A THESIS SUBMITTED TO
THE GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES
OF ÇANKIRI KARATEKİN UNIVERSITY

DESIGN AND CONSTRUCTION OF MULTI-PURPOSE ROBOT CONTROLLED FROM REMOTE

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR
THE DEGREE OF MASTER OF SCIENCE
IN
ELECTRICAL AND ELECTRONICS ENGINEERING

BY

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ÇANKIRI

2023

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June 2023

We certify that we have read this thesis and that in our opinion it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Science

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Saad Rajab Mohammed MOHAMMED

ABSTRACT

DESIGN AND CONSTRUCTION OF MULTI-PURPOSE ROBOT CONTROLLED FROM REMOTE

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The realm of robotics, encompassing a broad spectrum of functionalities and applications, has made momentous strides over the decades. Robots, fundamentally described as intelligent tools meticulously programmed to execute specific tasks, embody the pinnacle of technological advancement. The dynamic nature of robotic science ensures that it perpetually evolves, remaining congruent with technological progressions and societal requirements. Through extensive review and analysis of prior research, there emerged a pronounced need for a specialized robot, adept in executing crucial missions, particularly in domains of forest firefighting and critical military operations. The paramount objectives guiding its design are two-fold: the ability to access and function in challenging terrains, such as forested areas or war zones, and the facilitation of explosive device detection and removal, thereby significantly mitigating risks to both military personnel and civilians. The robot is innovatively designed with dual arms to manipulate and transport objects efficiently. These arms boast a six-degree freedom movement, ensuring agility and precision in its operations. The robot's "head" is equipped with a state-of-the-art camera, serving as the primary observation tool, offering clear and comprehensive visuals of its surroundings. Traditional feet are substituted with four robust wheels, optimizing mobility across varied terrains. In an era where timely detection can be the thin line between life and death, the robot is fortified with an assortment of sensors, the most notable being the temperature sensor, pivotal for hazard detection, especially in firefighting scenarios. One of the standout features of this robot is its remote operability. Operators can seamlessly control its functionalities through a spectrum of devices - be it mobile applications, dedicated remote control sticks, or laptops. The communication conduit between the controller and the robot is facilitated by the ZigBee module. This state-of-the-art technology ensures uninterrupted signal transmission, covering expansive distances of several kilometers. Such a feature not only amplifies the robot's operational range but also ensures that human operators can remain at a safe distance from potential harm. Post-production, rigorous testing was undertaken to assess the robot's carrying capabilities across varied objects and terrains. The outcomes were overwhelmingly positive. The robot exhibited impeccable performance, with all joints manifesting fluid movement, perfectly aligning with its intended design and purpose. In essence, this robot is not just a marvel of technological prowess but is a beacon of hope, poised to significantly augment safety standards in high-risk domains, potentially saving countless lives.

2023, 54 pages

Keywords: Robot Construction, Multi-purpose robot, Arduino, Web application, Camera

ÖZET

UZAKTAN KONTROLLÜ ÇOK AMAÇLI ROBOT TASARIMI VE YAPIMI

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Robotik alanı, geniş bir işlevsellik ve uygulama spektrumu içererek, onlarca yıl boyunca büyük ilerlemeler kaydetmiştir. Robotlar, temelde belirli görevleri gerçekleştirmek için özenle programlanmış akıllı araçlar olarak tanımlanır ve teknolojik ilerlemenin zirvesini temsil ederler. Robotik biliminin dinamik doğası, sürekli olarak evrim geçirdiğini, teknolojik ilerlemelerle ve toplumsal gereksinimlerle uyumlu kaldığını garanti eder. Önceki araştırmaların kapsamlı bir incelemesi ve analizi sonucunda, özellikle orman yangını söndürme ve kritik askeri operasyonlar gibi alanlarda hayati görevleri gerçekleştirmede yetenekli bir robot için belirgin bir ihtiyaç ortaya çıktı. Tasarımını yönlendiren en üst düzeydeki amaçlar iki katlıdır: Ormanlık alanlar veya savaş bölgeleri gibi zorlu arazilere erişme ve işlev görme yeteneği ve patlayıcı cihazın tespiti ve kaldırılmasını kolaylaştırarak hem askeri personel hem de siviller için riskleri önemli ölçüde azaltma. Robot, nesneleri etkili bir şekilde manipüle etmek ve taşımak için çift kol ile yenilikçi bir şekilde tasarlanmıştır. Bu kollar, operasyonlarında çeviklik ve hassasiyeti garanti eden altı dereceli özgürlük hareketine sahiptir. Robotun "başı", çevresinin net ve kapsamlı görsellerini sunan birincil gözlem aracı olarak görev yapan son teknoloji bir kamera ile donatılmıştır. Geleneksel ayaklar, çeşitli arazilerde hareket kabiliyetini optimize etmek için dört sağlam tekerlek ile değiştirilmiştir. Zamanında tespitin yaşam ile ölüm arasındaki ince çizgi olabileceği bir çağda, robot, yangın söndürme senaryolarında tehlike tespiti için kritik olan sıcaklık sensörü de dahil olmak üzere bir dizi sensörle güçlendirilmiştir. Bu robotun öne çıkan özelliklerinden biri uzaktan işletilebilir olmasıdır. Operatörler, mobil uygulamalar, özel uzaktan kumanda çubukları veya dizüstü bilgisayarlar olmak üzere bir dizi cihaz aracılığıyla işlevlerini sorunsuz bir şekilde kontrol edebilir. Kontrol cihazı ile robot arasındaki iletişim, ZigBee modülü ile kolaylaştırılmıştır. Bu son teknoloji, birkaç kilometrelik geniş mesafeleri kapsayacak şekilde kesintisiz sinyal iletimini garanti eder. Bu özellik, sadece robotun operasyonel menzilini artırmakla kalmaz, aynı zamanda insan operatörlerin potansiyel zarardan güvenli bir mesafede kalmasını da sağlar. Üretim sonrası, robotun çeşitli nesne ve arazilerde taşıma yeteneklerini değerlendirmek için titiz testler yapıldı. Sonuçlar büyük ölçüde olumluydu. Robot, tüm eklemlerin akıcı hareketini sergileyerek kusursuz bir performans sergiledi, bu da tasarlanan amacı ve amacıyla mükemmel bir şekilde uyumlu oldu. Özünde, bu robot sadece teknolojik bir başarı harikası değil, aynı zaman yüksek riskli alanlarda güvenlik standartlarını önemli ölçüde artırmaya hazır olan umudun bir ışığıdır ve potansiyel olarak sayısız hayatı kurtarabilir.

2023, 54 sayfa

Anahtar Kelimeler: Robot yapımı, Çok amaçlı robot, Arduino, Web uygulaması, Kamera

PREFACE AND ACKNOWLEDGEMENTS

This work is a tribute to the undying love and unwavering support that I have received throughout my life, particularly from my cherished family - my parents Dr. Rajab Muhammad Al-Dulaimy and Hanan Al-Dulaimy; my sister Reem Rajab Al-Dulaimy, whose absence is deeply felt; and my brothers Marwan Rajab, Mohammed Rajab, and Mahmoud Rajab, who have been my pillars of strength. My sincere gratitude extends to Asst. Prof. Dr. İsmail TOPALOĞLU, who, like a guiding light, has been a constant source of wisdom, patience, and inspiration. My friends and colleagues, PhD. Hussein Majeed, PhD. Nawras Fodeal, Eng. Marwa Al-Dulaimy, and Eng. Mona Alqam, deserve special recognition for their companionship and unwavering support. Lastly, I wish to express heartfelt thanks to everyone who has supported me, sharing their kindness and encouragement along this journey.

Saad Rajab Mohammed MOHAMMED
Çankırı-2023

CONTENTS

LIST OF SYMBOLS

6DOF	6 degree of freedom
DH	Hartberg dynamite
PIR	Motion sensor
DHT11	Temperature and humidity sensor
Web	Website application

LIST OF ABBREVIATIONS

AI	Artificial intelligence
CAD	Autocad
AGV	Automated guided vehicle
Cam	Camera
FLC	Fuzzy logic control
IOT	Internet of things
Mech	Mechanical
PUMA	Programmable universal machine for assembly
CLMR	Tip cleaner for robot with metal brushes

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1. INTRODUCTION

The term “Robot” is an ancient term where it was used by the Romans and others but the newly term phrase appeared in the twentieth century in 1920 refers to intelligent machine that perform certain tasks on man's behave by a specified Artificial Intelligence (AI) programming. A robot is a smart machine designed according to smart engineering scheme for certain purpose controlled remotely by a laptop, joystick, even by a mobile phone or other technologies. Robots mechanical structure is made of different materials including iron, aluminum and plastic which are selected base on the purpose the robot designed for, and programmed with Java, python, or C++. The robot consists of three main parts. First the body of the robot which consists of the electrical and electronic parts, and the cover of the robot. Second, the sensors which they are responsible for reading and analysis danger. The last part is the controlling unit of all physical parts of the robot. In the old days, the robot was made to perform typical work as we usually saw the robot in factories such as car manufacturing factories like Mercedes, Toyota, Hyundai, and other companies where the robot is represented as an arm for welding a specific part or lifting heavy weights and large sizes or other works. On the other hand, in nearly times and after technological advance and the revolution harvested by expertise, the robots began to enter all fields including medical, scientific, military, agriculture and even homes with huge success. Special dangerous tasks such as in military where soldiers in wars have to risk their lives moving to deactivated explosives, where now all can be done using an intelligent robot using mechanical, electrical and mechatronics engineering with intelligence programming to design prototypes of robots without and casualties. Recently, robots were found in entertainment field such as children public play areas for children with disabilities, restaurants for serving as in China and home robots for cleaning the floors and dish washing and other jobs. As we believe that the robot can replace humans in other jobs like accounting by the continuity of the robotic science and AI development.

