

HAND EXOSKELETON FOR REHABILITATION

Submitted in partial fulfillment of the requirements for the award of Bachelor of
Engineering Degree in Electronics and Communication Engineering

by

G.AJAY BABU (37130131)

M. THARUN KUMAR REDDY (37130226)



**DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING
SCHOOL OF ELECTRICAL AND ELECTRONICS ENGINEERING**

SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY (DEEMED TO BE UNIVERSITY)

Accredited with Grade “A” by NAAC

**JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI - 600 119
MARCH 2021**



**SATHYABAMA
INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**



Accredited with Grade “A” by NAAC

JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI - 600 119

www.sathyabama.ac.in

**DEPARTMENT OF ELECTRONICS AND COMMUNICATION
ENGINEERING**

BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of
M.THARUN KUMAR REDDY(37130226) and **G.AJAYBABU**(37130131)
who carried out the project entitled “**HAND EXOSKELETON FOR
REHABILITATION**” under our supervision from December 2020 to March 2021.

Internal Guide

Mrs. VIJAYASHREE. T, M.E.,(PhD)

Assistant Professor, Department of ECE

Head of the Department

Dr. T. RAVI, M.E., Ph.D.

Submitted for Viva voce examination held on _____

Internal Examiner

External Examiner

DECLARATION

We, **M. THARUN KUMAR REDDY (37130226)** and **G.AJAY BABU (37130131)** hereby declare that the Project Report entitled “**HAND EXOSKELETON FOR REHABILITATION**” done by us under the guidance of **Mrs. VIJAYASHREE. T, M.E.,(PhD)** is submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering degree in Electronics and Communication Engineering.

1) **M.Tharun Kumar Reddy**

2) **G.Ajay Babu**

DATE: 14/04/2021

PLACE: Chennai

SIGNATURE OF THE CANDIDATES

ACKNOWLEDGEMENT

We are pleased to acknowledge our sincere thanks to Board of Management of **SATHYABAMA** for their kind encouragement in doing this project and for completing it successfully. We are grateful to them.

We convey our thanks to **Dr. N. M. NANDHITHA, M.E., Ph.D. Dean, School of Electrical and Electronics Engineering** and **Dr. T. RAVI, M.E., Ph.D. Head of the Department, Department of Electronics and Communication Engineering** for providing us necessary support and details at the right time during the progressive reviews.

We would like to express our sincere and deep sense of gratitude to our Project Guide **Mrs. VIJAYASHREE. T, M.E.,(PhD). Assistant Professor, Department of Electronics and Communication Engineering** for her valuable guidance, suggestions and constant encouragement paved way for the successful completion of the project work.

We wish to express our thanks to all teaching and Non-teaching staff members of the **Department of Electronics and Communication Engineering** who were helpful in many ways for the completion of the project.

We express our gratitude to our parents for their constant encouragement and support for the completion of the project.

ABSTRACT

Hand injuries are a common problem. A large number of hand injuries are not only a problem for victims, but also a financial consequence, as rehabilitation takes a long time. Physical therapy after surgery is associated with high labor costs. The exoskeleton was developed manually to improve treatment outcomes and reduce rehabilitation costs. The portable exoskeleton is specifically designed to meet the requirements of medical applications. To study control algorithms and rehabilitation programs, a prototype was constructed that supports four-finger degrees of freedom. The device is easy to attach and adapts to deformed or cracked hands. Given that many hand injuries occur with only one finger, this prototype could already be used for physical therapy. This project introduces the design and management system of the hand exoskeleton and its potential applications in the treatment of hand injuries. This application suggests that stroke patients should wear soft exoskeleton gloves on the paralyzed arm and check the response of the gloves with a pneumatic air source. The soft flex actuator is controlled by the Arduino Mega 2560 because the main control board and relay module are used to drive the 3/2-way single solenoid valve by turning on the 24VDC power supply. The activation of the soft bending device can be controlled by setting the on and off delay of the switch relay. In this way, the repetition of bending movements can be tailored to the patient's rehabilitation needs. In the modern scientific literature you can find a wide range of robotic devices capable of activating or assisting human hand movements. Depending on the field of use, there may be irregular elements in the exoskeleton of the hand. For example, a rehabilitation exoskeleton must be capable of a wide range of movements so that it is manageable enough and flexible enough to perform a variety of rehabilitation exercises. Conversely, the extra exoskeleton should be strong enough to hold objects reliably, which can be present during everyday activities and sacrifice mobility flexibility in favor of a predetermined grip pattern.

TABLE OF CONTENTS

Chapter No.	TITLE	Page No.
	ABSTRACT	V
	LIST OF FIGURES	IX
	LIST OF TABLES	IX
1	INTRODUCTION	1-2
2	LITERATURE SURVEY	
	2.1 An Attention-Controlled Hand Exoskeleton for the Rehabilitation of Finger Extension and Flexion Using a Rigid-Soft Combined Mechanism	3
	2.2 Low-Cost Soft Robotic Hand Exoskeleton for Use in Therapy of Limited Hand–Motor Function	3
	2.3 Connected Elbow Exoskeleton System for Rehabilitation Training Based on Virtual Reality and Context-Aware	3
	2.4 Design and development of a hand exoskeleton for rehabilitation following stroke	4
	2.5 Training of Hand Rehabilitation Using Low Cost Exoskeleton and Vision-Based Game Interface	4
3	AIM AND SCOPE OF THE PRESENT INVESTIGATION	
	3.1 PROPOSED METHODOLOGY	5
	3.2 SUBJECT DIFFERENCES	10
	3.3 THEORIES OF REHABILITATION	10
	3.4 APPLICATION OF HAND REHABILITATION ROBOTICS	11
	3.5 EVALUATION OF TREATMENTS	11
	3.6 HARDWARE SYSTEM	12
	3.6.1 ROBOT TYPE	13
	3.6.2 END-EFFECTOR	13
	3.6.3 EXOSKELETON	13

	3.6.4 ACTUATION	14
	3.6.5 ELECTRICAL MOTOR	14
	3.6.6 PNEUMATIC	14
	3.6.7 HYDRAULIC	15
	3.6.8 CONTRALATERAL EXTREMITY	15
	3.6.9 TRANSMISSION	15
	3.6.10 SENSOR	16
	3.6.11 PHYSICAL SIGNAL	16
	3.7 RESISTIVE	17
	3.7.1 ACTIVE	17
	3.7.2 ASSISTIVE	18
	3.7.3 ACTIVE-ASSISTIVE	18
	3.8 PATTERNS OF MOVEMENT	18
	3.9 HUMAN-ROBOT INTERACTION	18
	3.10 DETECTABLE INTENTION	19
	3.10.1 FROM BRAIN	19
	3.10.2 FROM MUSCLE	20
	3.10.3 FORCE AND MOTION ON HAND	21
	3.11 USER FEEDBACK	21
	3.11.1 FEEDBACK OF REAL-TIME STATE	21
	3.11.2 FEEDBACK OF MOTOR PERFORMANCE	22
	3.12 GENERAL LIMITATION	
4	MATERIALS AND METHODS USED	
	4.1 COMPONENTS	24
	4.1.1 ARDUINO UNO	24
	4.1.2 16*2 LCD MODULE	33
	4.1.3 BLUTOOTH	36
	4.1.4 PUSH BUTTON SWITCH	37
	4.1.5 SERVO MOTOR	37

	4.2 SOFTWARE MODULE DESCRIPTION	40
5	RESULTS AND DISCUSSIONS 5.1 JOINT RANGE OF MOTION 5.2 IDEAL VIEW	43 44 45
6	CONCLUSION AND FUTURE WORKS	47
	REFERENCES	48

LIST OF FIGURES

FIGURE NO.	TITLE	PAGE NO.
3.1	AN OVERVIEW OF THE HAND REHABILITATION ROBOTICS	9
3.2	ROBOTS WITH DIFFERENT TRANSMISSIONS	12
4.1.1a	ARDUINO PINOUT GUIDE	25
4.1.1b	ARDUINO UNO	26
4.1.1c	TECHNICAL SPECIFICATIONS	28
4.1.1d	ARDUINO CONNECTIONS ON CIRCUIT BOARD	29
4.1.2a	2D MODEL OF 16*2 LCD	34
4.1.2b	LCD VIEW	34
4.1.2c	LCD PIN DESCRIPTION	36
4.1.3	BLUETOOTH(HC-05)MODULE	37
4.1.5	SERVO MOTOR	39
4.2a	ARDUINO IDE INSTALLATION	40
4.2b	APPLICATION	41
4.2c	CREATING A FILE	41
4.2d	CODE STATUS BY COMPILING	42
5.2.1	DEMONSTRATION	45
5.2.2	THUMB OPEN	46
5.2.3	THUMB CLOSE	46
5.2.4	INDEX FINGER CLOSE	46
5.2.5	INDEX FINGER OPEN	46

LIST OF TABLES

TABLE NO.	TITLE	PAGE NO.
5.1.1	Maximum angle to create the best prints without self exclusion.	44
5.1.2	Maximum angle for connecting INDEX to EXOSKELTON and without EXOSKELTON	44

CHAPTER-1

INTRODUCTION

In the modern scientific literature you can find a wide range of robotic devices capable of activating or assisting human hand movements. Depending on the field of use, there may be irregular elements in the exoskeleton of the hand. For example, a rehabilitation exoskeleton must be flexible enough to allow a large number of movements to perform various rehabilitation exercises. Conversely, the extra exoskeleton should be strong enough to hold objects reliably, which can be present during everyday activities and sacrifice mobility flexibility in favor of a predetermined grip pattern. These varying requirements result in different power transfer architectures.

Some devices use couplings to transmit power from an actuator to a human joint. It is a sturdy architecture that provides good control over the arm posture, although the kinematic communication center and the person's joints must be accurately aligned. Due to the design flexibility, these mechanisms can achieve complex movement patterns with simple actuators when properly dimensioned.

Another high-end architecture is the cable glove. These are more flexible and streamlined options that rely on human joints to control movement, so they use less awkward gestures. Conversely, a pulley is required to exert a high force, and it is more difficult to control in an intermediate position. Additionally, this type of exoskeleton requires a pair of cables in opposing configurations to facilitate extension and flexible movement.

Finally, some devices use deformable actuators such as pneumatic muscles or shape memory alloys connected directly to the hand with a glove. The result is a very light and simple device, but the device is not the most advantageous place to put great effort into it.

For loop-based exoskeletons, especially those based on electric actuators, measuring the interaction force between the user and the device can lead to interesting features that facilitate control tasks and improve security. Some devices use a variety of sensor technologies such as torque sensors, strain gauges, bending sensors, and small load cells. These sensors can be effective in their respective applications, but when integrated into the exoskeleton, they have several drawbacks. In particular, the torque converter measures the load on the motor shaft, so it may not be possible to measure all interaction forces in an overloaded application. Load cells are difficult to place in the correct position and small cells may not function properly, so a shape similar to the size of a human phalange is required. Other miniature sensors, such as voltage sensors or power sensitive resistors, can usually measure force in only one sense (compression or tension), and sensors that can measure both directions are too large for a human hand.

CHAPTER 2

LITERATURE SURVEY

In recent years, rehabilitation techniques have played an important role in improving hand and finger function after stroke. Robotic applications and mechatronic devices are rapidly expanding in industrial environments to help people recover and improve their functions. Rehabilitation engineering has improved the quality of life for people with disabilities by providing special education that works better than traditional methods.

2.1 An Attention-Controlled Hand Exoskeleton for the Rehabilitation of Finger Extension and Flexion Using a Rigid-Soft Combined Mechanism

Manual recovery should be improved by improving key features such as simplicity, miniaturization, two-way operation, low cost, portability, safe human-robot interaction and intuitive features. This article presents a brain-controlled exoskeleton based on a multi-segment steel segment mechanism. Functional rehabilitation training is performed using a threshold of attention measured by an EEG sensor with a switch in the exoskeleton controlled by the brain.

