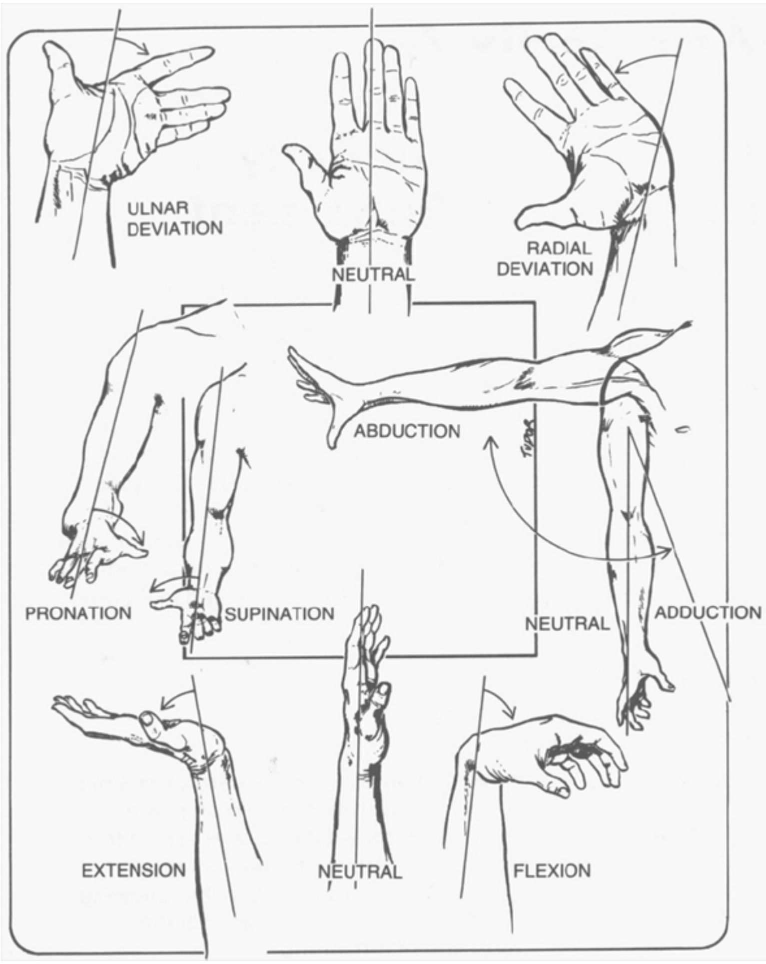


Figure 3.2: Wrist and fingers joint movements

3.1.2 Description of joint movement

The particular movement of the hand is designed by turns of its proximal joint and could be demonstrated by the joint's turn focuses. Here each joint position was characterized with adjacent organize systems (Figure 3.2) and talk to any joint turn by a course of action of revolutions happeningaroundthe 3 tomahawks of the neighborhood organize system. Joint revolution around an rotate is communicated by ef (fl, where a talks to the turn, fi indicates the joint, and y represents the finger). The joints of human hand can be classified as flexion, bend, arrange, or circular concurrent to.

The sort of improvement or conceivable transformation tomahawks. A flexion movement joint to a single opportunity DOF is the elbow or knee, whereas a rotation movement joint with a DOF is the protrusion of the lower arm. Command movement via2 DOF awards flexion movement which shows more than 2 headings. Circular advancement, as inside the bear or hip, has 3 DOF and gifts concurrent order and bend motions.

Figure 3.2 demonstrates the joints which utilized by our hand , in conjunction via their related allow able motion sorts. Each finger (I1- V) has 4 DOF (two of them at the metacarpophalangeal or MP, one of them at the distal interphalangeal or Dip and one at the proximal interphalangeal or PIP), whereas the thumb (I) has 5 DOF (two at the MP, two at the PIP, and one at the Dip). The wrist's bend movement is involved since the hand must be considered independently from the lower arm. In the classification and arrangement of this joint movement, there are 27 DOF for the hand, counting 6 DOF to position. The prosthetic hand was controlled by android mobile phone (Nova 3I, Huawei), which a specific application was arranged for this reason it is showed up in Figure 3.2. The arrange can be summarized in stream chart showed up in Figure 3.2 . The application consolidates two modes of operation which can be successfully traded between by clicking of a button inside the app.

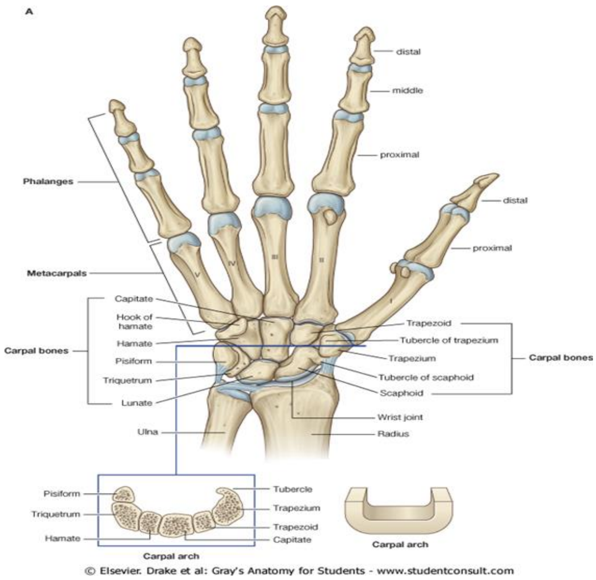


Figure 3.3: Bones of The Human hand

A hand skeleton seenby the Palmar side (adapted from pernkop`s anatomy).Then the specified terminology was used. For example, M(III) represent the metacarpal bone of the middle finger. It shows as follows;

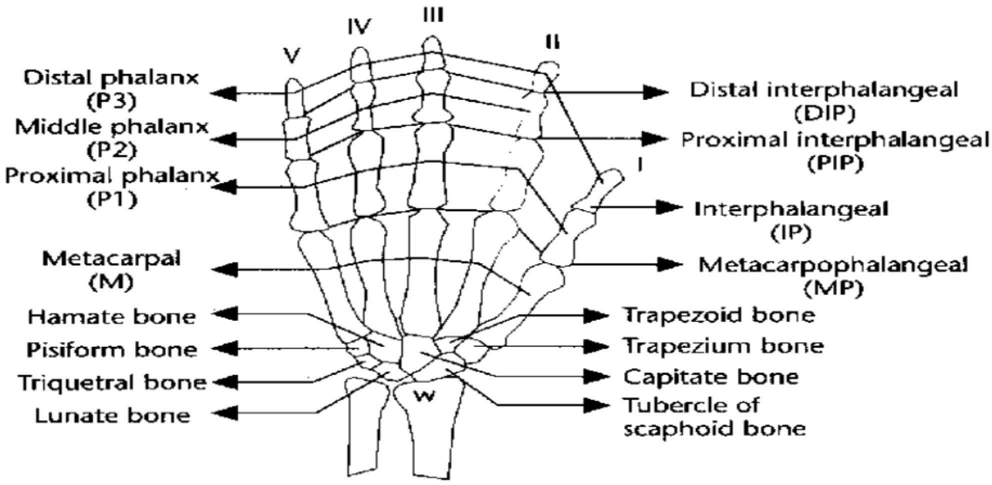


Figure 3.4: A Hand skeleton

Local coordinate system of fingers and thumb described by conventional right hand coordinate system. The rotation of each joint is indicated by a series of rotations around the x, y, z axes of the local coordinate system.