1.1 The History of Robots

The history of robotics is intertwined with the history of the basic principle of the technological development, science. The technology used in computing, electricity, and even pneumatic and hydraulic materials can be considered part of the history of robots. The first use of the term ‘Robot’ was in 1921, by the Czech writer Karel Capek, of his play “R.U.R”(Pierre DUYSINX *et al.* 2004), derived from the Czech word for forced labor. The plot was simple, where a person creates a robot to serve humans and years later, these robots, have come to dominate them completely. This name began to be applied to every device that is manufactured such as computers, medical and engineering devices, and even household appliances such as cleaning brooms. The development of robots continued, and our current era is considered to be the era of the technological revolution, because of the various inventions it carries, such as a self-driving car, sensors, medical devices, and many robots and inventions in this field.

1.2 What is the Robot

The word robot is derived from the term Robota, which means the worker, as there are several definitions that explain the concept of robot, the closest of which is the industrial robot as a multi-functional, programmable manipulator designed according to programming to transfer materials, tools other tasks that it performs (Werneckm 2019). We can say that the robot is an electromechanical lord. It is designed according to precise engineering measurements according to the need or the goal to be done. It is closely linked to smart computing through AI algorithms, which in turn are the middle part between man and machine in terms of giving orders and executing them.

1.3 Study Statement

This project was designed and implemented for several purposes, where the main objective was to remove explosive or harmful tools in places that pose a danger to humans, and in factories, where they replace humans for the purpose of removing harm and danger from humans through two arms designed on a body consisting of 4 wheels moving in 4 tracks and a number of cameras that transmit instantaneous image signals for the purpose of correct functioning by the main controller of this robot.

1.4 Background Study

This project was mainly designed and analyzed through AutoCAD program. The construction of this project practically consisting of two arms to replace people, which reduces the potential danger and increases the efficiency of the military, professional and industrial sectors. This production can motivate manufacturers of military tools and increase opportunities for researchers in terms of developing the idea of robotics automation and developing it. Building and developing robotics automation increases the efficiency of the industrial sector and enhances the capacity of security capability.

A detailed study was conducted on "Designing a DOF6 robotic arm that has the ability to analyze its own workspace where the model controls the maneuvers to achieve an accessible position and direction in an unregulated environment (Paolillo 2018). different study conducted on robotic arm where its purpose was to imitate the movements of the human arm through the use of sensors for the purpose of obtaining data of the natural motors of the arm. The result was to achieve accurate movement and easy control (Shekhawat 2016).

1.5 Research Problem

The main problem in this project lies in the balance of the robot when performing the task of movement in a rough place, and when moving the arms to carry a specific part. When the part that carries the arms turns to the left or the right, especially when carrying from the ground, there will be an imbalance affecting the stability of the entire robot. In the case of rough terrain, where the stability of the robot before and during the performance of the task, is a huge interest and taking this problem as an essential part into consideration. The other problem which is the balance of the arm and carrying capacity, as a study conducted on the work of the arm and its ability to perform tasks and balancing when rotating and lifting, 70% of the engine's energy will be used for the extra weight (Kumar 2021). The weight of the arm and the installation of motors on it is a different problem that must be taken into consideration as well as the type of material from which it is made, and the type of engine used in terms of its capacity and torque. There must be a relationship between the weight of the engine and its high-performance capacity and the quality of the material from which the arm is made of.

1.6 Implementation of Purpose

The basic idea in this project is the implementation of robotic arms. Although it can be implemented in different ways, but this implementation is the most feasible and safest when used because of the integration between human and robot through the implementation process, so this project is considered an auxiliary factor for humans to perform as it is also considered the boundary between humans and places of total damage.

1.7 Objective of Study

The objective of this study is divided into several sections, including two main objectives:

- The first objective is in the military field, to remove explosive devices that are visible on the ground, detect them and cut the wires in which must be disposed of. Also, a second goal in the military field is periodic surveillance because of its ability to move over long distances and send instant pictures through the camera installed on it, which in turn visualizes 360 degrees at the same moment.
- The second objective is in the industrial field. Despite the development of industrial robots, it does not prevent the continuation of the development of this field. There is no doubt that there are places in factories that are difficult for a person to reach, or that may pose a danger to him when carrying a specific piece, such as working in a specific room which temperature exceeds 60° C or carry a piece of high temperature. This study can be used in various fields, such as hospitals, because it is characterized by having two arms and the ability to control it remotely and the ease and flexibility of its movement in the four directions due to the size and quality of the materials made from it.

2. LITERATURE REVIEW

The manufacture of robots in their various forms has become very common, and it is available in the market in different mechanical structures and dimensions that cannot be counted, as it increases with the increase of technological development. This multi-use robot consisting of two arms and 4 wheels was designed and built for several uses, including removing harmful things that threaten human life. Many studies have been conducted on arms and the mobile vehicle, some of which are self-propelled, and some that are manual control according to the task involved. Therefore, we divide the studies into two parts.

2.1 Car Robot

There are many studies that that cannot be counted have been conducted on the movement of robot-consisting wheels. About the inference for this work, the most prominent studies that are suitable for this field have been taken. Designing a robotic car that can be controlled through a mobile phone running on the Android system" (Ullah *et al.* 2019) and in another study "a robotic car was designed to be used for monitoring in military operations for detection using a mobile phone connecting to Bluetooth between the car and the phone to move the robot up the back and the right and left sides" (Maity *et al.* 2017). Another design applying “The Internet of Things” (IOT) to control electric car parameters such as brakes, acceleration, and steering using Wi-Fi technology to provide vehicle location events through an updated GPS system every 5000-millisecond interval" (Kulkarni *et al.* 2018). An attempt to document and link AI in Robot work: An automatic intelligence car was designed that has the ability to sense the environment and determine the path of movement without human intervention using AI (Shekhawat *et al.* 2016). A four-wheeled car was designed using AGV to move from one station to another without human intervention during the implementation of the task to reduce human effort” (Thakur *et al.* 2017). Different study conducting a fire extinguisher robot that works with the control system built through an Android mobile phone and an Arduino with Bluetooth, as the result showed, the robot can be controlled. Also, the accuracy in identifying the barrier between the fire and the robot reaches 97%, as the robot can move at an average movement speed of 22.2 seconds for each extinguishing stage. A robotic car was designed and controlled remotely using a desktop device for humidity and temperature measurements using Bluetooth simulation". "A mobile monitoring robot was designed via Wi-Fi using Atmega 8 that is controlled by an Android smartphone, as it can walk by user commands to monitor places that are difficult or dangerous for humans" (Pane *et al.* 2018)

2.2 Control for Car Mobile Robot

With the expansion of robotics technology, many robots are manufactured locally and available in various controlling types, some of which are autonomous, and others are controlled by an actual controller to give orders, as many studies have been conducted, various methods of controlling the robot, including modeling and simulation, self-tracking, mechanical and electrical, etc. A study was conducted for the design of a car-like robot whose control is based on neural prediction. A multi-layered propagation neural network was used. The posterior model of the nonlinear kinematics modeling of the robot instead of the linear regression estimator in order to adapt the robot to wider operating range (Gu *et al.* 2002). In a study of controlling by image processing, "a robot that looks like a CLMR car has an independent position and has been designed Possibility of standing through image processing" (Li *et al.* 2003). Also, "designing a robot that deals with the problem of standing by implementing a specific algorithm to control the movement of the robot to a certain point" (Lee *et al.* 1999). In another study: "the concepts of auto maneuvers, fuzzy logic control (FLC), and sensor-based behaviors were combined to implement human-like driving skills with a mobile autonomous vehicle-like robot (CLMR). Four types of FLCs are being manufactured. The fuzzy wall tracking control, the fuzzy corner control, and the garage parking fuzzy control" (Li *et al.* 2003). In different study, "An AIC robot with AI sensing that has the ability to sense the environment and determine the path to navigate without any human intervention, has features such as line follower, obstacle avoidance, path finder and wireless controller with Bluetooth assistance" (Shekhawat *et al.* 2016). The study of "Developing a robotic car using the Arduino uno system, a smartphone and a computer used for spying in a dangerous environment, has the ability to record broadcasts in real time day and night as well as through a wireless camera. It was controlled manually” (Akilan *et al.* 2020). Also “a remote-control car was developed using a smartphone and Bluetooth to monitor the movement of the car through installed camera "(Meteab *et al.* 2021). "The fire fighting vehicle was designed using Arduino system for remote control "(Taha *et al.* 2018). "The controlled robotic car was carried out via the internet wirelessly, and the results were satisfactory.” (Okatan 2001).