2.2 Low-Cost Soft Robotic Hand Exoskeleton for Use in Therapy of Limited Hand-Motor Function

We present the design and validation of an inexpensive and customizable 3D soft anthropomorphic robotic arm exoskeleton for the rehabilitation of arm injuries using a remote controlled physical therapy procedure. This design is based on previous work done in a mammary exoskeleton design that uses the same kinematic functions, but emphasizes ease of assembly and cost effectiveness, allowing patients and clinics to produce and assemble what they need for treatment.

2.3 Connected Elbow Exoskeleton System for Rehabilitation Training Based on Virtual Reality and Context-Aware

Traditional rehabilitation systems for physical therapy are being developed as advanced

systems based on exoskeleton systems and VR environments that enhance and enhance rehabilitation and training approaches. Current connected systems and paradigms such as Internet of Things (IoT) or Peripheral Intelligent Systems (Aml) systems can also design and develop advanced, efficient and affordable medical devices accessible to patients. House. This article presents an inexpensive elbow exoskeleton associated with a context-sensitive architecture, and thanks to a virtual reality system, patients can interactively perform rehabilitation exercises.

2.4 Design and development of a hand exoskeleton for rehabilitation following stroke

The device was developed to restore motor function of the hand after stroke treatment, and can be used by stroke survivors to train bilateral movements. Of the 21 degrees of freedom of the fingers, the passive exoskeleton prototype allowed 15 degrees of freedom. This device is designed to be portable so that users can engage in other activities while using the device. The prototype was built with a device that fully agile extends the finger to the left hand (injured hand) based on the movement of the right hand (healthy hand) fingers. We also tested the device with healthy testers to make sure the design met the requirements.

2.5 Training of Hand Rehabilitation Using Low Cost Exoskeleton and Vision-Based Game Interface

In recent years, serious games have become a very useful tool in the field of rehabilitation. It aims to stimulate body mobility through an immersive experience that places users in an interactive virtual environment. This article focuses on the development of personal augmented reality systems for stroke rehabilitation. This is done by integrating a serious interactive game interface with a portable exoskeleton device. The in-game rehabilitation system allows users to perform physical therapy rehabilitation treatment with a natural user interface based on Kinect skeletal tracking and electromyography (EMG) sensors.

CHAPTER 3

AIM AND SCOPE OF THE PRESENT INVESTIGATION

Hand injuries are a common problem. A large number of hand injuries are not only a problem for victims, but also a financial consequence, as rehabilitation takes a long time. The design presented in this project uses an excellent design based on the natural movements and limitations of the joints placed by the patient's skeleton. This method of ejaculation is not suitable for injuries or diseases that have destroyed the skeletal structure of the finger. Our design cannot control the rotation of the thumb-metacarpal joint. This is usually done on other rigid bracket structures that are not suitable for soft robot structures like ours. Our design keeps the carp wrist in its natural range of motion for these tasks so it can capture movement. Eliminating mechanical and structural connections greatly simplifies the design and assembly of mechanical parts.

3.1 PROPOSED METHODOLOGY

The proposed system falls into this category, another key factor is how it learns the system, which can be complementary, passive, functional or functionally complementary. The operating system is not triggered, but it can be measured. The patient is constrained by the appropriate range of motion. Passive systems interact and use actuators that use force to facilitate movement to help your arm or wrist achieve the correct range of motion. An active support system is a hybrid system that includes mods that can be used in a similar way to an operating unit. Main components used: Arduino Mega 2560, 5 channel 5V relay module, buttons and resistors. Here is the top controller for rubber actuators. The process of connecting the rubber circuit and actuator to the 24V DC power supply, compressor kit, air filter with controls is in progress. The most important design goal of making these devices is to minimize the technical impediments that arise when using the system. The purpose is to simulate the way physical therapists interact with patients during rehabilitation as closely as possible. Additionally, the system should provide greater continuity and smoother transitions between interacting with the physical therapist and using the device. Device aesthetics and

consumer comfort (physical and psychological) are important. Patients need to feel comfortable in order to continue using the device.

In medical robotics, robot design must adapt to the challenges of the living world. In that sense, some fields of science, such as bionics and biomechanics, have become an interest that has grown dramatically over the past 20 years thanks to significant innovations. Applications in which biomechanical or bionic devices complement the human body are diverse and can be divided into two main fields: internal and external. The study of this project will focus on the outside. The external extension of the human body can be divided into two main branches: prosthetics and braces. The main focus of this project is on orthosis and robotic technology used in robotic recovery devices for passive motor recovery therapy. Statistical studies have been developed based on several technical terms that exist in the scientific literature in this field to show progress in this field of research. Statistics relate to work from 1994 to 2017. Research data was collected from the Science Direct online database. It contains an extensive database of research in science, medicine, economics and many more. This database contains over 12 million articles from over 3,500 academic journals. In this study, the terms rehabilitation, robotic rehabilitation, stroke rehabilitation, orthosis, biomechanics, bionics, robotic orthosis, exoskeleton, robotic exoskeleton, manual exoskeleton, soft robot and soft drive were chosen. The data collected are shown in Table 1, which shows the number of published scientific papers in relation to the terms analyzed. From the diagram in Figure 1, you can see that biomechanics, soft robots, and soft actuators are some of the most widely used keywords in scientific articles over the past 20 years. Given the key work involved in biomechanics, soft robots, and soft actuators, the narrower keyword statistics such as the following are not directly compared to these terms.

A stroke due to brain cell death that occurs as a result of blockage of blood vessels supplying the brain (ischemic stroke) or bleeding in or around the brain (hemorrhagic stroke) is a serious medical emergency. Stroke can cause death or serious damage to the nervous system and contribute significantly to long-term disability. The World Health Organization (WHO) estimates that around 15 million people worldwide suffer from

stroke each year. Despite advances in health technology, stroke rates are expected to increase over the next decades. Treatment and rehabilitation costs are enormous and reach \$34 billion per year in the United States. More than half of stroke survivors have some degree of persistent hemiplegia or hemiparesis due to nerve tissue damage. These patients are unable to perform daily activities on their own, so they must rely on human assistance to perform basic daily activities (ADL) such as feeding, self-care, and mobility.

The human hand is very complex and diverse. Studies have shown that the link between the function of the peripheral limb (i.e., the arm) and the ability to perform ADL is stronger than that of the other limbs. Hand dysfunction can seriously affect the patient's quality of life and more effort is required to restore hand movement. However, while most patients experience satisfactorily recovery of proximal upper extremity motility, related studies indicate that recovery of the distal limb is limited due to its weak efficacy. There are two main causes of difficulty with arm recovery. First, the arm's degree of freedom of movement (DOF) becomes more flexible than 20 degrees, making it difficult for therapists or educational devices to meet boredom and mobility needs. Second, the functional part of the cerebral cortex that corresponds to the arm is much larger than that of other motor cortex, giving it considerable flexibility to create different arm positions and control individual arm joints. However, to date, most studies have focused on the lack of individualization of opposing finger movements. There is a desperate need for better recovery treatment.

Robotic therapy for stroke rehabilitation is a new form of physical therapy in which patients train a paralyzed leg by using or resisting the force provided by the robot. For example, the MIT-Manus robot uses a mass-learning method to practice movement movements for upper limb training. The MIME (Mirror Image Motion Enablement) tool uses a two-sided learning approach to train a paralyzed limb to reduce abnormal synergies. Robotics has evolved significantly over the past 30 years thanks to advances in robotics such as exoskeletons and biotechnology that have become important additions to traditional physical therapy. For example, hand exoskeletons were compared to therapists who emptied patient training with physical labor, Wege et al.

You can touch the patient's fingers skillfully and repeatedly. In addition, some robots can also be controlled according to the patient's own intention, which is caused by vital signs such as electromyography (EMG) and electroencephalography (EEG) signals. This makes it possible to build a closed robotic rehabilitation system that cannot be achieved with conventional rehabilitation treatment.

Current reviews of robotic hand rehabilitation for motor recovery after stroke are inadequate, as most of the research focuses on the use of robotic therapy on limbs other than the arm. Additionally, the current review focuses on designing robotic equipment or using a specific educational paradigm, both of which are indispensable for an effective waving robot. The hardware system supports the functioning of the robot, while the training paradigm serves as a real functional part of engine recovery, which determines the effectiveness of rehabilitation training. These two parts are closely connected.

This project focuses on the application of robotic therapy to hand rehabilitation and requires a comprehensive understanding to develop an effective robotic recovery system, so it provides an overview of robotics for hand rehabilitation, from hardware systems to educational patterns for ongoing projects. The second part gives an overview of the robots in the entire recovery robot system. The third section summarizes and classifies hardware systems and learning parameters according to several important aspects from the author's point of view. Finally, we discuss the state of modern robots for hand rehabilitation and look forward to the possible future direction of robots for hand rehabilitation.

Post-robotic stroke treatment for upper limbs dates back to the 1990s. In recent decades, advances in robotics have made great strides and have become an important addition to traditional physical therapy. Hand robots were initially developed for demanding tasks and became the best place for therapists. This first robot focuses on structural design, actuators, control technology, etc., making the robotic arm more suitable for leg and joint movement functions and more effectively meeting rehabilitation needs.

Today, robotics for hand rehabilitation has undergone significant advances due to the rapid development of neurobiology and clinical knowledge, which means that designing robotics for hand rehabilitation for stroke rehabilitation has led to interdisciplinary knowledge such as anatomy, neurobiology, cognitive science and learning. Makes it even more difficult for you. . Also comprehensive information. Clinic experience. In order to develop an effective robot for hand rehabilitation, knowledge, rehabilitation theory and evaluation of the differences between stroke patients as well as the robot itself is required. The following is a summary of the basics of hand rehabilitation robots in rehabilitation to give researchers an overview of hand rehabilitation robots. The contents are displayed in figure.

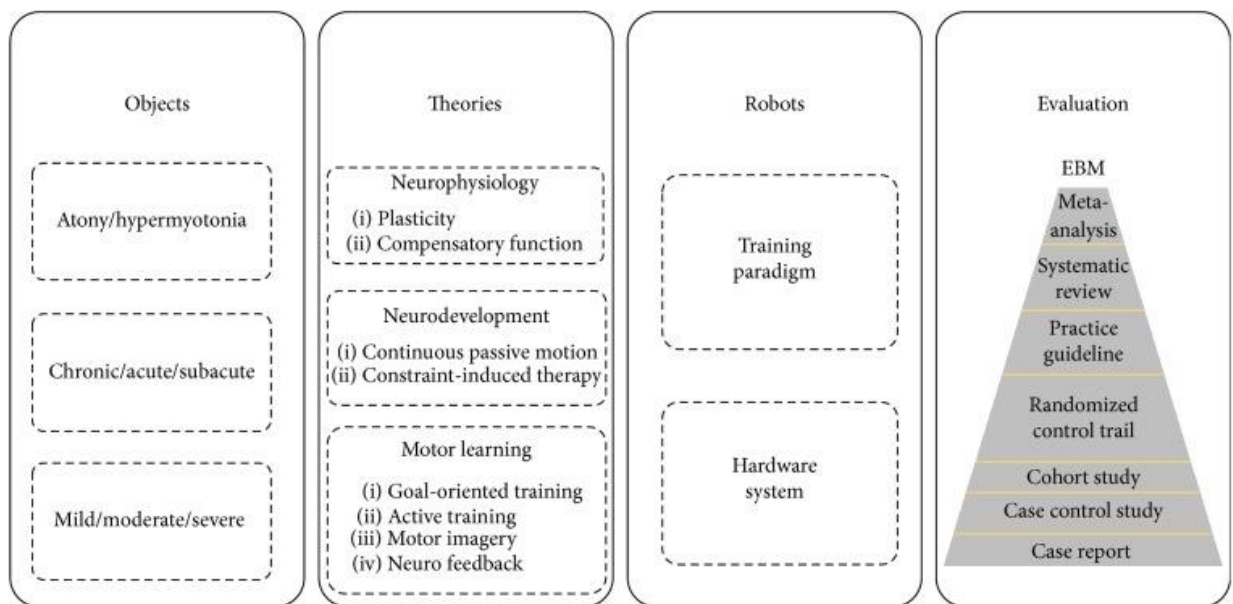


Figure 3.1: An overview of the hand rehabilitation robotics.