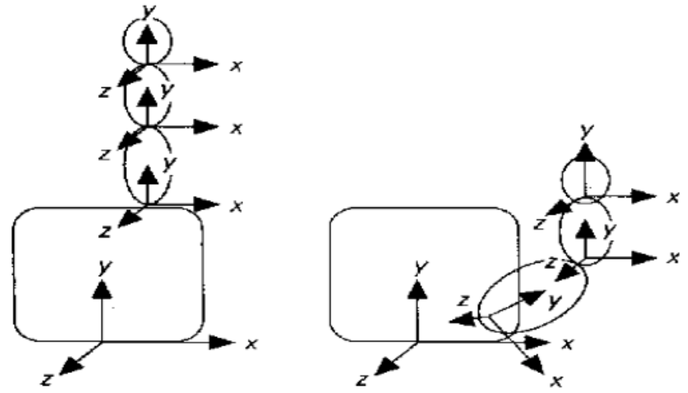


Figure 3.5: Local coordinate system of the fingers and thumb

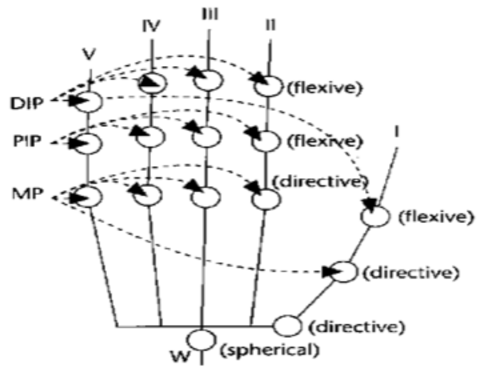


Figure 3.6: Hand Joints and Movement Types

3.1.2.1 First mode (slider input mode)

First mode (slider input mode): In this mode the fingers of the prosthetic hand are controlled straightforwardly by 5 slide bars on the android mobile phone application. Movements of these fingers are produced by servo motors inside the arm. Each slide bar compares to the position of a particular servo motor from degree to 180 degree. In the first mode, all fingers of the prosthetic hand can perform Extension and Flexsion movements at the same time. We can also apply Extension and Flexion gestures on each finger individually, all you need to do is open the manual mode in the application that is on the phone screen. If the setting is zero, the finger is in the extension position. as the number of degrees increases, it applies the flexion movement.

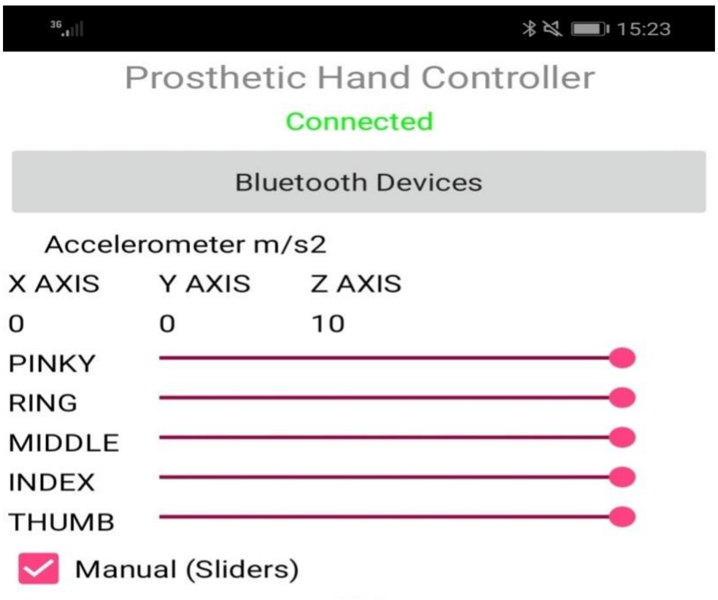


Figure 3.7: Mobile phone application screen

3.1.2.2 Second mode (Gestural input mode)

Second mode (Gestural input mode) Gestural input mode was outlined to change over gestural movement of the mobile phone into complex movements of prosthetic hand. In this mode, inertial sensors counting accelerometer and whirligig implanted within the mobile phone are utilized to distinguish the hand gestures of the client to form more complex and foreordained hand and finger movements.

In this mode, the X, Y, Z axes were given values from -10 to 10. If the phone is parallel to the ground on a flat surface, the values of x and y axis are one, and the value of z axis is ten. In this case, the controller circuit is commanded for full extension coding. When we turn the screen of the phone to the right, our X and Z value is one and the Y value is smaller than minus nine, So Pinky and Ring fingers are flexion and other fingers are extension. When we turn the screen to the left, our X and Z values are one and the Y value is 10. Thus Middle, index and Thumb fingers are flexion and other fingers are extension. When we turn the screen towards the ground, Y and Z are one, and x is 10, and since we introduce full flexion to the microprocessor, all fingers will be closed.

Figure 3.8: Hand movement depend to mobile phone gyroscope feature

3.2 MATERIALS

3.2.1 Arduino

Open Source is all over with Linux Innovation and GNU establishment. In expansion to open source software's and operating frameworks, Open Source Equipment is additionally advancing and getting to be center point of fascination for analysts over the niche and corner of the whole world. The foremost broadly received Open Source hardware accessible right presently is “Arduino”. Arduino has different items like boards, Lilypad's and shields. The point of this thesis is to investigate the world of Arduino innovation in terms of Boards, Lilypad's and Shields covering in depth regarding-Technical Details, features and real-world applications. Arduino innovation has empowered different manufactures and investigate devotees to come out with their possess customized boards and shields as per their inquire about requirements and area of executions. Arduino Open Source community is additionally giving stage for analysts to come up with inventive inquire about applications and showcase prepared items in terms of Domestic Automation, Robotics, Wireless Connectivity, Rambles and numerous others.