2.3 Car Mobile Robot Monitoring

The development of the monitoring robot is an important factor and a technological development that should not be neglected as it provides a safe environment and saves lives, in particular, in military operations, places of fire and earthquakes, which means the development of robots contributes to helping humans. Therefore, many robots have been designed in this field, and the development is still continuing. The development of robots cannot be limited. It continues with the continued development of smart devices, especially with the development of AI sciences. Many studies have been conducted on this field, we can infer a number of studies that are closest to our field. A robotic car was developed using the Arduino uno system, a smartphone and a computer, used for spying in a dangerous environment. It has the ability to record broadcasts in real time day and night as well as through a wireless camera. It is controlled Manually"(Pane *et al.* 2018). A robotic car was also designed based on a Track Car , to travel on the roads and for monitoring that contains of a computer that can send instructions to the crawling robot using manual control or automatic control” (Cheng *et al.* 2017). “A robotic car is designed with a remote monitoring system it was equipped with a camera, ultrasonic sensor, DHT11 sensor and PIR sensor, the sensors were installed according to the environment in question. Instructions are given to the vehicle using the Blynk app as a user interface through a Wi-Fi connection "(Sowmya *et al.* 2020). " An open-source robotic car that is designed to work with a smartphone through the Bluetooth monitoring feature and it is programmed with an automatic obstacle detection and prevention algorithm based on the ultrasonic range sensor (Chakraborty *et al.* 2016).

2.4 Design and Implement Robotic Arm

Numerous studies have been conducted on arm design with different sizes and patterns that suit specific working conditions and the task to be performed in terms of the number of joints, the materials they are made of and torque efficiency. A study was conducted on "Developing a DOF 6 robotic arm using MATLAB that analyzes its own area. The motor system of this arm relies on Hartberg Dynamite (DH) parametric diagram for positioning the robot arm. The results showed that the accuracy of the arm for positioning was ± 0.5 cm" (Iqbal *et al.* 2012). In 2012, a study was conducted on "Developing two arms where they are controlled through the internet by the computer through the Arduino piece using the Arduino Ethernet Shield, and this work was successful" (Kadir *et al.* 2012). In another study conducted on an arm consisting of two joints using a powerful microcontroller "Control units were built for pulsed input current signals on a 2DOF robotic arm to improve performance using H2/H flight with the help of MATLAB/ Script Toolbox where simulation results have been proven. -5DOF using LabVIEW to calculate the IK model to evaluate the joint angles of the robot arm, where the correct location of the final responder was achieved. Reducing the materials on the second axis by 10%, and it was observed that the joint did not deform. (Bugday *et al.* 2019) This study is important to solve a problem that lies in the rigidity of the arm and its torque. During this study we conclude that the torque of the arm is related to the amount of materials made from it. As for the control of the arm, the robot arm was controlled using natural dynamics, and its joints are controlled using simple nonlinear oscillators." (Williamson *et al.* 1999). "a smart system consisting of a robotic arm with two web cameras was designed to implement commands on a smartphone based on image processing, pattern recognition and personality. the recognition was carried out using 43 features in the training data, and the result was that the robot could successfully perform various tasks (Juang *et al.* 2015).

2.5 Arm Control

Controlling the arm has many ways that cannot be counted, as it is somewhat similar to controlling the wheels. It can be made Self-propelled or Remote Control. "a study developed a controller for a robotic arm where computer simulations were performed to verify the feasibility of a robot controller. The controller was experimentally evaluated on a PUMA 560 robotic arm. Experiments showed that the controller produces good and robust trajectory tracking performance in the presence of errors in the model" (Tarn *et al.* 1991). "a model used for a 3D simulation to train a 7-DOF robotic arm in a control task without any prior knowledge was presented where intermediate priority results were obtained" (James *et al.* 2016).

By examining a number of old and recent studies to design a mobile robot and a controlling arm, we noticed that all were designed separately, meaning that the mobile robot was designed for monitoring and detection only, and arms of all kinds were implemented and with a different number of joints for one purpose that may have been static when performing, and we also did not notice the work of two arms at the same time from one controller. we installed two arms on a vehicle consisting of 4 mobile wheels according to the controller's commands from the computer board and the control sticks to detect dangerous places and monitor, and at the same time remove harm without causing danger to humans, especially in military operations when detecting the perimeter before walking on it and removing explosive devices through the arms, as these arms have the ability to cut wires and lift objects, which contributes to saving lives without losing them.

3. MATERIALS AND METHODS

A robot is an electromechanical machine that is designed according to measurements and dimensions that suit to the implemented target, where the robot interacts with the human according to specific programming. It replaces human in threat places and present for the purpose of avoiding harm, A body with 4 wheels that moves in 4 directions completely freely and 360 degrees, equipped with two arms moved in 180 degrees to the right and left and 180 degrees up and down, each arm consists of 6 joints that move freely and can perform duties, but its controlling done through the computer and Joystick, and this robot also equipped with a surveillance camera that sends instantaneous signals to the controller, videotaping in 360 degrees, which facilitates performance and monitoring. and threats detection in places that threating human life and military operations detection of harmful tools to monitor such as explosive devices, and this robot also has the ability to cut wires and lift visible objects. when designing and implementing any robot, it consists of two main methods, Hardware & Software, and each part has its own study. Programming languages such as C++, this feature is called Software.

3.1 Car Mobile Robot

A car robot is a robot designed to move on wheels and is capable of navigating through a variety of environments. A mobile robot is a software-controlled machine that uses sensors. Mobile robots operate using a combination of AI and physical robotic elements, such as wheels, tracks, and legs. They are used to assist in work procedures and even to complete tasks that are impossible or dangerous for human workers. Mobile car robots can be autonomous, which means they are able to navigate and make decisions on their own, or they may be remotely controlled, which means they are controlled remotely by a human operator. Some car mobile robots are also equipped with sensors and other technology that allow them to gather information about their surroundings and interact with their environment, such as manipulating objects or following specific paths. Mobile car robots are often designed to be versatile and adaptable, allowing them to perform a wide range of tasks and operate in a variety of different environments “a car-like mobile robot navigating a dynamic environment.

3.1.1 Mechanical design

The mechanical design of a mobile robot involves the selection and integration of various components and systems that enable the robot to move, navigate, and perform several tasks. These components may include wheels, tracks, motors, actuators, and other types of mechanical devices. A major consideration in the mechanical design of a mobile robot is selecting the correct type of propulsion system. This may include choosing between wheels, tracks, or another type of locomotion, depending on the intended use of the robot and the operating environment. The wheels or tracks of the robot must be selected to provide the necessary traction and stability, and may need to be designed to adapt to different types of terrain or obstacles. In general, the mechanical design of the moving robot must be carefully considered to ensure that ability to meet the specific requirements of the intended application. At the beginning of the project study, it was designed with AutoCAD program and detailing it into several parts with a 2D feature, a multi-use robot means that it has a controller that moves as required. Figure 3.1 shows the CAD design for wheels.

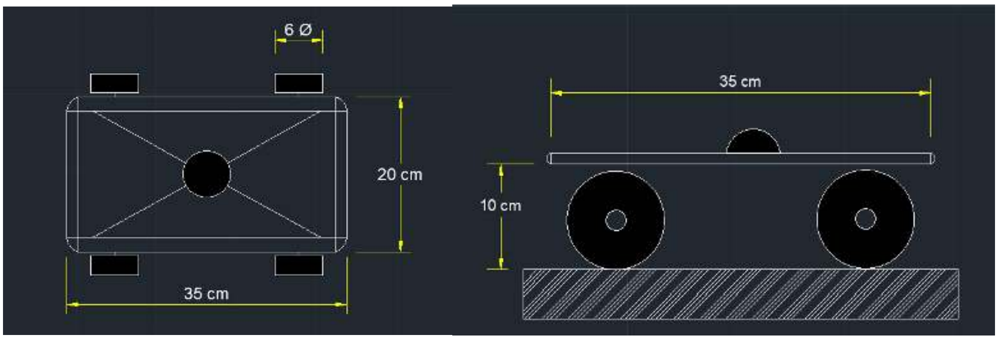

Figure 3.1 CAD design for wheels

When designing this robot and taking the necessary measurements, we took into account the balance of this robot when moving on stable ground or limp land and the balance of those arms when one of them moves or Both together, and by the balance of the arms, we mean the reliability when lifting, lowering, carrying, and the stability of the whole robot when the arms are working, as the measurements for the design of the cart are the first basis for generating sufficient balance for the entire robot according to Newton's second mathematical law to calculate the balance of the rigid body on the three axes X, Y, Z if a force affects a body What it gains acceleration is directly proportional to its force as in Equation (3.1) and Equation (3.2) and inversely proportional to its mass.

$$\mathrm{F} = \frac{dp}{dt} = \frac{d(mv)}{dt} \tag{3.1}$$

$$\mathrm{F} = m\frac{dv}{dt} = ma \tag{3.2}$$

where F is the force, m is the mass of the Body and a is the acceleration.

For the arms, measurements were taken for several aspects, including free performance in terms of fixation on the wheel and reaching the ground. The measurements between joint to the next joint according to the natural human arm. Therefore, the robot design was according to three main requirements "balance and freedom, reliability, ease of performance and control".