3.2 Subject Differences

Movement disorders in stroke patients vary from person to person and depend on their condition and improvement. For individual treatment, factors such as the type of muscle condition (e.g. asymptomatic or hypermyopathy), stroke episode (chronic, acute or subacute) and stroke rate (mild to severe) should be considered. For example, Atonic patients cannot use assistive robots that require remaining motor skills or too many strength training kits that can cause abnormal movement patterns. The advantage of using robotics for hand rehabilitation is that robotics can be used to quantify and track the motor behavior or vital signs of an individual patient. Thus, rehabilitation robots can be a sophisticated method that can be used today to accurately manage treatment interactions and measure accurate outcomes. Failure to account for differences between subjects can significantly reduce the effectiveness of robotic therapy.

3.3 Theories for Rehabilitation

While current theories of motor recovery are rare, some of the current rehabilitation theories are still beneficial and important for the use of robotic therapy. The three most important references are Neurophysiology, Neurodevelopment and Motor Learning Theory. Neurophysiological mechanisms such as plasticity and compensatory function are the theoretical basis for motor recovery after stroke. Derived primarily from clinical experience, the Nervous System (NDT) or Bobath concept focuses on improving hemiplegic lateral recovery by normalizing muscle tone and motor patterns, and inspires learning strategies such as continuous passive exercise and inhibition therapy. ... learning theories like Hebbian learning or motor retraining, which have given guidance on many strategies, including directed learning, active learning with all kinds of feedback, are the current trend in robotics for hand rehabilitation. While there is no conclusive evidence to support this strategy, many applications involving robotic arms have actually been used in rehabilitation and have had good results. Further research into the better application of these search theories will affect future RHH designs.

3.4 Application of Hand Rehabilitation Robotics

The use of robotics for manual rehabilitation is to achieve effective rehabilitation through a series of design decisions for hardware systems and educational paradigms. For projects focused on hardware systems, it addresses issues such as machine security and device portability or flexibility issues. For example, Wege et al. To solve the joint coordination problem, it adopts transverse joint structure, and the fingers can be flexibly adjusted with 4 degrees of freedom. In et al. Design a safe, lightweight and non-explosive exoskeleton. In projects focused on this paradigm, they address the interactions between humans and robots, promoting retraining in motor skills. For example, Ueki et al. And Sarakoglou et al. Development of a system that provides real-time feedback in virtual reality (VR) scenes to enhance the motion experience during training; Sarakoglou et al., Hu et al. And Ramos et al. The patient's own intensity signal, EMG signal, and rehabilitation robot driven by EEG signal are manually examined to stimulate patient participation in movement. For robotic arm systems, hardware systems and training patterns are important and interdependent.

3.5 Evaluation of Treatments

The evaluation of rehabilitation robotics reflects the effectiveness of human function restoration that requires a complete design. Methods for evaluating robots in the current study include movement during movement (ROM) of joints, speed of movement, force exerted on the arm, and performing functional tasks. A set of classical clinical measures are also used to measure patient recovery and evaluate patterns. The most common scales are the Manual Trial Assessment Test (ARAT), Bud Meier Assessment (FMA), and Motor Activity Log (MAL). Due to the specific clinical application, a focus should be placed on evaluating rehabilitation robots that are different from conventional robots. For pre-clinical use confirmation, treatment must follow the principles of Evidence-Based Medicine (EBM), which shows that many ongoing studies are being collected to demonstrate its usefulness. For example, the unexpected results of independent studies show that modern robots are useful for hand rehabilitation, while studies based on the EBM principle show little benefit. This is limited to supporting evidence in current research in robotics for hand rehabilitation due to its small sample size and poor

experimental quality. This shows why robotic validation, especially the development of a more standardized RCT (Randomized Control Trial) with large sample sizes and high quality, is necessary for rehabilitation robotics.

3.6 Hardware System

The hardware system is the heart of the manual recovery robot. It describes the types of movement the robot can provide to the patient and the possible signals the robot can receive from the patient. Equipment systems can be subdivided according to mechanical classification. However, the classification here is done as a smarter classification to highlight many of the most important aspects of robotic design for hand rehabilitation. The hardware system is divided into aspects including robot type, actuator, transmission type and sensor. Other aspects, such as strength, were not mentioned as they are not an important part of the robot for hand rehabilitation, and the researchers have already discussed the details.

3.6.1 Robot Type

Conventional manual rehabilitation robots can be divided into two main types: final effectors and exoskeletons, depending on the unit and location of use. The final effect is outside the patient's body, and the exoskeleton is carried by humans.

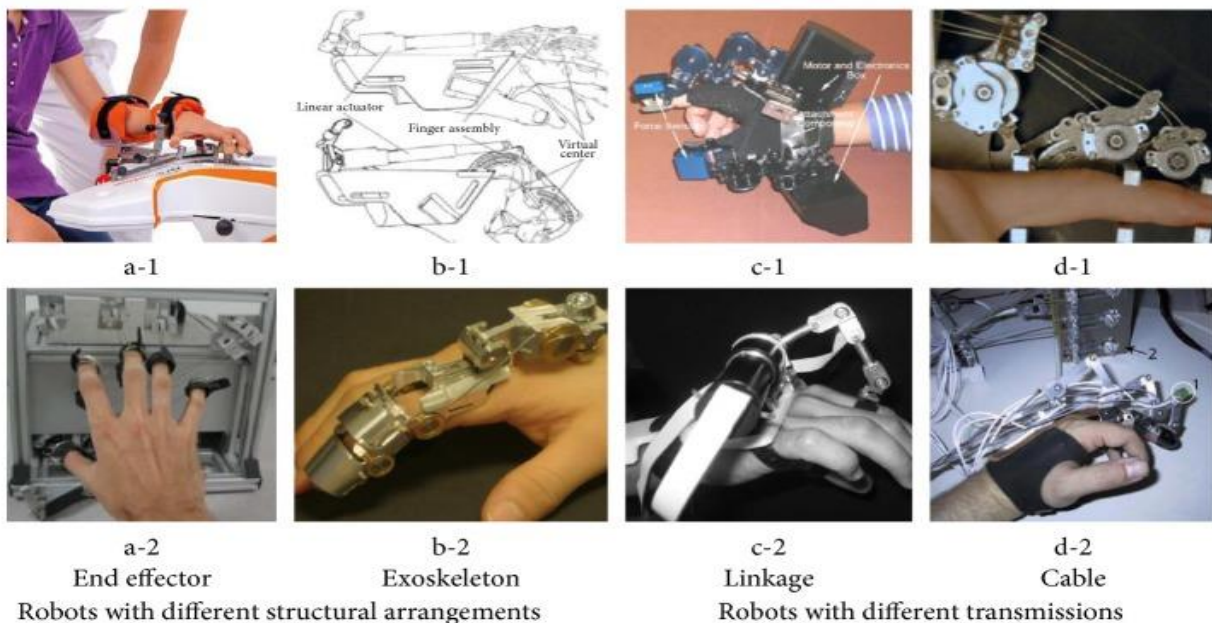


Figure 3.2 ROBOTS WITH DIFFERENT TRANSMISSIONS

3.6.2 End Effector

The end effector is outside the patient's body and provides the required force at the ends of the user's limbs to aid or resist movement. For example, the AMADEO robotic system developed in Austria (Figures 3 and 1) is already a commercial product. When a finger is attached, it supports the finger and thumb, and can be moved and extended along the slider. HandCARE (Figures 3 and 2) is another final effect developed by Dovat et al., where each finger is connected to a loop of the appliance cable, primarily enabling power control and linear displacement. The end effect is that it provides force regardless of the individual joint movements of the patient's limb, causing problems such as a limited range of movement and closure. Also, since the end effector is outside the human body, it cannot be carried, and its practical use in the clinic is limited.

3.6.3 Exoskeleton

Unlike the final effect, the exoskeleton can be worn on the patient's body. Robot joints and connections directly correspond to someone's joints and limbs. For example, Ho et al. Development of a portable robot for the rehabilitation of hands with a 2 degree of freedom of fingers (Fig. 3, b-1); Chiri et al. HANDEXOS is small in size and light in weight (Fig. 3, b-2). The portability of the exoskeleton is a good option for stroke rehabilitation, especially for patients with late stroke stages who can exercise at home. There are the same problems as robotic shafts that must be applied to the anatomical shaft of the arm, but exotic robots are widely used in rehabilitation robotics and have made a lot of progress over the years. There is a story about functional degrees of freedom (fDOF), which provides a way to simplify complex movements with multiple degrees of freedom using less complex shooting strategies, and the development of soft-body robots promotes the use of exoskeleton robots. In et al. Very lightweight undeveloped, unplanned robot. Robotic exoskeletons have now become the trend of passive recovery robots for stroke rehabilitation.

3.6.4 Actuation

The trigger function is to convert various types of energy into a power robot. There are 5 types of activation mentioned here: selective motor, hydraulic, pneumatic, pneumatic and human muscle. There are still other types of actuators, such as piezoelectric and shape memory alloys that promise to be thin and light, but they are not mentioned here due to technical dilemma or theoretical design in practical applications.

3.6.5 Electrical Motor

Electric motors are the most widely used devices in arm recovery robots because they are accessible, reliable, easy to use and very accurate. For example, HANDEXOS is described in Chiri A et al. It is driven by the power delivered from the DC motor to the Bowden cable. Robotic arm training device with exoskeleton developed by Ho et al. It is driven by a linear micro motor. Due to the common function of the torque velocity space, electric motors are useful in applications such as hand restoration robots that require a variety of control strategies. One of the potential drawbacks of electric motors is that safety concerns can arise due to the rugged construction of electric motors. However, electric motors can be controlled by torque, allowing actuators to access robot information without additional sensors.

3.6.6 Pneumatic

Pneumatic drives are used much less than electric motors in manual recycling robots such as ASSIST developed by Sasaki et al. This device has the advantage of reduced maintenance and the ability to remain loaded without causing damage. Problems such as noise can be overcome with the help of a pre-compressed air accumulator, but the size problem cannot be solved because an air storage room is required. Therefore, pneumatic actuators can be used better for systems with less mobility.

The development of artificial pneumatic muscles makes activation another option. Air muscles made of enlarged or enlarged inner rubber tubes may be present. An example is a commercial robotic hand holding system manufactured by Kinetic Muscles Inc. (USA), powered by air muscle power unit. There is another type of pneumatic muscle, the curved pneumatic muscle. For example, pneumatic rubber muscles are described in Noritsugu et al. The downside of pneumatic operation is that it is difficult to control the actuator due to its change over time and its nonlinearity.

3.6.7 Hydraulic

Hydraulic actuators have very good properties. It can generate higher torque than electric or pneumatic systems, for example, and can be controlled with high precision and frequency. However, hydraulic actuators are rarely used in handheld robots because more space is required to accommodate the pipelines and pipelines.

3.6.8 Contralateral Extremity

The opposite bone can also be considered a trigger. Member-oriented two-way recall robots are commonly used in robotic systems that use two-way learning strategies. The robot for the injured arm can be driven directly by the force of the healthy arm or indirectly by controlling the healthy arm signal at the same time. So far, only the latter has been studied. For example, Rahman et al. According to the data of gloves worn on healthy hands, we have developed a two-sided therapeutic hand device in which the exoskeleton performs unstable movements.

The human muscles of the injured arm can be activated by functional electrical stimulation (FES) to complete the movement of the injured arm in the same way a robot is triggered. Also, some applications combine with robot drives for rehabilitation. Thus, human muscles can be classified in the broadest sense as a form of activation. Rong et al. We proposed the FES robot arm and robot hand robot, which achieved better arm function restoration through FES and robot balance. Researchers often limit spontaneous motor skills by stimulating FES with processed EMG or EEG signals generated by the patient's spontaneous motor skills.