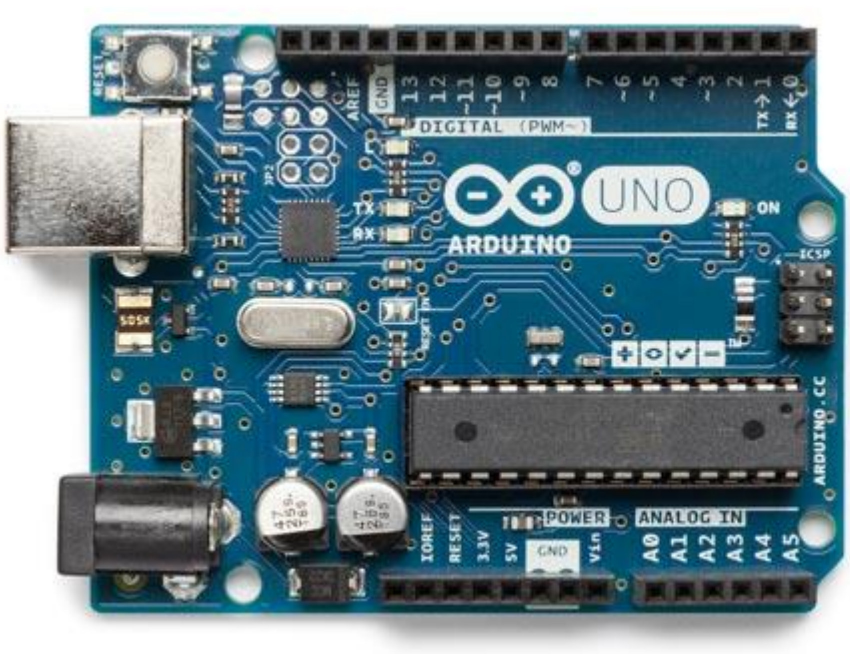


Figure 3.9: Arduino circuit

3.2.1.1 Overview

Arduino is essentially not a "MicroController" but respected as "Open Source Equipment Movement" and was established by Massimo Banzi and David Cuartielles, Tom Igoe, Gianluca Martino and David Mellis in 2005. Arduino has simple to memorize dialect and libraries based on C++ Dialect and IDE environment for appropriate programming interface. Arduino is respected as Stage Independent Equipment and can work on Windows, Linux and MAC working System.

3.2.1.2 Hardware Specifications

Arduino, an open source equipment board is based on ATMega328 Microcontroller based on 8-, 16- and 32-bit AVR Innovation. ATMega328 is essentially AVR 8-bit RISC controller based on Double Inline Bundle (Plunge) innovation; has 20 MHz clock oscillator, 32kB streak, 1kB SRAM, 23 I/O Programmable Pins, 6 Channel 10-Bit ADC and 6 PWM outputs.

Table 3.1: Specifications of Arduino board (Nayyar and Puri, 2016)

Microcontroller	**Atmel Atmega328**
Operating Voltage (logic level)	5V
Input Voltage (recommended)	7V-12V
Input Voltage (limits)	6V-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
Analog Input Pins	8
DC Current Per I/O Pin	40mA
Flash Memory	32KB of which 2 KB used by bootloader
SRAM	2KB
EEPROM	1KB
Clock Speed	16MHz
Dimensions	0.73" x 1.70"
Length	45 mm
Width	18mm
Weight	5g

3.2.1.3 Arduino Software (IDE)-Integrated Development Environment

Arduino Integrated Improvement Environment (IDE) is an independent base for Arduino equipment and can operate in multiple operating frameworks. It is a multi-tier application based mainly on Java Innovation and the Processing Programming dialect and Cabling Initiatives are established. The Arduino IDE can be a solid stage for all analysts, software engineers and other industries to expand their progress experts to build initiatives on Arduino Controllers and other sensors.

Arduino IDE is bundled with computer program library named “Wiring” to encourage simple I/O operations. The complete program structure can be composed primary capacities:

setup():This function is used to initialize the settings and is executed at least once during program execution.

loop(): This function is executed iteratively till powering off the main board.

{setup(): This work is utilized for initialization of settings and executes at least once at execution of program.

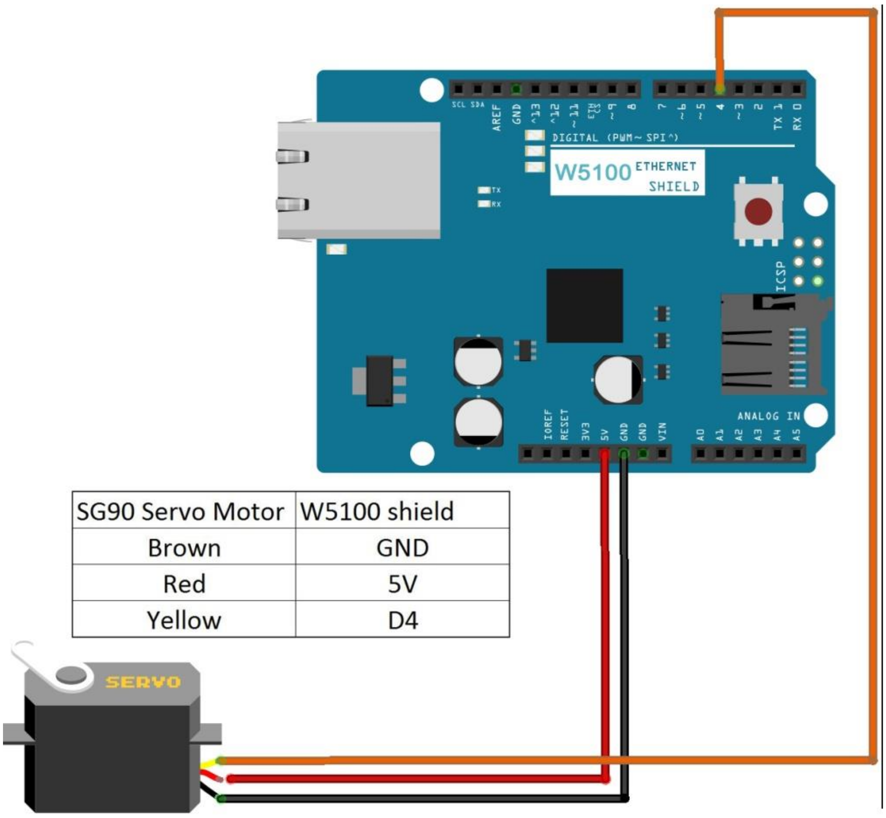
loop(): This work is executed iteratively till controlling off the most board.}

After writing the program on the Sketch, the program is to be compiled by clicking tick button. After successful compilation, the program is uploaded to the board by clicking the “Upload Button” --> . On clicking of the upload button, the code is written to a Temporary File which includes extra include header at top and simple main () function at bottom (Nayyar and Puri, 2016).