3.1.2 Stability for mobile robot

This part is the basic cart consisting of 4 wheels that have been replaced instead of feet to achieve greater balance and ease of movement in the four directions (front, back, right, left). thr measurement designed 30 cm wide, 25 cm wide, and 15 cm high from the ground. The measurements were taken to achieve balance when the robot is in a state of static and moving. As for the material used to build the structure, Acrylic was used because of its strength, durability, and lightness, and it is not heavy in weight, which It helps in installing electronic parts on it, and the wheels were printed in a 3D printer from carbon material, with measurements of 6D diameter and 1.5D width. Figure 3.2 represented to car force analysis as illustrated in Equation (3.3):

$$x^2 + y^2 + z^2 = f^2 \tag{3.3}$$

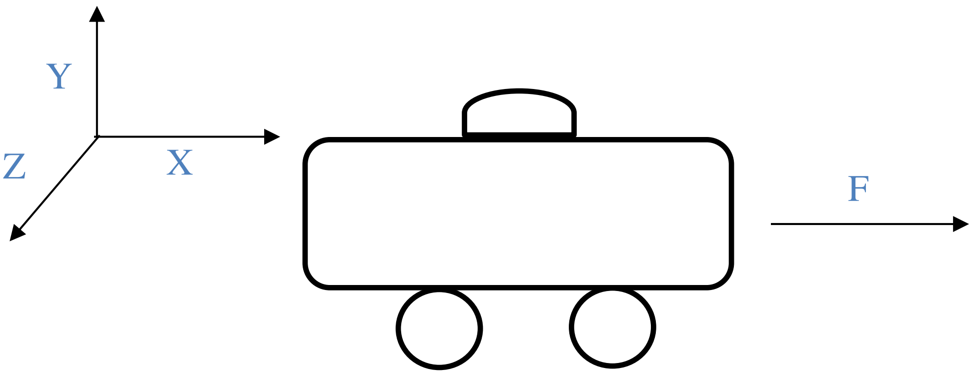

Figure 3.2 Car force analysis

3.1.3 The structure and control for wheeled mobile robot

Controlling the wheels is the first basic step that must be focused on. The base platform is the main structure for the balance of the robot and this platform that contains all the necessary electronic parts such as Arduino board, battery, current transformer, speed controller, in addition to the motors installed with the wheels. Figure 3.3 shows the structure for electrical wheel.

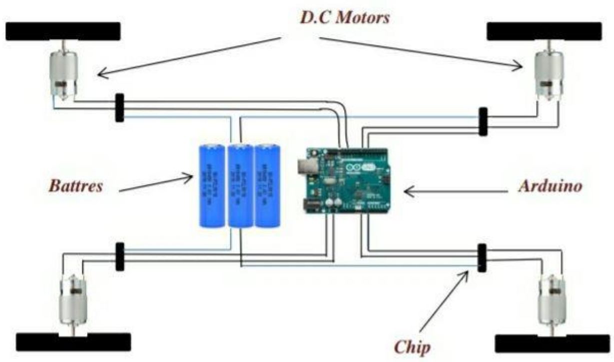

Figure 3.3 Structure for electrical wheel

The robot controlling is done by simulating all the electronic parts together through a specific algorithm, where we used the C++ programming language for simulation, where controlling signal wireless transmitted between the robot controller's and a computer with joystick via the Bluetooth signal that is linking PC to the controller. The Bluetooth signal connects the robot controller in the robot by an algorithm in order to form a secure link between the controller and the mobile robot as it is considered as the signal carrier layer as in the following diagram

The robot has 4 movements directions forward, backward, right and left, and each movement has a mechanical feature when given the order by the controller to work. When a signal is sent to move the cart forward, all the wheels will move clockwise in a complete electrical cycle, as shown in the illustration Figure 3.4a when sending A signal from the controller to the robot to move it backwards. All wheels will move counterclockwise. In this case, the polarity will be reversed, which means that the wave state will be reversed, as it is in the illustrative Figure 3.4b. In the case of turning to the right, the wheels on the right will rotate, the wheels on the left will turn counterclockwise, and those on the left will turn counterclockwise, as shown in Figure 3.4c, the wheels on the left will rotate, the wheels on the right will turn counterclockwise, and those on the left will turn clockwise, as shown in Figure 3.4d, in order to facilitate the Rotation movement without pressure on a certain part of the motors and for balance also without losing control. We noticed during the experiment that the work of all the wheels in turning to the right or the left gives greater space and higher balance to the robot.

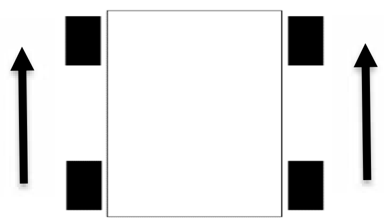

Figure 3.4a Forward

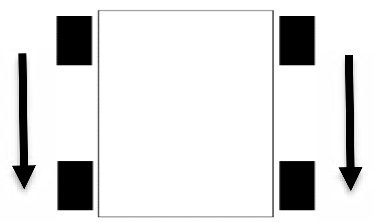

Figure 3.4b Backword

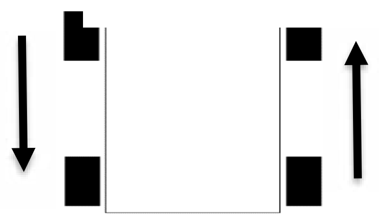

Figure 3.4c Left

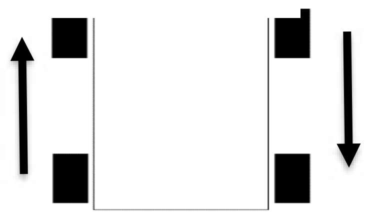

Figure 3.4d Right

Figure 3.4 Robot movement

Figure 3.5 and Figure 3.6 are the electrical circuit and the wave form.

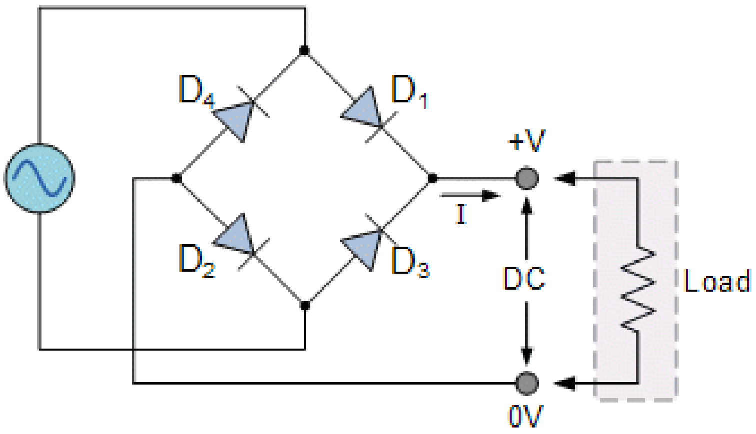

Figure 3.5 Electrical circuit

The Equation (3.4) would look something like:

$$Vd = 0.636 * Vm \tag{3.4}$$

Vd represents the DC voltage (direct current), and Vm represents the peak voltage (maximum voltage). These are related in a Full Wave Rectifier where the average (or DC) voltage is approximately 0.636 of the peak voltage.

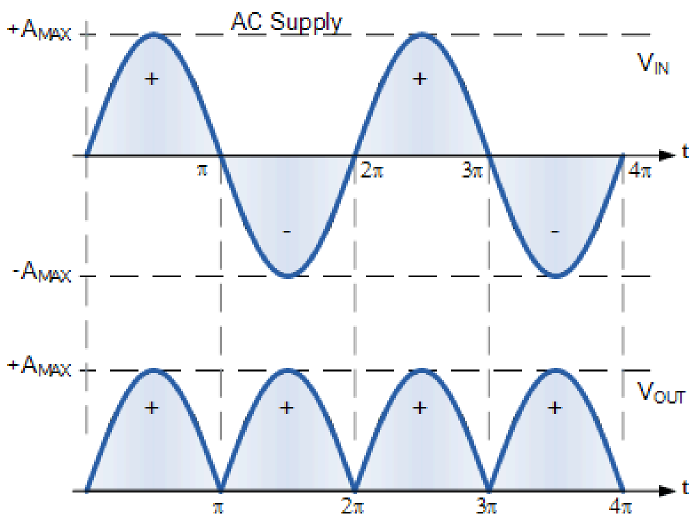

Figure 3.6 Signal for electrical circuit

Moving the robot requires high torque because it is the basis for the robot to work and move it in four directions. As shown in Figure 3.7, in the main wheels, a DC servo motor 12v was used (Riazollah 2008). Its specifications as shown in Table 3.1.

Table 3.1 DC servo motor datasheet

Model	Knowledge ability
Effort	12 v
Speed	300 round per minute
Torque	5.2 Kg. Cm
Motor weight	0.23 Kg
Power	200 Watt
Body length	7.2 Cm
Current	1 Ampere

Figure 3.7 DC servo motor

A DC motor is any motor within a class of electrical machines where current electrical energy is converted into mechanical energy. Most often, this type of motor depends on the forces produced by magnetic fields. Regardless of the type, DC motors have a kind of internal mechanism, which is electronic or electromechanical. In either case, the direction of the current flow in part of the motor is changed periodically; the speed of the DC motor is controlled by using a variable supply voltage or by changing the current strength within its field springs. This type of high equipment is common in terms of usage due to the small size and price compared to other devices as its 12v energy consumption is suitable for setting up projects that have the ability to generate such a value of energy.