Other syntaxes involved in active training methods may not provide triggers, but are controlled entirely by the patient's hand. This means a high demand for the rest of the patient's motor skills. Another compromise is to use springs as activation. Here, the spring provides the force to compensate for the muscle tone effect.

3.6.9 Transmission

The function of transmission is to transform the motion of actuator into a desired direction to complete the execution of a hand's motion. Most of these are a consequence of the choices of actuator or the mechanism.

3.6.10 Sensor

The robotic arm retrieval system has only some effects according to the CMP (Continuous Passive Motion) concept, but the patient's participation in the rehabilitation system appears to be more effective. Therefore, sensors are very important in robotic hand recovery systems. Sensors detect personal information and provide feedback or control signals to a person or robot. Here, sensors are classified according to the type of signal detected.

3.6.11 Physical Signal

Sensors that detect physical signals such as strength and position (or movement) are the most commonly used sensors in robotic recovery systems. The function of a force or position signal is to provide the physical state of the hand, such as the applied force or the angle of agility of the finger. For example, the sensor force feedback exoskeleton (SAFE) robot was developed by Ben-Zvi et al. When optical position sensors and strain gauges are installed to detect motion and force signals.

Bioelectrical Signal

Other types of sensors that detect bioelectrical signals such as EEG or EMG signals are also frequently used in robotic systems for manual rehabilitation. The function of the bioelectric signal reflects someone's intention to move, and can be used as a control signal for the robot. EEG and EMG signals are the most representative signals received from the brain or muscle, and other possible but uncomfortable signals, such as magnetic resonance imaging (MRI) signals, are not listed here [90]. Examples include robots developed by SAFE and Hu et al. that use EEG caps to detect EEG signals in the brain. It uses multiple EMG electrodes located on the extensor finger muscle and abductor thumb muscle.

3.7 Resistive

In resistance training mode, the patient completes the exercise under the influence of the resistance force exerted by the robot. Since this type of training is mainly focused on strength training, robots usually use impedance control circuits. Lamercy et al. Development of a tactile pen for hand rehabilitation. The robotic system consists of two control methods. In the open position the robot is controlled by a PID position controller

and in the closed mode the robot provides a constant force and a resistive force consisting of damping components. The strength of the resistance was adjusted to the level of the experimental point of view, and the hand function was improved considerably evenly. Research on arm resistance training is relatively rare and mostly focuses on other parts of the arm, such as the shoulder, elbow, or wrist. The limitation of the resistive learning method is that it requires the remaining motor skills to be strong enough to overcome the resilience of the robot. Therefore, it is best used for patients in the late stages of stroke.

3.7.1 Active

In active learning mode, the patient moves independently while using the robotic function as a measuring device for patient feedback. In this teaching methodology, movement is completely human-controlled and does not require a management plan. Adamovich et al. A rehabilitation system where patients use CyberGloves and CyberGrasp devices for location and strength information. As the patient performs the movement on his own, the information is collected manually in real time and comes with a virtual scene and intensity of feedback. There isn't much research on pure active handshake training in practice because most of these robots can be replaced by intelligence gloves. In addition, leadership training requires the patient to have sufficient capacity to move independently.

3.7.2 Assistive

In supported learning modes, the patient uses a robot to perform arbitrary arm movements. The robot pushes continuously as the arm moves. This type of training can be as simple as the HandSOME developed by Brokaw et al. In this training, auxiliary forces are created by springs to compensate for muscle tension. Support training generally uses path training. For example, a manual recovery system developed by Wege et al. Adopting standard PID control and slide control model. The PID controller gives satisfactory position control results, while the sliding control model is more reliable and the track was tracked with good accuracy. However, the auxiliary training method requires the patient to have the remaining motor skills.

3.7.3 Active-Assistive

In active assisted learning mode (also known as passive active), the patient performs robot-assisted movements, but here the robot does not exert force on the arm until the patient can move independently. Active assisted training is most widely used in robotic rehabilitation systems. Executive assistant training can also use a simple management plan, such as in the case of AMADEO, where auxiliary power is applied only when the patient is unable to complete the full motion. Patients with impaired motor function may find this care plan less useful. Although increasingly actively supported learning methods are using biosignals as line inputs, the most recent research is based on binary (two-site) control schemes that limit the use of biosignal inputs. While flexible muscle and control models require more applications for passive rehabilitation, they are a new trend in control circuits that benefit from active training methods. Assistive training methods require the remaining motor skills, or at least allow the patient to generate appropriate motor intent.

3.8 Patterns of Movement

According to the collected articles, the modern maneuvering design of a manual recovery robot can be divided into two models. The first template focuses on range of motion, strength, and stiffness, and the second one specifically focuses on performing functional tasks in ADL. It follows the structure of the International Classification of Action, Disability and Health (ICF) (Figure 5), in which human function is described at three levels. Functional level (body structure and function), activity level (task completion) and level of participation (participation in life situations) [109, 110]. While initial results of meta-analysis of robotic clinical trials demonstrated the effectiveness of robotics in improving functional levels, the level of ICF activity did not improve. This may be due to a lack of people's understanding of the relationship between functional and activity levels, but now the focus of rehabilitation for hand impairment is slowly shifting from the functional ICF level to the activity and participation level.

3.9 Human-Robot Interaction

The difference between different learning paradigms is largely determined by different human-robot interactions, also called learning strategies for different projects. Human-

robot interaction is essential for motor recovery. This is because the key to robotic recovery systems is human beings who are often not properly reported. This differs from traditional industrial or field robots that perform movements automatically or in a specific human sequence because humans are the control unit and part of the robotic recovery system. The three main components of human-robot interaction are brain guidance, intention, and feedback. Induction makes the motor move. Robots present the right intent and provide better or transformative feedback to the patient. These components form a closed nerve pathway for the engine.

3.10 Detectable Intention

As a common method for healthy subjects, an electrical signal can be used to transmit the motion intent to the muscle to trigger arm movement directly, and the receiver's intent is detected by the robot and then by the robot. Activate hand movement. Intent can be determined in the brain, muscles and contralateral paralyzed, healthy arms.

3.10.1 From Brain

EEG signals are represented as brain signals containing detectable motor intent. The EEG signal is the most convenient signal in the BCI (Brain-Computer Interface) system. BCI technology has been advancing over decades and has found many effective applications in robotic arm rehabilitation. The use of the BCI technique is primarily based on the fact that motor imagination (MI) contributes to limb recovery. The effectiveness of myocardial infarction during rehabilitation has been proven in good time. Studies have shown that MI provides paralyzed limb sensation through MI because MI activates the motor cortex of the brain, even if the patient has not performed proper movements. Combined with BCI technology, we can directly control restorative robotics by extracting and propagating brain signals induced by a patient's spontaneous myocardial infarction. As MI is involved in brain and arm movement, rehabilitation robots activate artificial pathways that replace normal highways in individuals and have a great future.

Biebaumer was the first to show that stroke patients can trigger MI-related ERD/ERS in a healthy way. Unexpectedly, the researchers found that muscle tension in stroke patients decreased after participating in the experiment. On this basis, various research groups conducted further research. Ang et al. Many experiments have confirmed that stroke patients have a great potential to induce MI-BCI, making MI-BCI possible. Barsotti et al. MI-BCI Complete Robot Free Skeleton Development. After calling MI-BCI, the patient can come forward and hold it. In these cases, we can see that the benefits of intentional brain discovery enable direct brain learning, thus promising a practical rehabilitation robot. However, the weakness of the current study is that real-time problems arise from processing large EEG data, and the accuracy of determining the exact engine identification rate limits the effectiveness of practical applications.

3.10.2 From Muscle

EMG signals from stroke patients are not enough to move the parietal arm, but powerful enough to collect data with data collection tools, providing a new approach to dealing with rehabilitation robots that control arm movements. Robotic arm that has processed the signal received from the muscle. Ho et al. Development of portable robots with electromyography (EMG) devices. When the patient voluntarily triggers the motor intent, the device collects and filters the EMG signal and then controls the robotic arm motor with the processed signal. The study was conducted in eight chronic patients, and the results confirmed the effectiveness of the recovery robotic arm in restoring arm function as the patient's FMA score improved. Also, Fleischer et al. Combined with leg or arm strength sensors to develop EMG-based rehabilitation robots. This work, in conjunction with EMG, improves a control strategy based entirely on power signals. However, this study is for foot only and no relevant studies have yet been found.

EMG technology performs business maneuvers by detecting motor intent directly from the patient's EMG signal. This is why it works better than traditional muscleless manual training. However, there are a few more things to look for when it comes to EMG rehabilitation robots.

First, the EMG signal depends on the stroke patient's condition, so the robotic rehabilitation system needs to adapt. Second, modern EMGs need to be able to manually identify more types of maneuvers so they can heal more efficiently. Kiguchi has developed a fog-controlled EMG recovery robot that recognizes various types of hand and arm movements. However, there are no related studies on finger recognition.

3.10.3 Force and Motion on Hand

One of the most direct ways to determine the user's intent is to measure the patient's force on the interface. This method has been applied to many passive exoskeletons for support applications. Likewise, the user's initial finger movement pattern can also act as a trigger command for a programmable grip based on pattern classification technology. The advantage of intent, perceived as force and motion, is that you can get more information from each path of travel compared to an EEG or EMG signal that contains too little information to act as a variable control input. Limiting arm strength and movement is the patient's continuous movement requirement. This means that people with severe myasthenia gravis may not be able to use these robots properly.

3.11 User Feedback

People have their own senses, but they are abnormal or too weak for a stroke patient. Robots can provide additional brain feedback to form integrated loop-closed pathways that are important for human-robot interaction. Feedback is usually better compensated for weakened tactile feedback. It can be visual, auditory, tactile, or multimode. Feedback can be divided into two types: motor status feedback and engine performance feedback.

3.11.1 Feedback of Real-Time State

The purpose of using real-time status feedback is to compensate for missed feedback, such as manual tactile feedback. Feedback can be an image of the force applied to the device, an index of an EMG/EMG signal, or a real mechanism driven joint motion compensator.

3.11.2 Feedback of Motor Performance

Feedback on movement activity is mainly used in game patterns. The effectiveness of this feedback can be explained by a simple Pavlov state. The reward for completing a

move provided by a computer program reinforces the engine's feedback loop and motivates the next step. However, somatosensory feedback on completing the actual movement is an effective feedback that helps control brain reconstruction. Now let's take a look at some of the discussions below.

As can be seen from the classification, all these studies have investigated designers of different types of handshake robots, which have led to significant advances in hand restraint robots in recent years. However, the increasing clinical use of robots for hand rehabilitation has not kept pace with prototype development. Even evidence-based analysis shows that many other alternative interventions have "more powerful evidence" than robotic therapy [50]. To remind you of future research, the general limitations of current research on hand rehabilitation robots are as follows: Discuss the experiences and predictions of research on hardware systems and teaching methods.

3.12 General Limitation

An obvious general limitation of the current study is that many researchers overlook the importance of evaluating robot designs for hand rehabilitation indicated in the table. There are three main ways to evaluate a design in a collaborative study. Most of the research uses the first approach that does not evaluate the robot and does not affect actual application development. This may make the robot look creative, but the design is not clear to the patient or therapist. Several studies have used a second design evaluation method to provide several tests to improve the physical parameters of the robot or the performance of some scenes. Physical parameters such as ROM of joints, speed of movement, and support acting on the arm were varied, and certain scenes such as target accuracy were set entirely subjectively by the researcher. Because these types of evaluations are different, it is difficult to say that some designs are cheaper than others. Few studies use the latter approach to evaluate the effectiveness of designs that combine clinical approaches, such as improving clinical scale, as the most acceptable rehabilitation method. Although many independent studies show many successful breakthroughs, systematic EBM studies have little proven usefulness of rehabilitation robots. This can be explained by the fact that most studies can lead to

positive biases in the reported effects due to methodological deficiencies such as the lack of blind procedures and the intention to process the analysis.