3.2.2 Servomotors

Any mechanical movement around is achieved by an electric motor which is capable of converting energy by taking electrical energy and producing mechanical energy. Electric motors provide power for hundreds of devices used in daily life. Small motors used in automobiles, robot, food blenders and hand power tools are typical examples. Other small motors find applications in micro-machines for separating red blood cells according to size and also in medicine (Pahuja and Kumar, 2014).

A robotic arm is proposed for servomotor controller design .This servomotor is used to control an arm, which has servomotors MG995, to accomplish the movement of gripping some goods (Moshi et al,2011) (Weng et al, 2012).



SG90 Servo Motor	W5100 shield
Brown	GND
Red	5V
Yellow	D4

Figure 3.10: Connection of Servomotor with Arduino board

3.2.3 HC-05 Bluetooth module

A robot is, as a rule, an electro-mechanical machine operated by computer and electronic programming. Many robots are manufactured and can be found in industrial plants around the world. Versatile Planning the latest modified ROBOT that can be controlled using an APP for Android. Robot movements can be controlled with them in the android application remote control buttons are created.

Bluetooth communication was used to interface controller and android. The controller can interface to the Bluetooth module despite UART rules. Robot movement can be controlled by accepting commands from Android. The reliability of a mechanical frame in combination with quality and repeatability is unmatched. Select and Place robots can be re-programmable and can be tooled to supply for different applications (Lanwind, 2010).

Figure 3.11: Hc-05 Bluetooth module

3.2.4 Resistance

Resistance is a measure that can withstand the current flow in an electrical circuit.

Resistance is symbolized by the omega (Ω) letter and its measurement is expressed in ohms. As a result of the analysis of Georg Simon Ohm, a German physicist between 1784-1854, Ohm was named after the relationship between voltage, current and resistance. Formulated according to Ohm's Law. All materials can withstand some degree of current flow. It is expressed between two broad categories:

- Conductors: The materials used provide little resistance where electrons can easily move. Examples: copper, silver, gold and aluminum.

- Insulators: Materials that present high resistance and restrict the flow of electrons. Examples: Rubber, paper, glass, wood and plastic.

Resistance measurements are generally taken into account to indicate the state of a component or a circuit.

- If the resistance value is high, the current flow decreases. If it is substantially high, there is the possibility of damaging the conductors due to combustion or corrosion. All conductors emit some heat, so overheating is often a matter of resistance.
- If the resistance values decrease, the current value becomes high. The reasons for this are insulators damaged by overheating or moisture.

Components such as heating elements and resistors have a constant resistance value. These values are often printed on the nameplates of the components or in the manuals for reference. In this study, 100kΩ resistance was used (Arataniet al, 2007).

Figure 3.12: 100K ohm resistor

3.2.5 Android Application

MIT App Inventor 2 is one of the most ideal platforms used to develop handsets and to control the hand. The program used for this platform can be downloaded free of charge and the program language is very simple to learn. MIT App Inventor 2 is a block editor style: instead of typing lines of code in the traditional way, drags and drops blocks to represent designer functions and variables. Each code section starts with a condition given by the "when" block and continues with"get"blocks or"set"blocks; indicates what the application will do when the "when" condition is met. Each "when", "get" and "set" block are specific to each component; for example, a button has "when Button1.Click", and the" when "condition that is correct when the button is clicked12.

App Inventor allows you to improve applications for Android phones using a web browser and a connected phone or emulator. App Inventor servers store your work and provide you keep track of your projects.

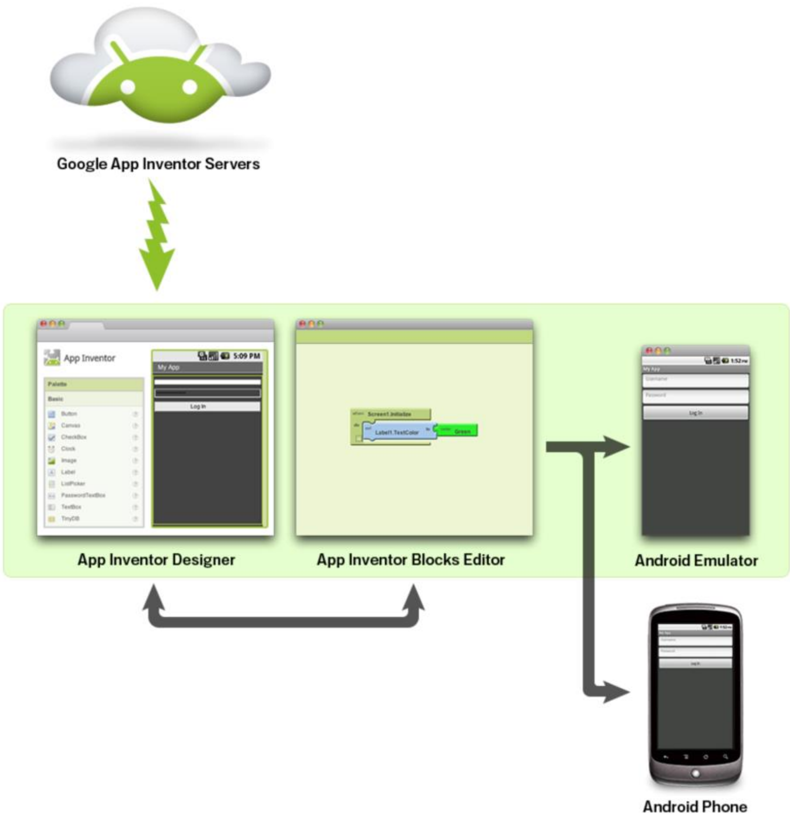


Figure 3.13: MIT App Inventor schematic description

You can create applications by reviewing the following steps:

- App Inventor Designer for which you choose components for your application.
- App Inventor Blocks Editor, where you merge program blocks that specify how components should behave. Bring programs together visually, assemble pieces like pieces of a puzzle.

When adding tracks, your app will appear step by step on the phone, so you can test your work while creating it. Once finished, you can package and upload your application to create a stand-alone application.

If you don't have an Android phone, you can create your Android emulator applications using software that runs on your computer and acts like a phone.