3.1.4 Modeling and simulation for wheels control

To model and simulate the movement of the wheels, we have used the Proteus simulation program to show how the wheels rotate to the right and left by linking the electronic circuit, one motor with the circuit to illustrate the principle of work. Figure 3.8 shows the servo motor simulation

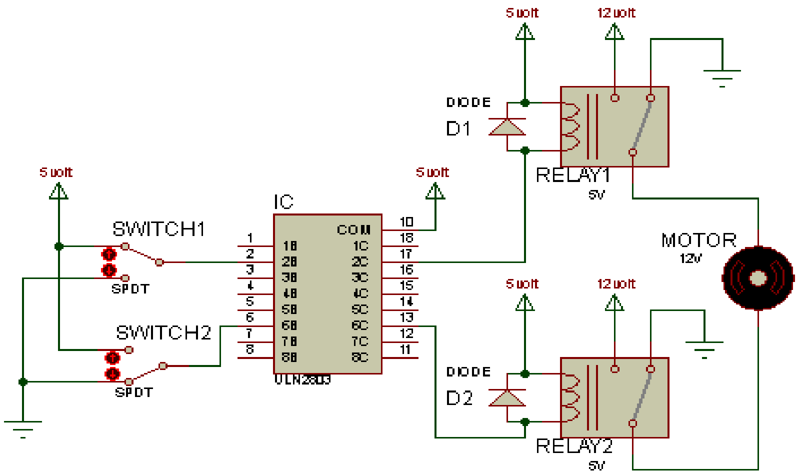

Figure 3.8 Servo motor simulation

Figures 3.9, 3.10, 3.11 and 3.12, represents for 4 cases in the operation of the first circuit when we make the two switches in the on state, the motor is stopped.

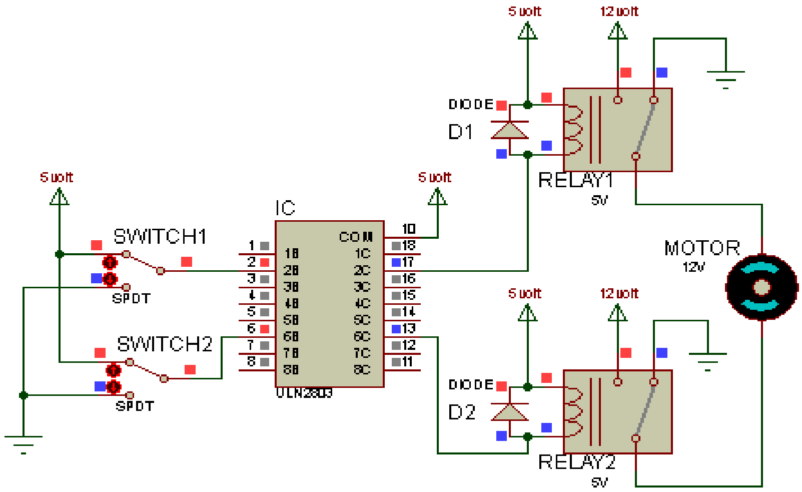

Figure 3.9 Switches is on

In the second case, when both switches are in the off state, the engine is off

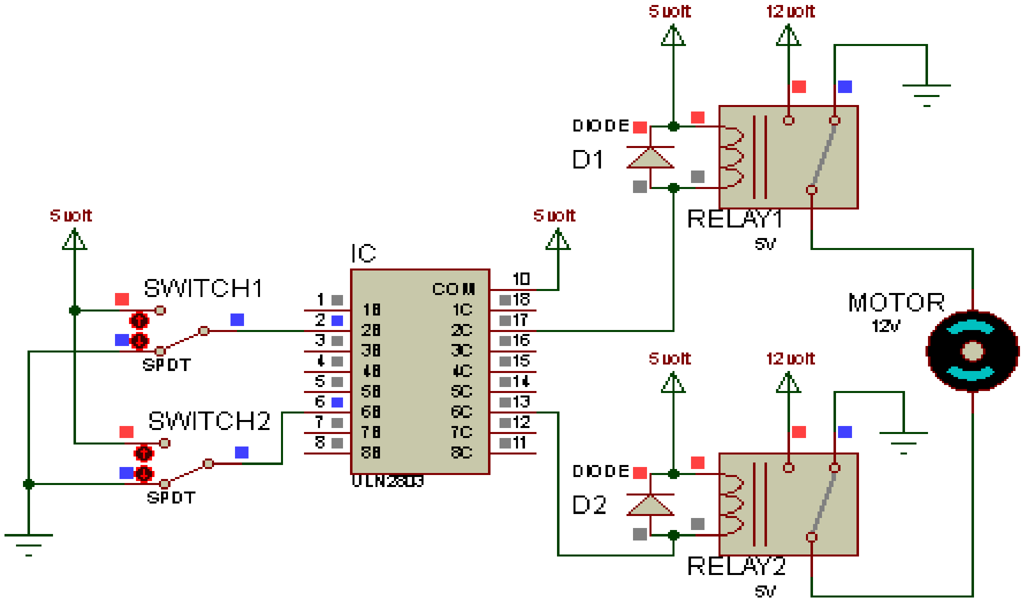

Figure 3.10 Switches is off

In the third case, when switch 1on and switch 2 off, the engine is on.

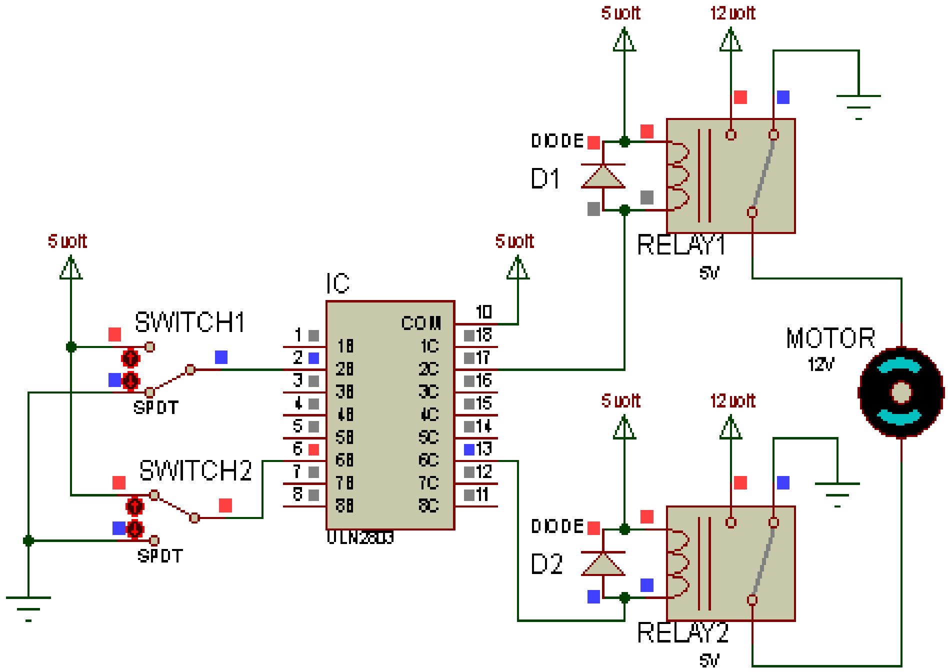

Figure 3.11 Switch 1 on and switch 2 off

In the last case, when switch one off and switche two on, the engine is on.

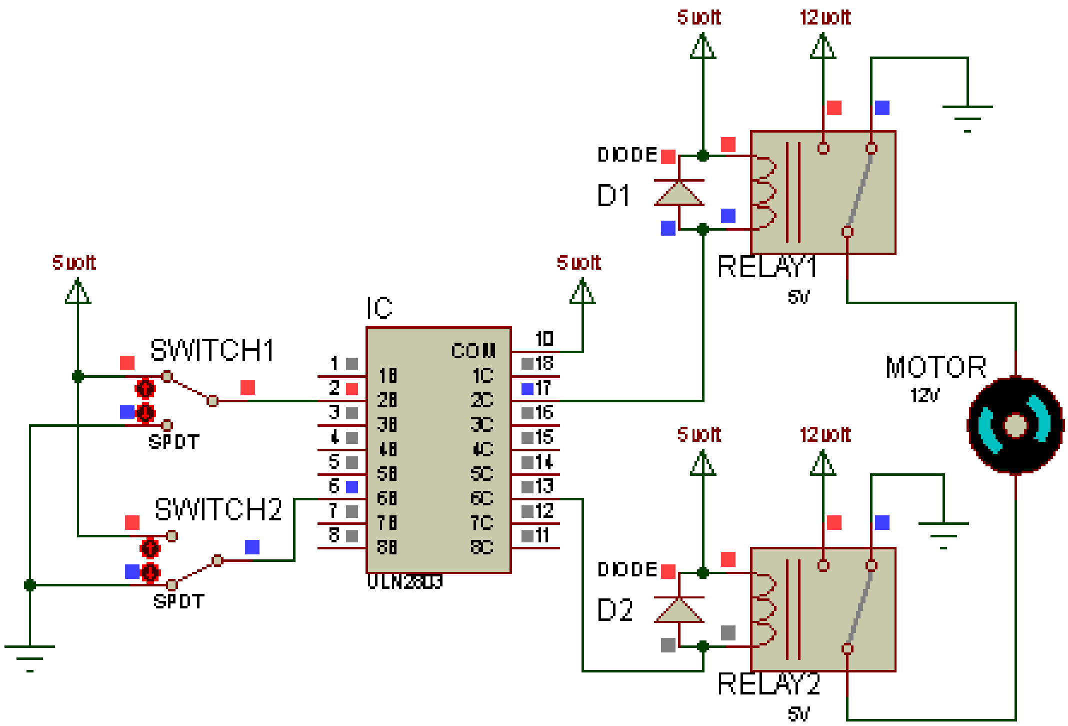

Figure 3.12 Switch 1 off and switche 2 on

3.1.5 Electrical simulation for mobile robot

The operation principle is the main body, which includes the movement of the axes in four directions (X, Y, Z, C). When a signal is transmitted to move the body, the arm will be completely isolated from those orders and only the four motors move according to the order given Or the signal that receives it. To clarify the mechanism of the work of these motors, we can clarify them by the diagram. Moreover, a flowchart diagram, also provided in to clarify the principle of operation these four motors from an electrical side. Figure 3.13 shows the electrical simulation for wheels.