CHAPTER 4

MATERIALS AND METHODS USED

4.1 COMPONENTS

The components used for doing this project were Arduino UNO, LCD, Bluetooth, Buttons, Uln2000a, Servo motor, Finger fixed frame, Power supply module.

4.1.1 ARDUINO UNO

Arduino is a company, project, and community for users of computer hardware and software that designs and manufactures microprocessor kits to create digital devices and interactive objects that can detect and control objects in the physical world. Project products are classified as open source hardware and software licensed under the GNU Reduced General Public License (LGPL) or GNU General Public License (GPL), allowing anyone to create Arduino cards and distribute software. Arduino cards are commercially pre-assembled or available as a DIY kit.

Arduino cards use a variety of microprocessors and controllers. The card has a set of digital input/output pins (analog (I/O)) that can be connected to various expansion cards (screen) and other circuits. The card has a serial communication interface including USB (Universal Serial Bus) on some models, and is also used to download software from a computer. Microcontrollers generally dialectically program the functions of the C and C++ programming languages. In addition to using existing compiler tools, the Arduino project provides an integrated development environment (IDE) based on the Processing language project.

The Arduino project began in 2005 as a student program at Ivrea Interaction Design [2] in Ivrea, Italy, which provides beginners and experts with a cheap and easy way to create eco-friendly devices using sensors and actuaries Aim to do. . Common examples of such devices intended for beginners are simple robots, thermostats and motion sensors.

The name Arduino comes from a bar in Ivrea, Italy, where some of the founders of the project used to meet. The bar named after Arduino of Ivrea, who was the margrave of the March of Ivrea and King of Italy from 1002 to 1014.

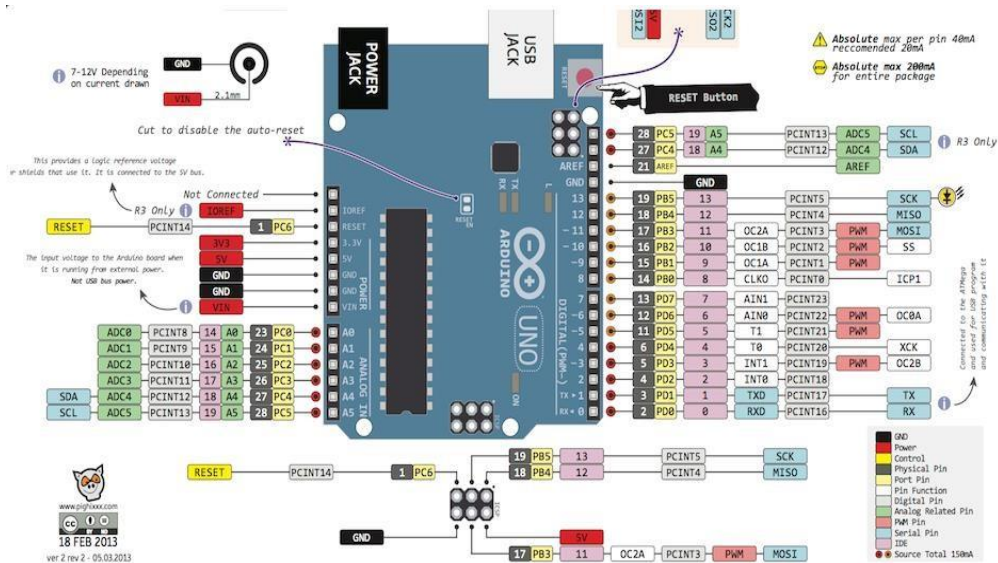


FIGURE 4.1.1a ARDUINO PINOUT GUIDE

Hardware of Arduino:

Arduino is open source hardware. Hardware reference samples are licensed under the Creative Commons Attribution Share-Alike 2.5 license and are available on the Arduino website. Layout and production files are also available for some hardware versions. The source code of the IDE has been released under version 2 of the GNU General Public License. However, Arduino has never released a list of official resources for Arduino cards.

Arduino cards contain 8-bit, 16-bit or 32-bit AVR microcontrollers (ATmega8, ATmega168, ATmega328, ATmega1280, ATmega2560), but microcontrollers from other manufacturers have been around since 2015. Cards use either a connection or a single socket. Headings to simplify programming connections and include in other diagrams. It can be connected to an additional module called a shield. Multiple screens can be tackled individually and can also be stacked over an I²C serial bus. Most cards have a 5V linear controller and a 16MHz crystal or ceramic resonator. Some designs, such as the LilyPad, run at 8 MHz and dispense with the onboard voltage regulator due to specific form-factor restrictions.

The Arduino microcontroller is pre-programmed with a starter charger that allows you to easily load programs into the spacecraft's mounted flash memory. The standard Arduino UNO initiator is the optiboot initiator. The board is loaded with software code through a serial connection to another computer. Some Arduino series cards contain level offset circuitry for conversion between RS-232 logic level and transistor-to-transistor logic level (TTL) signals. Modern Arduino cards are programmed via a Universal Serial Bus (USB) powered by USB to an IC serial adapter such as the FTDI FT232.

Some cards, such as the latest fusion cards, replace the FTDI IC with a separate AVR IC with USB series firmware reprogrammed through its own ICSP header. Other variants, such as the unofficial Arduino Mini and Boarduino, use detachable USB to board serial or cable adapters, Bluetooth or other modes when used with existing microcontroller equipment to replace the Arduino IDE, which is a standard AVR system internal programming (ISP) use.

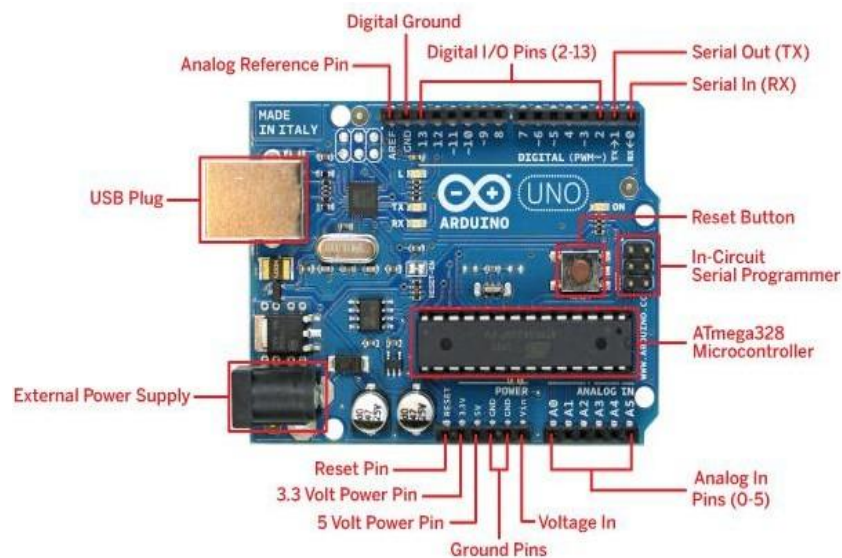


Figure 4.1.1b: Arduino UNO

The Arduino board provides most of the microcontroller I/O pins for use with other circuits. Diecimila, Duemilanove and Uno] have 14 digital I/O pins, of which 6 can generate PWM signals and 6 analog inputs can be used as 6 digital I/O pins. These pins are placed on the top of the board through a 0.1 inch (2.54mm) connector. There are also several commercially available plugin app screens. Arduino Nano cards and Arduino compatible bone boards and Arduino boards may have headers that can be attached to the soldered board at the bottom of the card.

There are many cards that are compatible with Arduino and Arduino derivatives. Some of them are functionally identical to the Arduino and can be used interchangeably. To make it easier for many people to make strollers and small robots, we improve the basic Arduino by adding an output driver for the school. Others are electrically the same, but sometimes by changing the form factor to maintain screen compatibility and sometimes not. Some variants use different processors with different compatibility

Software development

Arduino programs can be written in any programming language that generates binary machine code for the target processor. Atmel provides a development environment for microcontrollers, AVR Studio and new versions of Atmel Studio.

The Arduino Project provides an Arduino IDE (Integrated Development Environment), a platform application written in the Java programming language. Derived from processing and wiring IDE. It includes a code editor with features such as cut and paste text, find text, auto-insert, match brackets, and highlight syntax, and provides a simple mechanism to compile and download the application to a one-click Arduino card.

It also includes a message area, text console, a toolbar with common function buttons, and a hierarchy of action menus.

Sketch is the name of a program written in IDE for Arduino. The sketch is saved on the developer computer as a text file with the .ino file extension. Arduino software (IDE) prior to 1.0 saved thumbnails with a .pde extension.

The Arduino IDE supports C and C++ languages with specific code structure rules. The Arduino IDE provides a library of programs for Wiring projects that provide many common input and output routines. The user-written code needs the main function to run the sketch and a link to the main program, which compiles and links to the main compartment () to run the back loop executable with the GNU toolbox. IDE deployment. . The Arduino IDE uses the avrdude program to convert the executable code into a hexadecimal text file that is loaded onto the Arduino card by the bootloader program on the table hardware.

Applications

- Xoscillo, an open-source oscilloscope.
- Arduinome, a MIDI controller device that mimics the Monome.
- OBDuino, a trip computer that uses the on-board diagnostics interface found in most modern cars.
- Ardupilot, drone software and hardware.
- Gameduino, an Arduino shield to create retro 2D video games.
- Arduino Phone, a do-it-yourself cellphone.
- Water quality testing platform.
- Automatic titration system based on Arduino and stepper motor.
- Low cost data glove for virtual reality applications.
- Impedance sensor system to detect bovine milk adulteration.
- Homemade CNC using Arduino and DC motors with close loop control by Homofaciens.
- DC motor control using Arduino and H-Bridge.

Technical Specifications

Microcontroller	ATmega328P
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limit)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
PWM Digital I/O Pins	6
Analog Input Pins	6
DC Current per I/O Pin	20 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB (ATmega328P) of which 0.5 KB used by bootloader
SRAM	2 KB (ATmega328P)
EEPROM	1 KB (ATmega328P)
Clock Speed	16 MHz
LED_BUILTIN	13
Length	68.6 mm
Width	53.4 mm
Weight	25 g

Fig: 4.1.1c Technical Specifications.

Programming

The Arduino/Genuino Uno can be programmed with the (Arduino Software (IDE)). Select "Arduino/Genuino Uno" from the Tools > Board menu (according to the microcontroller on your board). For details, see the reference and tutorials.

The Arduino/Genuino Uno's ATmega328 comes with a pre-programmed bootloader that allows you to load new code without using an external hardware programmer. It communicates with the original STK500 protocol (link, basic C file).

You can also bypass the initiator and program the microcontroller via an Arduino ISP or similar ICSP (Circuit Internal Programming) header. See these instructions for more details.

The source code for ATmega16U2 (or 8U2 on rev1 and rev2 cards) is in the Arduino repository. The ATmega16U2/8U2 is loaded with a DFU initiator that can be activated.

- Rev1 card: Connect the soldering iron to the back of the card (next to the Italian card), then replace the 8U2.

- Rev2 or later card: There is a resistor connecting the 8U2 / 16U2 HWB line to ground, so you can easily enter DFU mode.

You can then use Atmel FLIP software (Windows) or DFU programmer (Mac OS X and Linux) to download the new firmware. You can use the ISP header with an external programmer (overwrite the DFU initiator). See this walkthrough guide for more details.

Here is a photo of the Arduino wired on a circuit board.

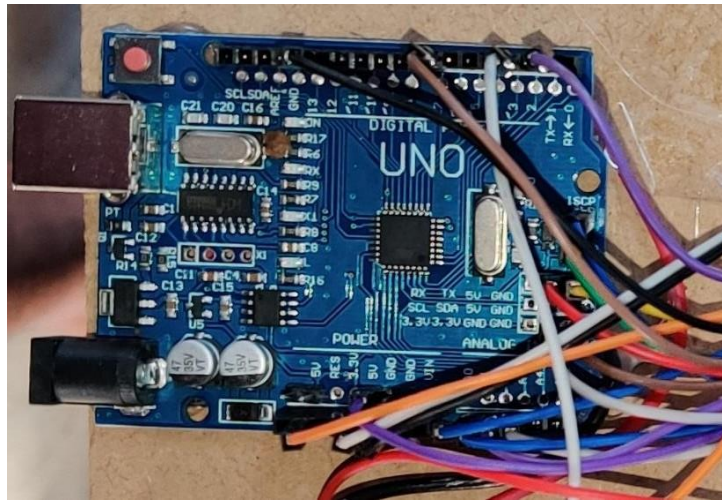


Fig: 4.1.1d Arduino Connections on circuit board.