The App Inventor development environment is supported to implement Mac OS X, GNU / Linux and Windows operating systems and various popular Android phone models. Apps created with App Inventor can be installed on any Android phone.

Before you can use App Inventor, you must set up your computer and then install the App Inventor Installation package on your computer.

The following figure is the designer page of the app inventor. On this page we design the project or application we want to run under what conditions.

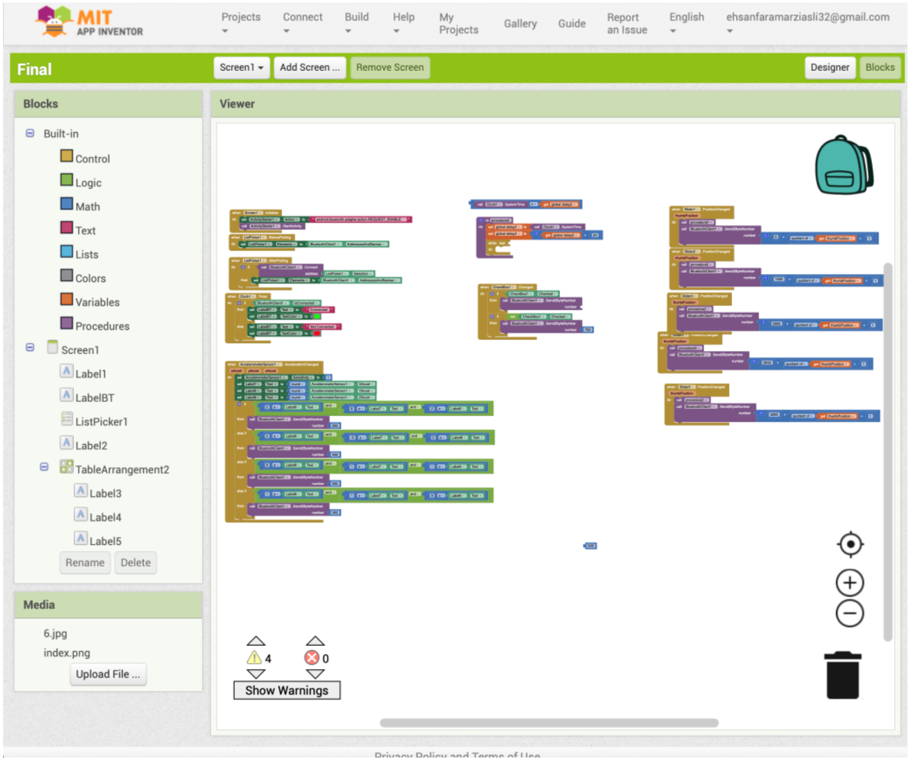


Figure 3.14: Designer page of app inventor

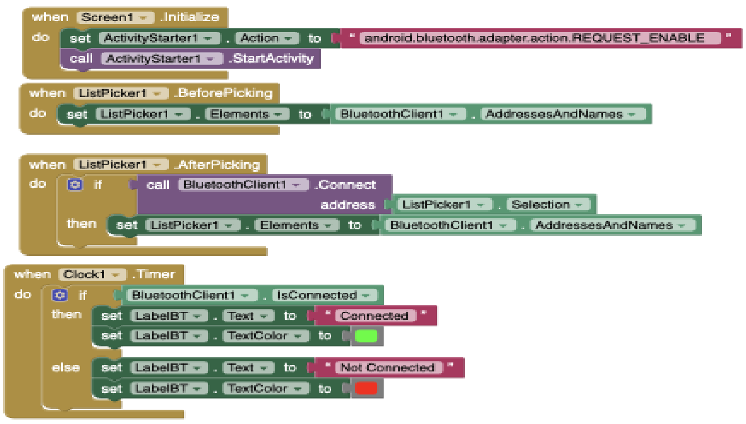


Figure 3.15: Connection of blocks for Bluetooth connection

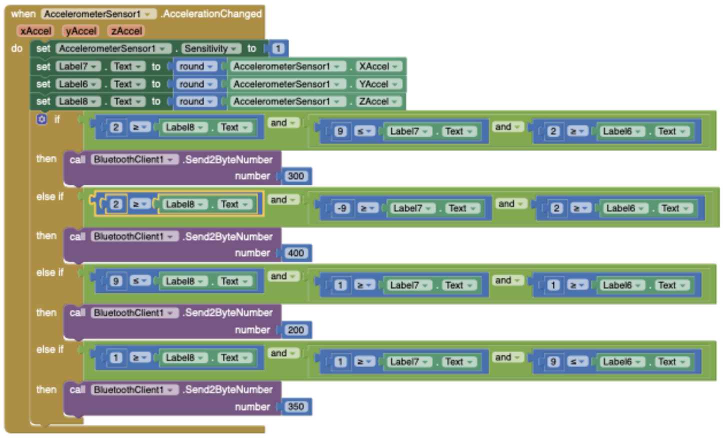


Figure 3.16: Connection of blocks for accelerometer sensor

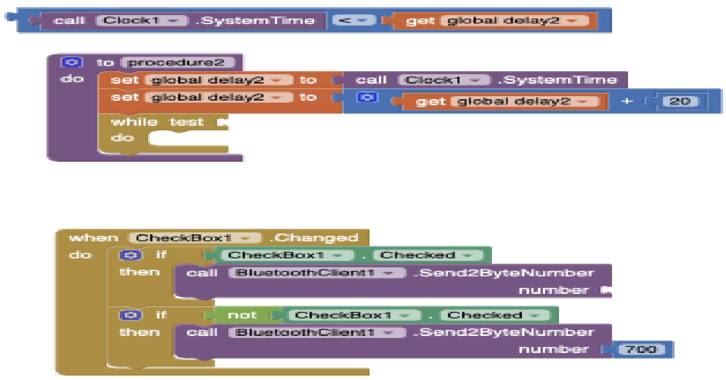


Figure 3.17: Connection of blocks for system time and check box

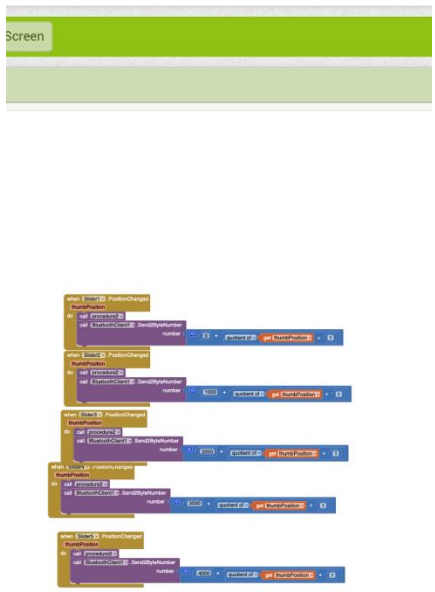


Figure 3.18: Connection of blocks for hand slide motion

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Result

The examples presented in this disclosure attempt to mimic human skeletal structures through activation by intelligent skeletal muscles. SM artificial muscle actuators reduce the total weight because a servo motor is lighter than the power connecting cables and performs at the same capacity as the servo. It has been shown that these systems can make great movements and can be used in artificial limbs. Furthermore, the prototypes and methods of this disclosure show that intelligent human muscles can be used in place of the actuator in artificial human limbs. However, both medical and non-medical applications and designs can be realized by the instruction of the present invention.