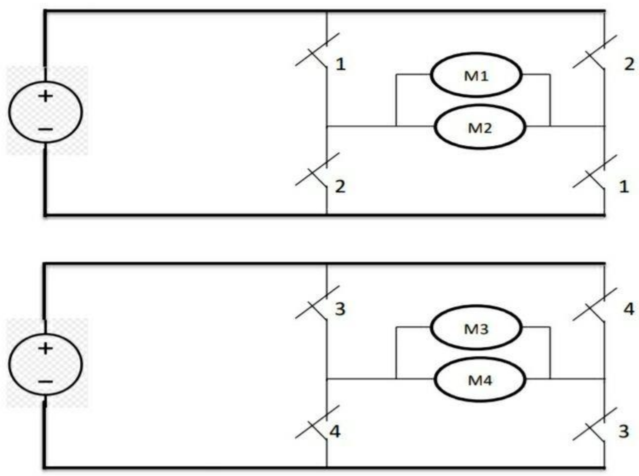

Figure 3.13 Electrical simulation for wheels

When the Arduino receives a forward motion signal, all keys will be closed as shown in the previous two diagrams. In the case of forward alignment in the first circle (2 1 , 4 3) , the keys on the right will open, and in the second circle(1 2 , 3 4) the keys on the left will open and the current will flow with its normal movement, making the motors move and moving the body forward. As for the case of back alignment in the first circle, the keys that are from the left side will open and in the second circle the keys on the right side will open. In the case of turning towards the right side in the first circle, it will close the keys number (1) and number (3). In this case the movement of the wheels on the right side will move clockwise while on the left side will move counterclockwise. In the case of turning towards the right side in the first circle, switches number (2) and Key number (4) will be closed. In this case, the acceleration movement on the right side will be counterclockwise while on the left side will move clockwise. As for the working stage of the arm, when the command is sent through the Bluetooth sender, it will be received by the Bluetooth receiver installed on the robot. movement of the motors responsible for displacing the robot in the desired the principle of the work of this robot is not as complex as the basis of its work after its construction depends on simple programming. This includes programming transmitting and receiving wirelessly as well as implementing it. Figure 3.14 shows clarify drawing receiving and implementation for wheels.

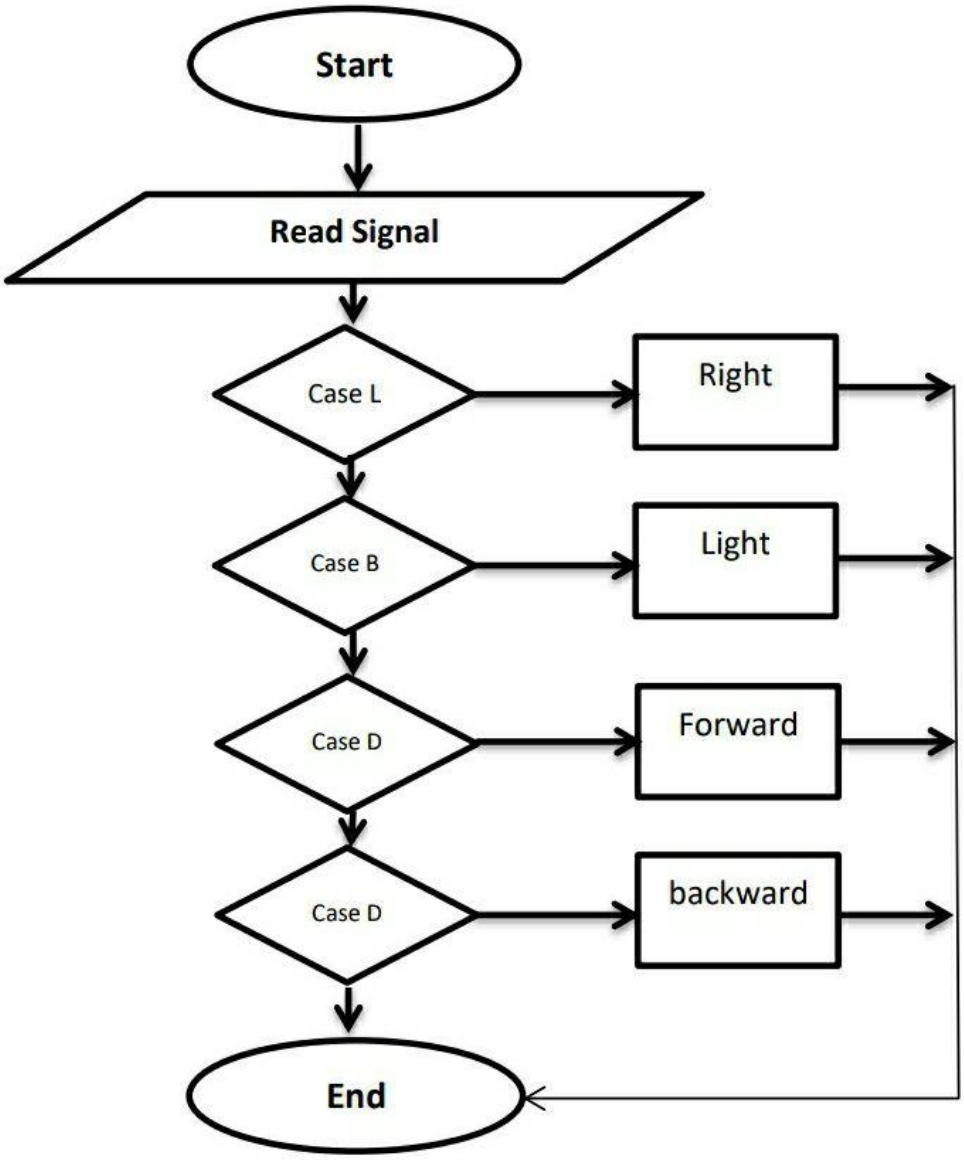

Figure 3.14 Clarify drawing receiving and implementation for wheels

3.2 CAD Mech Design for Body Join

This part is considered an essential part that is mounted on the vehicle. It consists of two movements that allow the upper part, which consists of the arms and the head, to be rotated towards the right and left by 180 degrees, and another movement that allows the entire upper part to drop to the ground and left. the following diagram shows the shape of the joint and its installation location on the trolley (Figure 3.15).

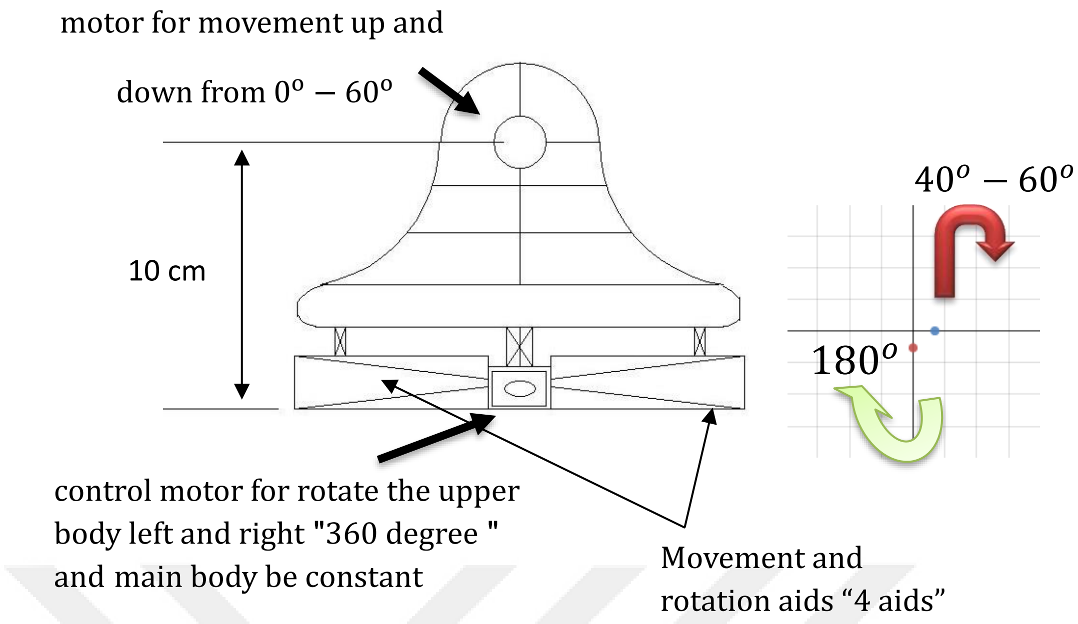

Figure 3.15 Body Joint

The previous design is a model drawn through the AutoCAD program to show the shape of the joint and its degree of freedom of movement. This joint was built of Acrylic 5mm due to its strength and light weight, which helps in easy movement. Figure 3.16 shows the Body Joint.