Memory

ATmega328 is 32kB (0.5kB is used by the bootloader). It also has 2KB SRAM and 1KB EEPROM (which can be read and written using the EEPROM library).

Input and Output

Arduino pin and ATmega328P port mapping. The display of the Atmega8, 168 and 328 is the same.

All 14 digital pins from Merger can be used as inputs or outputs using the `pinMode()`, `digitalWrite()` and `digitalRead()` functions. It works at 5 volts. Each pin can deliver or receive 20mA depending on the recommended operating conditions, and its internal resistance (disabled by default) is 20-50kΩ. The maximum value of 40mA is a value that should not be exceeded on the I/O pin to prevent irreparable damage to the microcontroller.

In addition, some pins have specialized functions:

- Serial: 0 (RX) and 1 (TX). Used to receive (RX) and transmit TTL (TX) serial data. This pin connects to the corresponding pin of the ATmega8U2 USB-to-TTL series.
- External Interrupt: 2 and 3. These pins can be configured to trigger a low value interrupt, a rising or falling edge, or a value change. See `Schedulterter()` function for more information.
- PWM: 3, 5, 6, 9, 10 and 11. Input `analogWrite()` to the 8-bit PWM pin.
- SPI: 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK). This pin supports SPI communication with the SPI library.
- LED: 13. The built-in LED is controlled by digital pin 13. The LED is on when the pin is set to HIGH, and off when the pin is low.
- TWI: pin A4 or SDA and pin A5 or SCL. Maintains TWI communication with the Wire library.

The Fusion has 6 analog inputs labeled A0 through A5, each with 10-bit resolution (i.e. 1024 different values). Basically it measures ground voltage up to 5V, but you can change the top of the range using the AREF pin and `analogReference()`.

There are a couple of other pins on the board:

- AREF. Reference voltage for analog input. Used with `analogReference()`.
 - Restart. Set this line to LOW to reset the microcontroller.
- Typically used to add a reset button so that the screen blocks the built-in button.

Communication

The Arduino/Genuino Uno offers a variety of ways to communicate with your computer, other Arduino/Genuino cards, or other microcontrollers. The ATmega328 provides TTL (5V) UART serial communication that can be used on digital pins 0 (RX) and 1 (TX). The built-in ATmega16U2 transmits this serial communication via USB and appears as a virtual COM port for your computer's software. The firmware 16U2 uses a standard USB COM driver and does not require an external driver. However, in Windows you need the .inf file. The Arduino software (IDE) includes a serial monitor that allows you to send and receive simple text information from the card. Built-in RX and TX LEDs flash when data is transmitted to a computer via a USB-series chip and USB connection (but not for serial communication on pins 0 and 1).

- SoftwareSerial library provides serial communication on all digital pins of Uno.
- ATmega328 also supports I2C (TWI) and SPI communication.

The Arduino software (IDE) contains a wire library that simplifies the use of the I2C bus. Please refer to the documentation for more details. For SPI communication, use the SPI library.

Official boards

The original Arduino hardware was manufactured by the Italian company Smart Projects.

Some cards labeled Arduino were developed by American companies SparkFun Electronics and Adafruit Industries. As of 2016, there are 17 commercially available versions of Arduino hardware. Software development. Arduino programs can be written in any programming language that generates binary machine code for the target processor. Atmel provides a development environment for microcontrollers, AVR Studio and new versions of Atmel Studio. The Arduino Project provides an Arduino IDE (Integrated Development Environment), a platform application written in the Java programming language. Derived from processing and wiring IDE.

It includes a code editor with features such as cut and paste text, find text, auto-insert, match brackets, and highlight syntax, and provides a simple mechanism to compile and download the application to a one-click Arduino card. It also includes a message area, text console, a toolbar with common function buttons, and a hierarchy of action menus.

The power pins are as follows:

- V in. Input voltage to the Arduino/Genuino card when using an external power supply (as opposed to a 5V USB connection or other regulated power supply). You can supply voltage through this pin or, if voltage is supplied through the power plug, you can access it through this pin.
- 5V. This pin outputs an adjustable 5V voltage from the ship's regulator. The card can act as a DC socket (7-12V), a USB socket (5V), or the VIN pin (7-12V) on the card. Installing a voltage past the control unit and through the 5V or 3.3V pin can damage the card.
- 3V3. 3.3V power generated by the built-in control unit. The maximum current consumption is 50mA.
- GND. Primary contact.
- OK. This pin on the Arduino/Genuino card provides the reference voltage through which the microcontroller operates. A properly configured monitor can read the voltage from the IOREF pin and select an appropriate power supply or have the voltage converter at the output operate at 5V or 3.3V.

Automatic (Software) Reset

Instead of physically pressing the reset button before expanding, the Arduino/Genuino Uno card is designed to be able to recover with software running on the connected computer. One of the ATmega8U2/16U2 (DTR) hardware flow wires is connected to the ATmega328 replacement line through a 100nF capacitor. When this line is required (lowered), the reset line is low enough to replace the chip. The Arduino software (IDE) uses it, so you can download the code by clicking the download button on the interface toolbar. This means the initiator can have a shorter timeout because the DTR descent can be well coordinated with the starter.

4.1.2 16*2 LCD MODULE

LCD modules are commonly used in most embedded projects due to their low cost, availability and convenience for programmers. Most of us come across these monitors in our daily lives, whether at PCOs or at calculators. The shape and pinout have already been done above, so let's talk about the technical details now.

The 16x2 LCD got its name. It has 16 columns and 2 rows. There are many combinations available, such as 8x1, 8x2, 10x2, 16x1, etc, but 16x2 LCD screens are the most commonly used. So (16x2 = 32) contains 32 characters and each character will be 5 x 8 pixels. Characters with all pixels are shown in the picture below.

Now you know that each character ($5 \times 8 = 40$) has 40 pixels and for 32 characters there are (32×40) 1280 pixels. Also, the LCD screen should be oriented towards the pixel position. This makes it difficult to handle everything with the MCU, so use an IC interface like the HD44780 mounted on the back of the LCD module itself. The function of this IC is to receive commands and data from the MCU and process them to display meaningful information on the LCD screen. You can use the link above to learn how to connect to an LCD monitor. If you are an experienced programmer and want to create your own microcontroller library to interact with this LCD module, you need to understand the commands HD44780 IC will work and appear in the datasheet.

2D model of 16×2 LCD module

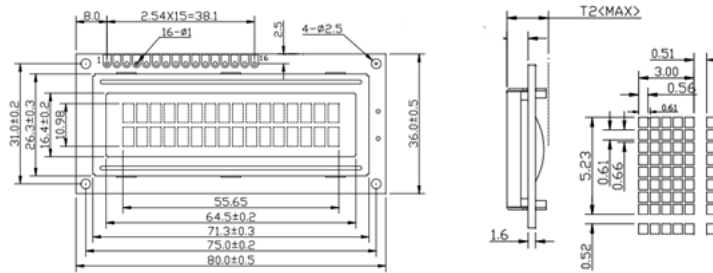


Figure 4.1.2a 2D model of 16*2 LCD

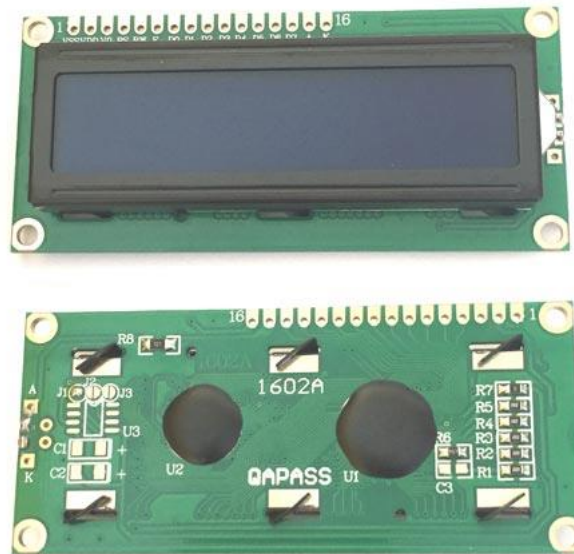


Figure 4.1.2b LCD VIEW

Features of 16×2 LCD module

- Operating voltage from 4.7V to 5.3V.
- Power consumption is 1mA without backlight.
- Alphanumeric LCD module, ie it can display letters and numbers.
- Consists of two lines, each line can print 16 characters.
- Each character has a 5 × 8 pixel square.
- Can work in 8 bit and 4 bit modes

- It can also display all symbols created by the user.
- Can be used with green and blue backlights.

Pin Configuration

Pin No:	Pin Name:	Description
1	Vss (Ground)	Ground pin connected to system ground
2	Vdd (+5 Volt)	Powers the LCD with +5V (4.7V – 5.3V)
3	VE (Contrast V)	Decides the contrast level of display. Grounded to get maximum contrast.
4	Register Select	Connected to Microcontroller to shift between command/data register
5	Read/Write	Used to read or write data. Normally grounded to write data to LCD
6	Enable	Connected to Microcontroller Pin and toggled between 1 and 0 for data acknowledgement
7	Data Pin 0	Data pins 0 to 7 forms a 8-bit data line. They can be connected to Microcontroller to send 8-bit data. These LCD's can also operate on 4-bit mode in such case Data pin 4,5,6 and 7 will be left free.
8	Data Pin 1	
9	Data Pin 2	
10	Data Pin 3	
11	Data Pin 4	
12	Data Pin 5	
13	Data Pin 6	
14	Data Pin 7	
15	LED Positive	Backlight LED pin positive terminal
16	LED Negative	Backlight LED pin negative terminal



Figure 4.1.2 c LCD PIN DESCRIPTION

4.1.3 BLUETOOTH

The HC-05 is a very nice module that allows you to add two-way (dual) wireless communication to your project. You can use this module to communicate between two microcontrollers like an Arduino, or any Bluetooth device like a phone or laptop. There are already many Android apps out there that make the process a lot easier. This module communicates with USART on the 9600 board, so you can easily interact with any microcontroller that supports USART. You can also change the module's defaults in command mode. So, if you are looking for a wireless module that can transfer data from a computer or mobile phone to a microcontroller or vice versa, this module may be the right choice. But don't expect this module to stream multimedia as images or songs. You may need to look into the CSR8645 module for this.

How to use HC-05 Bluetooth module

The HC-05 has two modes of operation. One is the data mode, which allows you to send and receive data from other Bluetooth devices, and the other is the AT command mode, which allows you to change the default settings of the device. You can use the device in these modes using the key pins described in the contact description.

Because the HC-05 module works with SPP (Serial Gateway Protocol), it is very easy to connect to a microcontroller. Turn on only the +5V module, connect the Rx-pin module to the Tx MCU and connect the Tx-pin module to the Rx MCU as shown below.