In the preceding chapters of the general, the importance and necessity of the topic was expressed. It also spoke about the science of prosthesis and orthotics, features, and uses of this technology. The science of prosthesis and orthotics has opened up to the world of science and technology and has revolutionized many of the ways in which modern human life has become a modern science in engineering. Medical science is not separate from this. The science of prosthesis in medical engineering has also done a lot.

In this thesis the results were taken by monitoring the response of the bionic hand to the commands issued from the mobile application and transmitted with Bluetooth communication protocol. the accuracy of system was calculated as 100% when each command was issued 50 times.

The baud rate of communication was 9600 bit/sec. The motion of the hand was generated by 5 servo motors. Each of the motors commanded by signal from Microcontroller board. the control and driving approach of the motors is based on PWM technique. The duty cycle of the command signal (PWM) will determine the position of the motor shaft. Thus, the position of the finger.

The pulse width of the PWM driving signal is related to the position of the finger. For example, if the pulse width is 0.5 millisecond the finger is in final flexion position. When the width of PWM is 2.5 millisecond the finger is in total extension position. Figure 3 shows the PWM driving signal of middle finger. Also Figure 4 shows the PWM driving signals for two fingers middle and thumb in different positions.

In addition to this, there are advantages and disadvantages. The most important advantage is that it is a remote-controlled prosthetic arm. Remote control is also easy for the user. This is because more cables are eliminated. This study will provide the user with a good understanding of the objects and ease of hand movements that he / she feels in daily life. In this project, using the smart phone's gyroscope feature, it can transfer the biological hand movements to the prosthetic arm.

As an example; The project is just a prototype. In other words, this project cannot be implanted directly in a patient who is amputated because it is not biocompatible.

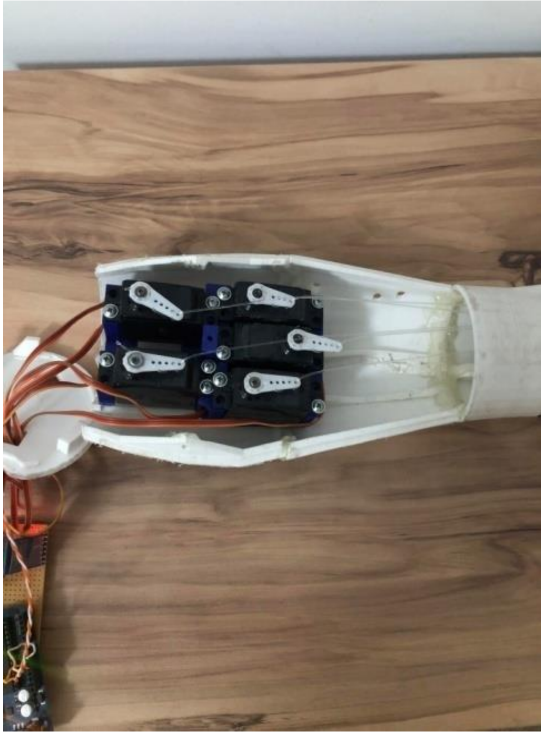


Figure 4.1: Position of servomotors in extension motion

Figure 4.2: Position of servomotors in flexion motion

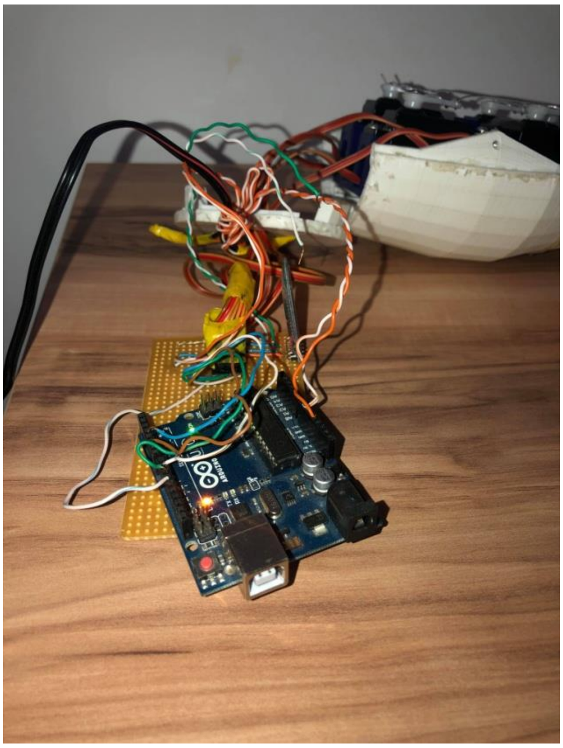


Figure 4.3: Connection of circuit with prosthetic arm

In the following photo (Figure 4.4), the middle finger PWM signal flexion position is detected through the oscilloscope. POS width is 522.4 microseconds, period is 20.00 milliseconds and frequency is 49.99 HZ.