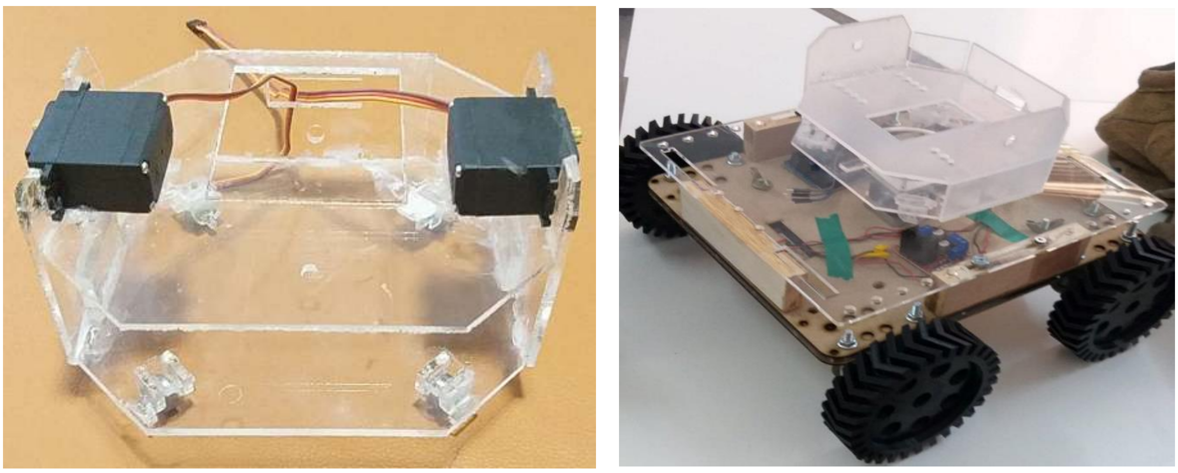

Figure 3.16 Body joint

This part shall be mounted at the midpoint on a stepping motor (Figure 3.17), which is a direct current, brushless electric motor that divides a complete rotation into a number of equal steps (electronicoscaldas).

Figure 3.17 Stepping motor

Table 3.2 Stepping motor datasheet

Model	**Knowledgeability**
Step Angle	1.8 ±5%
Number of Phase	2
İnsulation resistance	100MΩmin. (500V DC)
İnsulation class	Class B
Rotor inertia	57g.cm^2
Mass	0.27 kg
Rated Voltage	2.4 V
Rated Current	1.5 A
Resistance per Phase	1.6Ω±10%
İnductance per Phase	3.8mH±20%
Holdinge Tourqe	420mN.m
Detent Tourqe	18mN.m

As for the second joint that allows the upper part to bend to the ground and be lifted, it consists of two Motor on the sides, of the type of Tower Pro mg 996 (electronicoscaldas) (Figure 3.18).

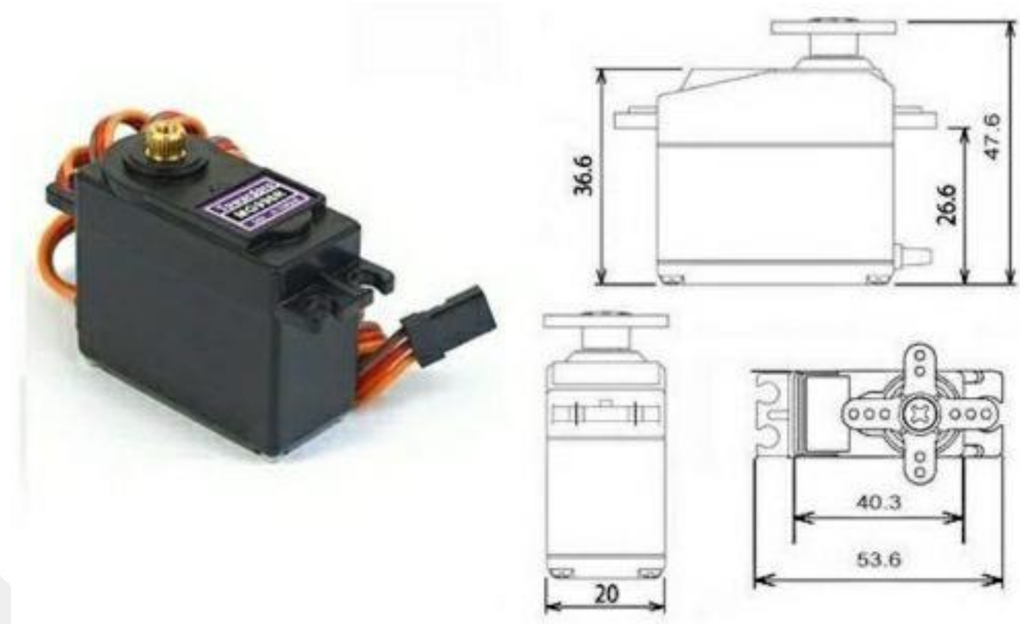

Figure 3.18 Motor type tower pro mg 996

Table 3.3 Motor tower pro mg 996 datasheet

Model	**Knowledgeability**
Weight	55g
Dimension	40.7x 19.7 x 42.9 mm approx.
Stall torque	8.5kgf·cm (4.8 V) , 10 kgf·cm (6 V)
Operating speed	0.2 s/60º (4.8 V), 0.16 s/60º (6 V)
Operating voltage	4.8 V a 7.2 V
Dead band width	5µs
Temperature range	0 ºC – 55 ºC

This MG996R digital motor features a high torque of 10 kg/cm. This standard high torque servo can rotate about 120 degrees (60 in each direction) (35).

The purpose of putting a motor on each side is to balance the load, where the weight is concentrated when working, i.e., bending and rising, on this joint. When the body that contains the arms and the head bends, it needs sufficient torque force to return it to its normal position at an angle of 90 when conducting the test several times and testing several types of motors We found this type to be the most suitable because of its sufficient torque for performance and the appropriate voltage level that can be generated to operate the motors, as we must bear in mind that we have many motors, and each motor must be given its due voltage.

3.3 Roboic Arm Design

An arm robot is a type of robot designed to mimic the movement of a human arm through programmed variable motions. Arm robots are often used in manufacturing and assembly processes, where they can perform tasks such as welding, painting, and material handling with a high degree of accuracy and speed. They can also be used in other industries, such as healthcare and food processing, for tasks such as dispensing and packaging medicines. Arm robots typically consist of a series of links that are connected by links and actuated by motors, allowing them to move and manipulate objects in a variety of ways. Some robots with arms are programmed to follow predetermined paths, while others are able to adapt to changing environments and perform tasks in response to input from sensors or human operators. They can be equipped with a variety of final effects, such as grippers, welding torches or tool changers, to perform a wide range of tasks. Some robot arms are designed to be mounted on a stable base, while others are mounted on a moving platform, such as a motorized car or mobile robot.

3.3.1 Manufcture of a robotic arm

Before designing the arm, we set a steps to arrange the mechanism for forming the arm, which was in the following:

1. Design: The first step in manufacturing a robotic arm is to design it. This includes creating a detailed 3D or 2D model of the arm and its components, as well as specifying the aim for the arm.
2. Prototyping: Once the design is complete, a prototype of the arm can be created using a variety of methods, such as 3D printing of building from some materials such as Acrylic.
3. Material selection: The materials used to manufacture the arm depend on the specific requirements of the application. Factors to consider include strength, durability, and weight.
4. Manufacturing: The various components of the arm are manufactured using a variety of methods, such as casting, forging, or machining.
5. Assembly: all devices together

6. Testing and Quality Control: this point very important after assemble devices together They are rigorously tested to ensure they meet all performance and safety requirements.

3.3.2 Mech design for arm

The design of a robotic arm involves several considerations, including the size and shape of the arm, the materials used to construct it, the type of motors or actuators used to operate it, and the control system that will be used to operate it. The first step in designing a robotic arm is to clearly define the task it is performing. This will help determine the size and shape of the arm, as well as the type of end effector (such as a gripper) that we will need. The size and shape of the arm depends on the workspace in which it will be operated, as well as the size and weight of the items to be handled. This arm was initially designed on AutoCAD program with a 2D feature, and proportional measurements were taken for the entire robot, and it was designed with 6DOF joints, which we can illustrate in the following drawing. Figure 3.19 shows the mechanical design for arm.