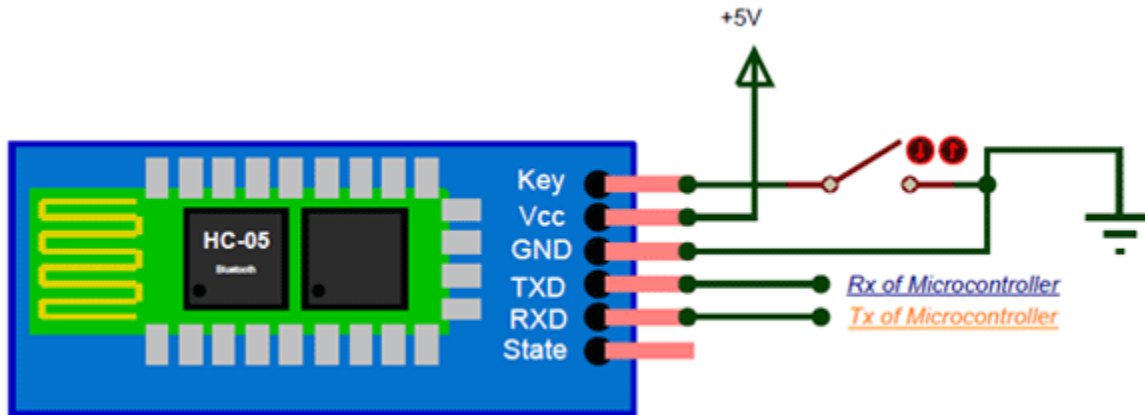


Figure 4.1.3 BLUTOOTH(HC-05)MODULE

4.1.4 PUSH BUTTON SWITCH

The button is usually an open tactile switch. The button allows you to activate the circuit or make a special connection only at the push of a button. When pressed, the circuit closes, and when released, it opens. This button is also used to trigger the SCR near the gate terminal. This is the most common button we see on our everyday electronic equipment.

Applications

- Calculators
- Push-button telephones
- Kitchen appliances
- Magnetic lock

4.1.5 SERVO MOTOR

Servo motors are a type of motor that can rotate very precisely. This type of motor usually contains a control circuit that provides feedback on the current position of the motor shaft, and this feedback allows the servo motor to rotate with great detail. Use a servo motor to rotate an object to a certain angle or distance. There is a simple motor that passes through a servo mechanism. If the motor is driven by a DC power supply, it is called a DC motor, and if it is an AC motor, it is called an AC motor. In this tutorial, only DC servo motor operation is described. In addition to these base classes, there are

many other types of servo motors depending on their performance and box type. Servo motors usually come with a gearbox, so you can get very high torque servo motors in a small and light cover. Because of these features, they are used in many applications such as toy cars, helicopters and remote control aircraft, robotics, etc.

Servo motors are displayed as kg/cm (kg/cm), and most hobby servo motors are displayed as 3kg/cm, 6kg/cm, or 12kg/cm. This kg/cm refers to the weight the servo motor can lift a certain distance. Example: 6kg/cm servo motor should be able to lift 6kg if the load is 1cm away from the motor axis. The longer the distance, the lower the load-bearing capacity. The position of the servo motor is determined by the electric shock, and the electric circuit is adjacent to the engine.

Servo Motor Working Mechanism

It consists of three parts:

- Controlled device
- Output sensor
- Feedback system

It is a closed loop system that uses a positive feedback system to control the movement and position of the shaft. In this case, the device is controlled by a feedback signal generated by comparing the output signal with the reference input signal. Here the reference input signal is compared to the reference output signal and a third signal is generated by the feedback system. And this third signal serves as an input to control the device. This signal exists as long as a feedback signal is generated or there is a difference between the reference input signal and the reference output signal.

Therefore, the main task of the servo is to keep the system output at the desired level in the presence of noise.

Servo Motor Working Principle

Servo drives include motors (DC or AC), potentiometers, gearboxes and control circuits. First of all, the gearbox is used to reduce the engine speed and increase the torque. Let's say the position of the potentiometer disk at the initial position of the servo motor shaft means that no electrical signal is generated at the output of the potentiometer. The electrical signal is now fed to the second input of the error detector amplifier. Now the difference between these two signals is that one is a potentiometer and the other is a signal from another source, so it is processed by the feedback mechanism and an error signal is provided to the output. This error signal acts as an input to the motor and the motor starts to rotate. Now the motor shaft is connected to the potentiometer and the potentiometer generates a signal when the motor rotates. So when the angular position of the potentiometer changes, the output signal changes. After a while, the position of the potentiometer, the output signal of the potentiometer reaches the same position as the external signal. In this state, since there is no difference between the signal applied externally and the signal generated by the potentiometer, the output signal from the amplifier is not applied to the motor input, in which case the motor stops rotating.

Interfacing Servo Motors with Microcontrollers:

It is very easy to connect hobby servo motors like servo motor s90 to MCU. The server has three outgoing wires. Two are used for power supply (positive and negative), and one is used for signals sent from the MCU. Here is the picture of the MG995 servo motor MG995 with metal tools most commonly used in humanoid robots, radio controlled cars, etc.

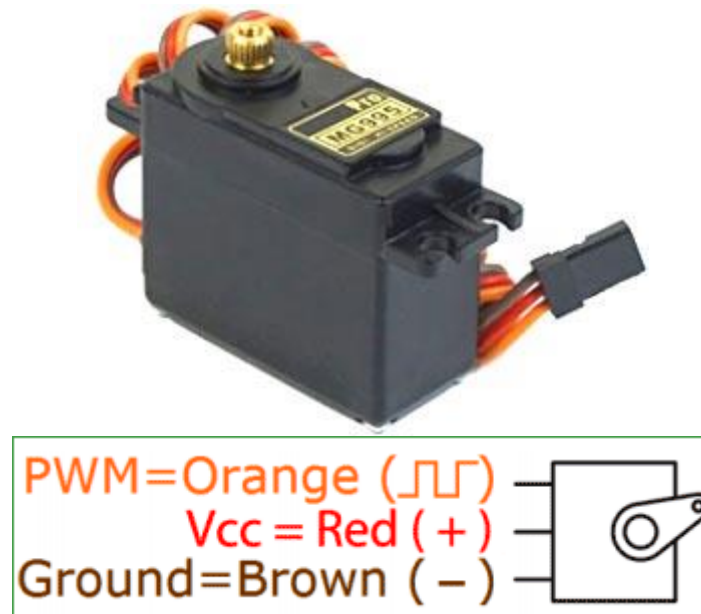


Figure 4.1.5 SERVO MOTOR

Servo motors may have different color codes, please check their data sheet.

Each servo motor works directly with the +5V power rail, but you need to pay attention to the amount of current the motor draws. If you plan to use more than one servo motor, you need to design a suitable servo shield.

4.2 SOFTWARE MODULE DESCRIPTION

Arduino Installation

After learning about the main components of the Arduino UNO board, you are ready to learn how to set up the Arduino IDE. Once you know this, you are ready to download the program to your Arduino card.

In this section, you can easily learn how to set up the Arduino IDE on your computer and prepare the card to receive programs via USB cable.

- First you'll need an Arduino card (you can choose the one you like) and a USB cable. If you are using an Arduino UNO, Arduino Duemilanove, Nano, Arduino Mega 2560 or Diecimila, you will need a standard USB cable (male A to B) to connect to a USB printer as shown below.
- Download the Arduino IDE software. You can get various versions of the Arduino IDE from the download page of the Arduino official website. You need to choose software that is compatible with your operating system (Windows, IOS or Linux). When the file is downloaded, unzip the file.

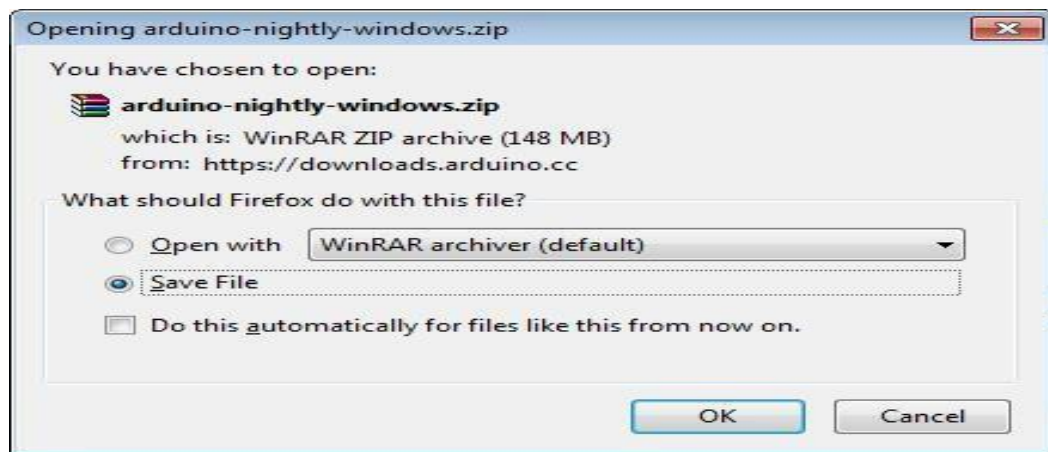


Figure 4.2a Installation

- Turn on the table. Arduino Uno, Mega, Duemilanove, and ArduinoNano automatically extract power from a USB-to-computer connection or external power supply. If you are using an Arduino Diecimila, make sure the card is configured to get power from the USB connection.

The power supply is selected using a jumper, a small piece of plastic that fits on two of the three pins between the USB connector and the power connector

- Make sure it is on the 2 pins closest to the USB port. Connect the Arduino card to your computer with a USB cable. The green power indicator (PWR) should be on.
- Launch Arduino IDE. After your Arduino IDE software downloaded, you need to unzip the folder. Inside the folder, you can find the application icon with an infinitylabel (application.exe). Double-click the icon to start the IDE.

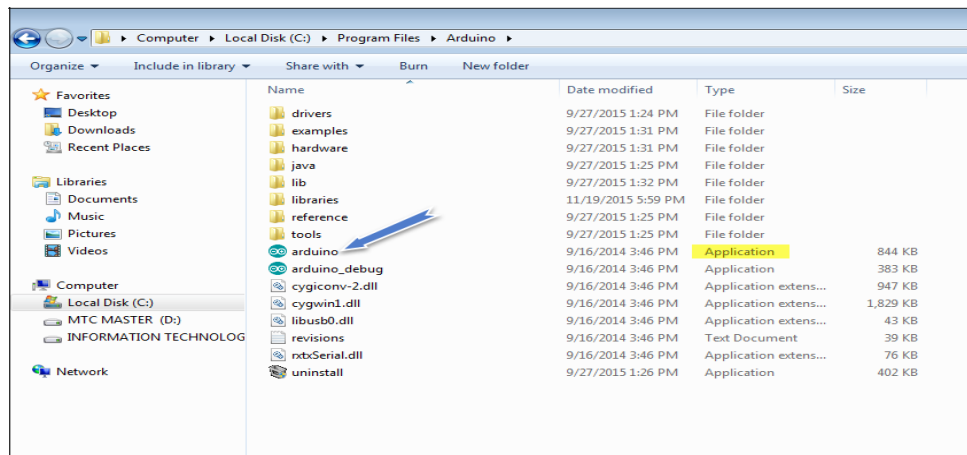


Figure 4.2b Application

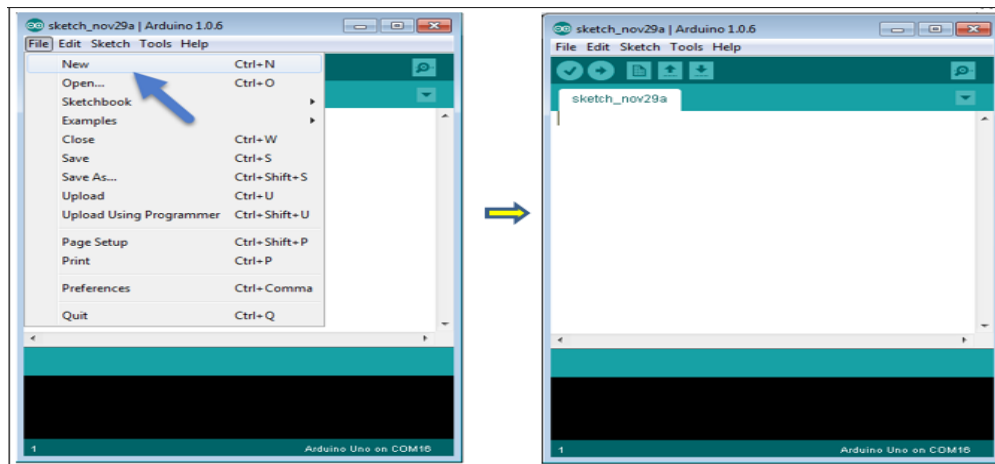


Figure 4.2c Creating a File

- Open your first project. Once the software starts, you have two options:
- Create a new project.
- Open an existing project example.
- To create a new project, select File --> New
- To open an existing project example, select File -> Example -> Basics -> Blink.