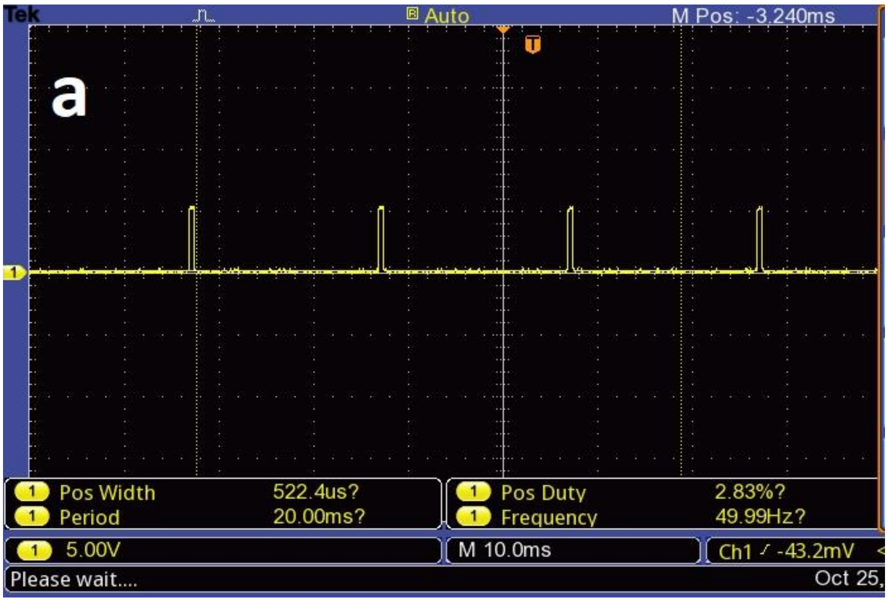


Figure 4.4: PWM signal of middle finger flexion

In the following photo (Figure 4.5), the middle finger's PWM signal is not detected by the oscilloscope when it is in the extension position. POS width is 2.403 milliseconds, period is 20.00 milliseconds and frequency is 49.90 HZ.

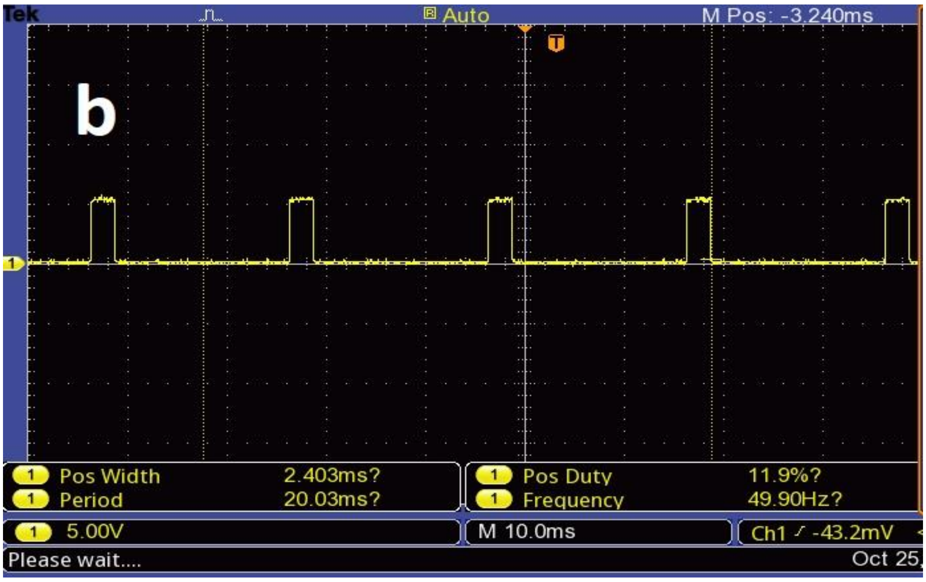


Figure 4.5: PWM signal of middle finger in total extension

In the following photo (Figure 4.6), the middle and thumb fingers PWM signal is detected through the oscilloscope when in the extension position. POS width is determined as 2.400 milliseconds, period 20.00 milliseconds and frequency 50.00 HZ.

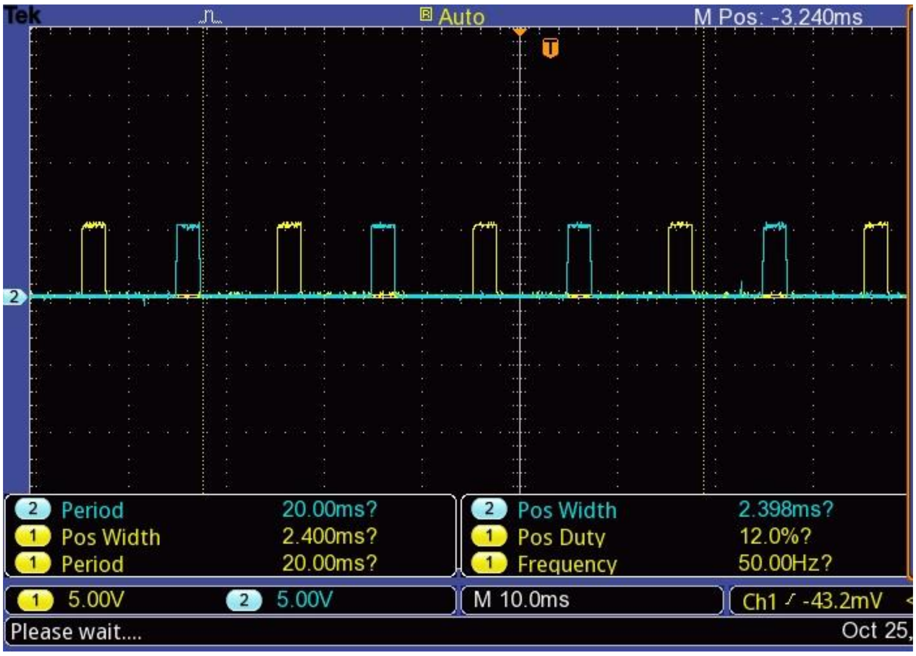


Figure 4.6: PWM signal of middle and thump fingers in two different position

CHAPTER 5

CONCLUSION

5.1 CONCLUSION

As a result of the literature researches, it was analyzed that the studies and inventions on biomedical, rehabilitation, biomechanical, prosthetic and orthotic engineering have an important impact on life. It enables people with disabilities to perform delicate procedures and allows specialist doctors to make quick decisions and perform successful treatments. This will lead to new devices, methods. Robotic systems can be applied to achieve operations such asbrain surgery,neurosurgery, knee arthroplasty and eye surgery. In addition, rehabilitation systems should be designed and controlled as assistive tools for people with disabilities, and should be used for robotic and mechatronic technologies by automatically providing home health care services.

Some changes in the corresponding structures in the methods described and illustrated will be apparent to those skilled in the art. Accordingly, a particularly described portion of the invention is produced according to the following steps.

Undoubtedly, the purpose of any research and the reason for choosing any scientific project is to solve the problem and challenge that exists in a scientific subject. This challenge attracts the attention of the project's collectors and makes them effective in removing it. This is a general and permanent rule in all scientific research. This thesis is no exception.

The main aim of this thesis is to improve a compact, light and portable hand structure for people in the field of rehabilitation and treatment. This structure is made possible by the addition of two cable-modular cable systems to traditional systems of the past, so that it can execute the correct configuration and movement of the robotic fingers like the finger of an adult person. Prior to the development of the mechanism, the analysis of the anatomy of the index finger and its kinematics was carried out and, through experiments performed with the physical substrate, the relationships between the joints of DIP, PIP and MCP were extracted.

The achievements of this research are listed below:

1. Two proposed coupling systems work desirable so that they can eliminate the imperfections associated with the incompatibility of human natural finger and this artificial hand movements in rehabilitation applications.

2. The whole structure is compact and light weight, so that it can easily be covered with a gloves, and even has no disruption in the skillful movements during the coating with gloves. It is such a hard thing to do with robotic fingers with bridge mechanisms. In the final step, based on the achievements of this study, an example of this finger was constructed using a 3D printer and presented in this thesis.

Utilizing the mobile phone sensors to command a bionic hand was implemented with a low-cost material. This approach will have a positive impact on the life quality of disabled subjects. Specially with upper limbs disability since this method is simple and controlling lower limbs is more complex and needs investigating the weight and balance of human body. Future work could be conducted on improving the algorithm of controlling. Employing additional sensors on the bionic arm to measure the grip strength.

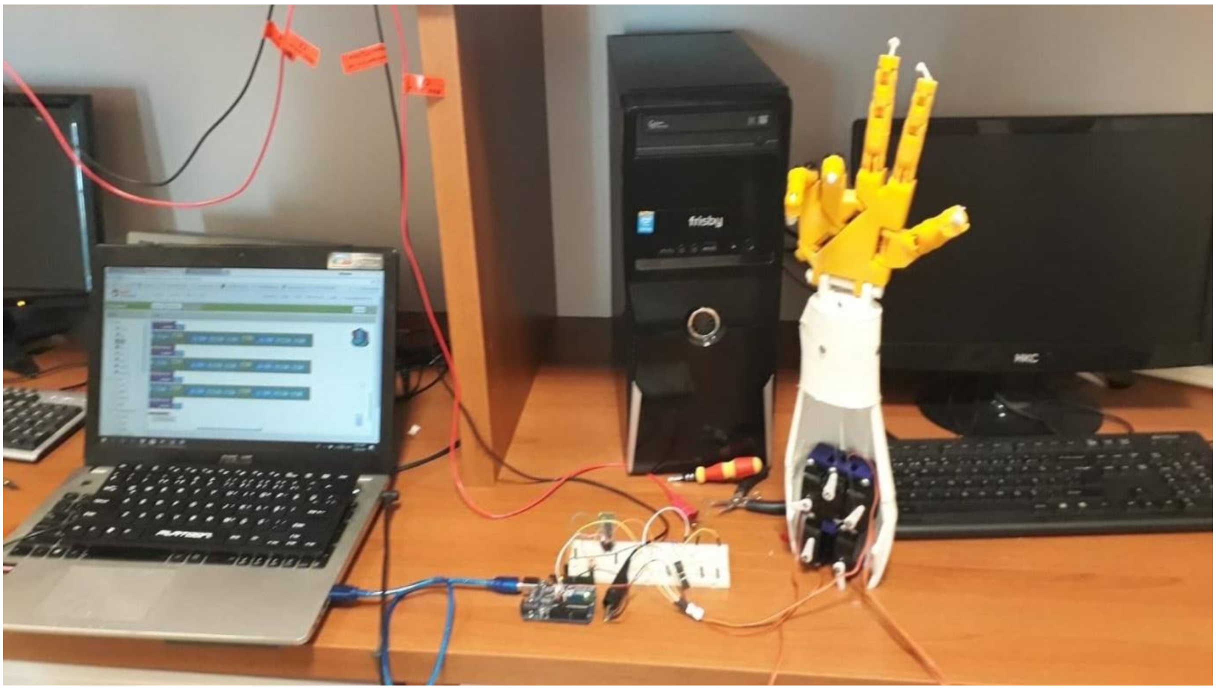


Figure 5.1: Connection of prosthetic arm with Arduino and application in laptop

5.2 Proposals and Future Work

Future investigate will aim lessening the sources of blunder and perform calculations in genuine time. Conceivable framework upgrades involve:

- Joining of a more precise show for mimicking palm movement.

- Collision avoidance of finger fragments employing a knowledge based on skin surface topology.
- Improvement of uncommon pointers to distinguish the 7 feature points on their artificial hand in an ordinary indoor environment.
- Utilize of parallel preparing and as of late created methods such as calculating the reverse kinematics in genuine time.
- When the speed and accuracy of our procedure move forward, curious and varied applications will normally be implemented.

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APPENDICES

APPENDIX

```
#include <Servo.h>


Servo servo1;

Servo servo2;

Servo servo3;

Servo servo4;

Servo servo5;

Servo servo6;

int f=0;

void setup() {

Serial.begin(9600);

servo1.attach(11); //servo 1

servo1.write(180);

servo2.attach(10); //servo 2

servo2.write(180);

servo3.attach(9); //servo 3

servo3.write(180);

servo4.attach(6); //servo 4

servo4.write(180);

servo5.attach(5); //servo 5
```

```
servo5.write(180);

}

void loop() {
if (Serial.available() >= 2 )
{
unsigned int a = Serial.read();
unsigned int b = Serial.read();
unsigned int val = (b * 256) + a;

if(val == 700)
{f=0;}
else if(val == 500){f= 1;}
if(f == 1)
{
if (val>= 0 &&val<= 180) // servo 1
{
servo1.write(val);
}
else if (val>= 1000 &&val<= 1180) // servo 2
{
servo2.write(val-1000);
```

```
}
else if (val>= 2000 &&val<= 2180) // servo 3
{
servo3.write(val-2000);
}
else if (val>= 3000 &&val<= 3180) // servo 4
{
servo4.write(val-3000);
}
else if (val>= 4000 &&val<= 4180) // servo 5
{
servo5.write(val-4000);
}
}
else if(f==0){
  if (val == 200){
   servo1.write(180); // reset
   servo2.write(180);
   servo3.write(180);
   servo4.write(180);
   servo5.write(180);
}
else if (val == 300){
```

```
  servo1.write(0);  // left
  servo2.write(0);
  servo3.write(180);
  servo4.write(180);
  servo5.write(180);
}
else if (val == 400){
  servo1.write(180); ///right
  servo2.write(180);
  servo3.write(0);
  servo4.write(0);
  servo5.write(0);
}
else if (val == 350){
  servo1.write(0); // closing
  servo2.write(0);
  servo3.write(0);
  servo4.write(0);
  servo5.write(0);
}
}
```

```
}


}
```