Here, we are selecting just one of the examples with the name Blink. It turns the LED on..and off with some time delay. You can select any other example from the list.

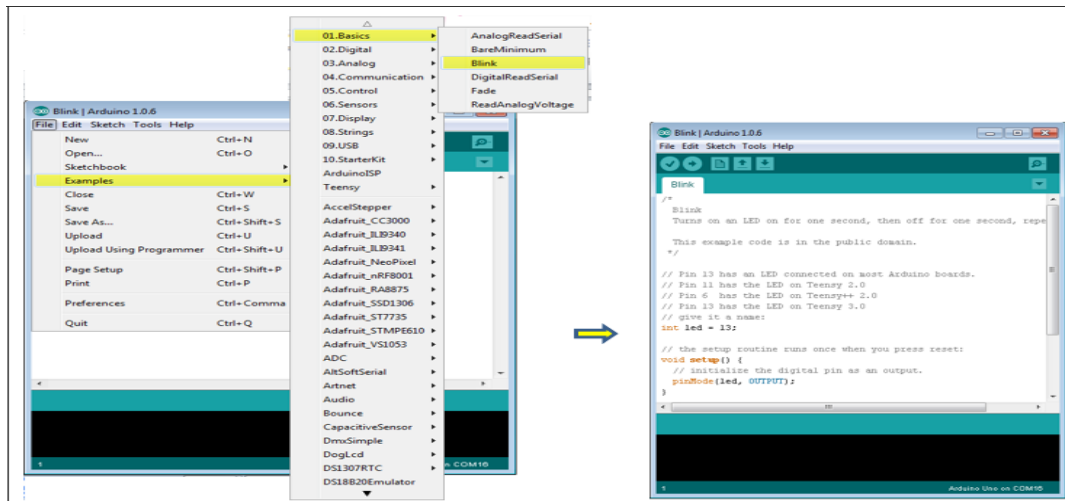


Figure 4.2d Code status by compiling

Select your Arduino board. To avoid any error while uploading your program to the board, you must select the correct Arduino board name, which matches with the board connected to your computer.

Go to Tools -> Board and select your board.

CHAPTER-5

RESULTS AND DISCUSSIONS

However, for safety reasons, the engine torque was limited to 20% of the upper torque to keep the exoskeletons stronger. The performance of the PID loop is tuned to the idle state. For continuous traffic. Website administration is more accurate than unnecessary tweaks or variations. The SMC constant was also determined in the no-load experiment. Velocity and acceleration are calculated as numerical discrimination. Both control loops currently operate at 2.5 kHz.

In the experiment, the transient response performance of 0 to 90 degrees in the MCP connection was evaluated for both types of controllers. In this experiment, the user was passive and did not object to or against movement. FIG. 3 shows the data entered for PID control and slider. The PID controller shows satisfactory performance. Deviation is the degree to which the desired value can be achieved. However, you cannot set up a faster response to maintain stability. What hinders approaching the desired value is due to changes in the load and friction of the Bowden cable. For comparison, SMC can provide a quick response while maintaining stability. The greatest deviations after the development and handling of passive exoskeletons for rehabilitation.

5.1 JOINT RANGE OF MOTION

For maximum rehabilitation outcomes, the exoskeleton's finger reachable ROM should be close to the natural ROM for healthy toes. To evaluate this performance, the angle was measured in the upper limb of the arm without an exoskeleton. In both conditions, the motif rotated each joint three times to the highest angle. A total of 30 angular values were collected for each joint, and the average values for the inch and index joints are shown in the table below.

TABLE 5.1.1 Maximum angle to create the best prints without self exclusion.

Thumb	Joint (°)			
	IP	MP	CMC1	CMC2
With Exos.	70.0	79.0	33.1	28.4
Without Exos.	82.0	86.0	35.0	32.3
Difference	12.0	7.0	1.9	3.9

TABLE 5.1.2 Maximum angle for connecting INDEX to EXOSKELTON and without EXOSKELTON

Index Finger	Joint (°)			
	DIP	PIP	MCP1	MCP2
With Exos.	46.5	102.1	84.1	24.0
Without Exos.	64.9	119.5	91.6	23.8
Difference	18.4	17.4	7.5	0.2

The results in the table show that the maximum angle of each joint with the device is less than without. This is due to the fact that the Velcro strap tightens the soft tissue of the phalanx pad and limits joint movement to some extent. In addition, lean design can lead to measurement

errors. However, these results are acceptable given that patients are generally less athletic and have a slightly lower limiting angle to protect the patient than a healthy person.

5.2 IDEAL VIEW

After all connections are established using the component and the device is activated.

The code is included in the arduino merger and the exoskeleton is ready to be reset.

The image below shows a portable exoskeleton.

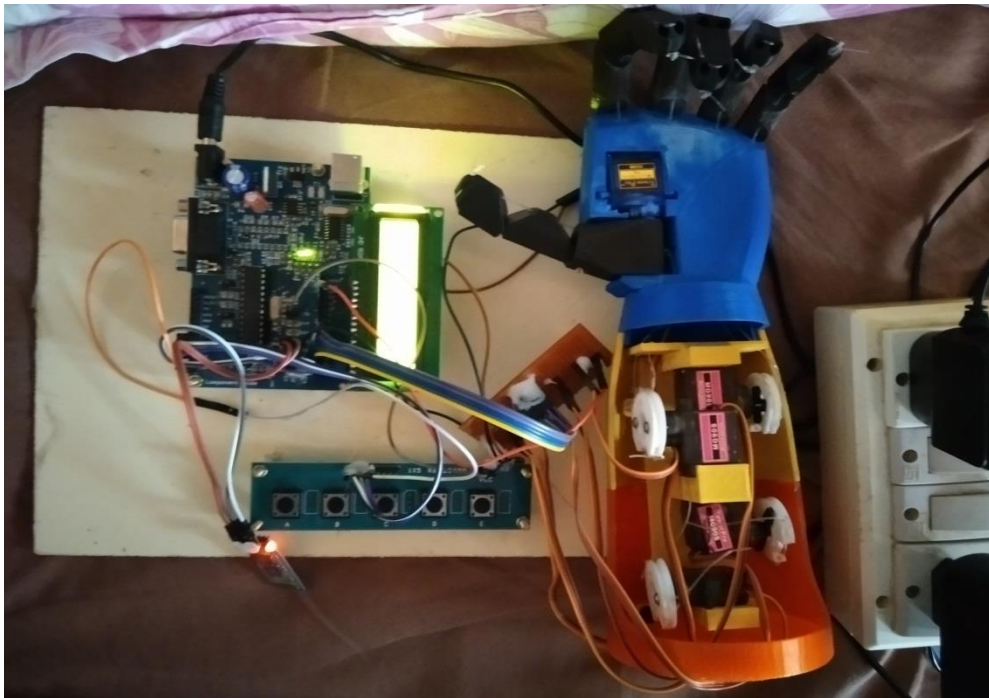


Figure 5.2.1 Demonstration

Here there are five buttons named (A,B,C..E), each button has a specific function to do. If we press button A, then thumb will be Closes. Similarly when we press B, Thumb will be opened. And when we press C, Index finger closes similarly pressing D index finger opens. And we can also control this using wireless network like bluetooth.



Figure 5.2.2 Thumb open



Figure 5.2.3 Thumb Close



Figure 5.2.4 Index finger Close



Figure 5.2.5 Index open

CHAPTER 6

CONCLUSION AND FUTURE WORKS

Taking into account the results obtained in the experimental class, it can be concluded that the developed unit is suitable for a wide range of tests aimed at patients with physical disabilities. With the newly developed force sensor, the exoskeleton now offers a custom interface that can contain multiple steps of reset. If in the early stages the patient is unable to perform the movements of the affected arm, the proposed MT-based robotic therapy may be an effective starting point. After the user has manually verified, you can use the trigger control method to include paired members in your workout. Ongoing strategies for managing police feedback during the advanced stages of the rehabilitation process can lead to interesting approaches to improving fine motor skills and grip strength. All presented tests were performed with the same finger module without any repair or maintenance between users. This is the first indication of the possibility of using technical polymers as structural materials. This fact can lead to lightweight devices and structures that can be manufactured inexpensively using casting techniques. In any case, this is just a preliminary conclusion that requires further investigation. After evaluating the load with the new built-in power converter, you can perform FEA structural modeling using a variety of polymers to select the most suitable building material. Knowledge of the resistance limits of various structural elements, along with force measurements, makes it possible to implement additional security measures to maintain the integrity of the device and the user.

REFERENCES

- [1] NINDS stroke information page (stroke information page: National Institute of Neurological Disorders and Stroke (NINDS)) 2017.
- [2] Mozaffarian D., Benjamin E. J., Go A. S., et al. Heart disease and stroke statistics-2015 update: a report from the American heart association. *Circulation*. 2015.
update: a report from the American heart association statistics committee and stroke statistics subcommittee. *Circulation*. 2007.
- [3] Birbeck G. L., Hanna M. G., Griggs R. C. Global opportunities and challenges for clinical neuroscience. *Jama the Journal of the American Medical Association*. 2014.
- [4] Mozaffarian D., Benjamin E., Go A., et al. Heart disease and stroke statistics–2015 update: a report from the American Heart Association. *Circulation*. 2015.
- [5] Miller E., Murray L., Richards L., et al. Comprehensive overview of nursing and interdisciplinary rehabilitation care of the stroke patient: a scientific statement from the American Heart Association. *Stroke*. 2010.
- [6] Ho N. S. K., Tong K. Y., Hu X. L., et al. An EMG-driven exoskeleton hand robotic training device on chronic stroke subjects: task training system for stroke rehabilitation. IEEE International Conference on Rehabilitation Robotics; July 2011.
- [7] Gustus A., Stillfried G., Visser J., Jörntell H., Smagt P. V. D. Human hand modelling: kinematics, dynamics, applications. *Biological Cybernetics*. 2012.
- [8] Basteris A., Nijenhuis S. M., Stienen A. H., Buurke J. H., Prange G. B., Amirabdollahian F. Training modalities in robot-mediated upper limb rehabilitation in stroke: a framework for classification based on a systematic review. *Journal of Neuroengineering & Rehabilitation*. 2014.
- [9] Iqbal J., Baizid K. Stroke rehabilitation using exoskeleton-based robotic exercisers: mini review. *Biomedical Research*. 2014.
- [10] Narang G., Narang A., Singh S., Lempiainen J. Use of unobtrusive human-machine interface for rehabilitation of stroke victims through robot assisted mirror therapy. 2013.
- [11] Barsotti M., Leonardis D., Loconsole C., Solazzi M. A full upper limb robotic exoskeleton for reaching and grasping rehabilitation triggered by MI-BCI. IEEE International Conference on Rehabilitation Robotics; August 2015.

- [12] Frisoli A., Loconsole C., Leonardis D., et al. A new gaze-BCI-driven control of an upper limb exoskeleton for rehabilitation in real-world tasks. *IEEE Transactions on Systems Man & Cybernetics Part C*; December 2012.
- [13] Bos R. A., Haarman C. J. W., Stortelder T., et al. A structured overview of trends and technologies used in dynamic hand orthoses. *Journal of Neuroengineering and Rehabilitation*. 2016.
- [14] Heo P., Gu G. M., Lee S. J., Rhee K., Kim J. Current hand exoskeleton technologies for rehabilitation and assistive engineering. *International Journal of Precision Engineering & Manufacturing*. 2012.
- [15] Gopura R. A. R. C., Bandara D. S. V., Kiguchi K., Mann G. K. I. Developments in hardware systems of active upper-limb exoskeleton robots: a review. *Robotics & Autonomous Systems*. 2015.