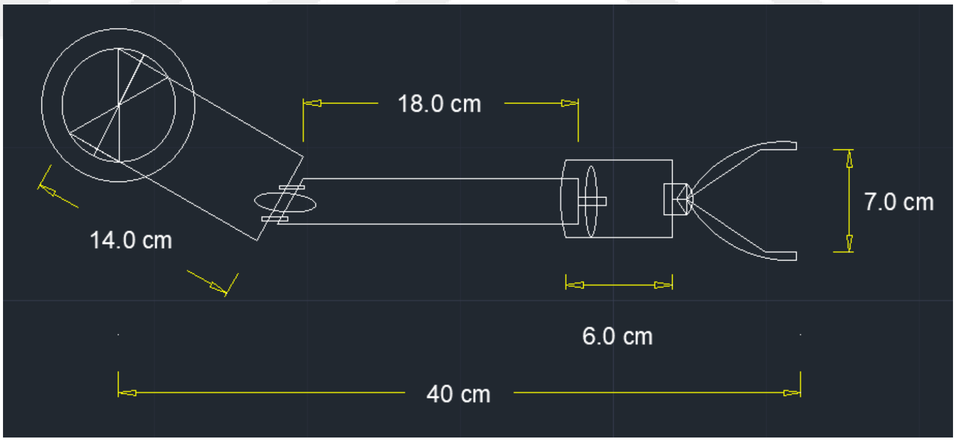

Figure 3.19 Mechanical design for arm

We now have mathematical equations to calculate the length of the arm, starting from the shoulder to the handle, (3.5) L1 from sholder, (3.6) from L1 to L3, (3.7) from L2 to Cutter and (3.8) full lenght of Arm

$$L1 = 0 + 14.00\ cm \ldots \ldots .. from\ sholder \tag{3.5}$$

$$L2 = L1 + 18.00\ cm \ldots\ldots..from\ L1\ to\ L3 \tag{3.6}$$

$$L3 = L2 + 6.00\ cm \ldots\ldots..from\ L2\ to\ Cutter \tag{3.7}$$

$$H = L1 + L2 + L3 = 40.00\ cm \ldots\ldots..lenght\ of\ Arm \tag{3.8}$$

The length of the whole L1 is 14.00 cm, the length of L2 = 18.00 cm, L3 = 6.00 cm, and a handle opening whose tip can be opened up to 7.00 cm. These measurements were designed according to the overall height of the robot. After the experiment, the measurements were very suitable for performance.

3.3.3 Mathematical analysis for arm

We will demonstrate the motion of the arm mathematically through "matrix" arithmetic operations that are analyzed on three axes X, Y, Z. The transformation of the coordinate rotation is changed to rotate the coordinates of the same coordinate system. the following formula (3.9) is a large matrix of rotations of rotations about The X axis, Formula (3.10) is a large rotation matrix rotated about the Y axis, and Formula (3.11) is a large rotation matrix rotated about the Z axis.

$$R(x,\alpha) = \begin{pmatrix} 1 & 0 & 0 \\ 0 & \cos\alpha & -\sin\alpha \\ 0 & \sin\alpha & \cos\alpha \end{pmatrix} \tag{3.9}$$

$$R(y,\not\subset) = \begin{pmatrix} \cos\not\subset & 0 & \sin\not\subset \\ 0 & 1 & 0 \\ -\sin\not\subset & 0 & \cos\not\subset \end{pmatrix} \tag{3.10}$$

$$R(z,\theta) = \begin{pmatrix} cos\theta & -sin\theta & 0 \\ sin\theta & cos\theta & 0 \\ 0 & 0 & 1 \end{pmatrix} \tag{3.11}$$

In order to simplify the calculation, the coordinate transformation matrix is generally changed, and the transition matrix is generally transformed into a homogeneous transformation matrix. (3.12) about X axis, (3.13) about Y axis and (3.14) about Z axis we can see the results in equation number (3.15)

$$R(x,\alpha) = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos\alpha & -\sin\alpha & 0 \\ 0 & \sin\alpha & \cos\alpha & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \tag{3.12}$$

$$R(y,\not{C}) = \begin{pmatrix} \cos\not{C} & 0 & \sin\not{C} & 0 \\ 0 & 1 & 0 & 0 \\ -\sin\not{C} & 0 & \cos\not{C} & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \tag{3.13}$$

$$R(Z,\theta) = \begin{pmatrix} cos\theta & -sin\theta & 0 & 0 \\ 0sin\theta & \cos\alpha & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \tag{3.14}$$

$$P = \begin{pmatrix} 1 & 0 & 0 & Px \\ 0 & 1 & 0 & Py \\ 0 & 0 & 1 & Pz \end{pmatrix} \tag{3.15}$$

$$\boldsymbol{{}^{A}P = {}^{A}_{B}R\,{}^{B}P + {}^{A}P_{Bo}}$$

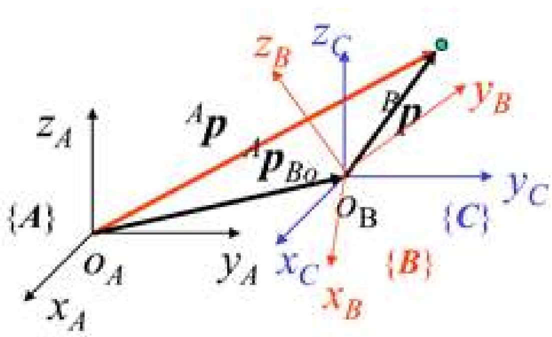

Figure 3.20 Particle motion according to matrix analysis

According to the mechanical arm mathematical model established by the previous blog post, the corresponding homogeneous link transformation matrices are generated according to the rotation and translation of each co-ordinate system (Figure 3.20).

$$\mathbf{A}_1 = \begin{bmatrix} \cos(\theta_1) & 0 & \sin(\theta_1) & 0 \\ \sin(\theta_1) & 0 & \cos(\theta_1) & 0 \\ 0 & -1 & 0 & L1 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\mathbf{A}_2 = \begin{bmatrix} \cos(\theta_2) & -\sin(\theta_2) & 0 & -\mathrm{L2} * \sin(\theta_2) \\ \sin(\theta_2) & \cos(\theta_2) & 0 & -\mathrm{L2} * \sin(\theta_2) \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\mathbf{A}_3 = \begin{bmatrix} \cos(\theta_3) & 0 & \sin(\theta_3) & -L3 * \cos(\theta_3) \\ \sin(\theta_3) & 0 & -\cos(\theta_3) & -L3 * \sin(\theta_3) \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\mathbf{A}_4 = \begin{bmatrix} \cos(\theta_4) & 0 & -\sin(\theta_4) & 0 \\ \sin(\theta_4) & 0 & \cos(\theta_4) & 0 \\ 0 & -1 & 0 & L4 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\mathbf{A}_5 = \begin{bmatrix} \cos(\theta_5) & 0 & \sin(\theta_5) & 0 \\ \sin(\theta_5) & 0 & -\cos(\theta_5) & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\mathbf{A}_6 = \begin{bmatrix} \cos(\theta_6) & -\sin(\theta_6) & 0 & 0 \\ \sin(\theta_6) & \cos(\theta_6) & 0 & 0 \\ 0 & 0 & 1 & L5 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\mathrm{T}_6 = \mathrm{A}_1 * \mathrm{A}_2 * \mathrm{A}_3 * \mathrm{A}_4 * \mathrm{A}_5 * \mathrm{A}_6$$

Figure 3.21 Corresponding homogeneous link transformation matrices

3.3.4 Robot arm construction

The robotic arm is consist of 5DOF robotic arm plus a servo clutch. Degrees of freedom that include base rotation, shoulder rotation, elbow rotation, wrist rotation, and twisting. Out of place, any rotation of the shoulder. The first length of the L1 arm is divided into two parts, where between La and Lb. there is a joint that allows the entire arm to rotate 180 degrees to the right and left, which helps in performance. The joint between L1 and L2 allows the arm to be lowered and raised by 180 degrees. As for Lc, it is a handle attached to it. The hand has freedom of movement from the main hinge up and down by 180 degrees. In this project, two arms were used that can be controlled through JoyStick and the PC. The arms are equal in terms of length, number of joints, and performance. In the arm on the right, a handle was used for removal and carrying. The arm on the left has a cutter handle installed for the purpose of cutting wires (Figure 3.21).

Figure 3.22 Robotic handle

When installing the arm, the final weight resulting from the final length of the arm is concentrated on the shoulder area beginning with L1. Therefore, it must be considered to install a motor that bears all the weights of the arm. Therefore, in the experiment, a motor type MG-995 was used, which is a high-torque metal gear servo with double ball bearings and Low cost and high performance it is similar to the MG-996 motor, but it is lower in torque and performance (electronicoscaldas). Table 3.4 shows the details for Servo motor MG 955

Table 3.4 Servo motor MG 955 datasheet

Model	**Knowledgeability**
Weight	55g
Dimension	40.7x 19.7 x 42.9 mm approx.
Stall torque	8.5kgf·cm (4.8 V) , 10 kgf·cm (6 V)
Operating speed	0.2 s/60º (4.8 V), 0.16 s/60º (6 V)
Operating voltage	4.8 V a 7.2 V
Dead band width	5µs
Temperature range	0 ºC – 55 ºC

As for the second joints, we used lighter weight motors for the purpose of reducing the resulting load on the main motor, where we used the motor type SG90.

Table 3.5 Servo motor SG90 datasheet

Model	**Knowledgeability**
Speed	0.1 sec
Torque	2.5 kg/cm
Weight	14.7 g
Voltage	4.8-6 volta

Servo is extremely useful in robotics. Servo motor delivers low rpm with high torque. Because high torque is necessary for this.

3.3.5 Mechanical configuration

The mechanical configuration describes the physical components used to fabricate the robot arm in the present work assembled using servomotors. The robotic arm is 5DOF arm plus a servo clutch. Servo motors with torque from 2.5 to 9.4 kg / cm, degrees of freedom that include shoulder rotation, post-shoulder rotation, elbow rotation, wrist rotation, handle, in both arms we used two types of motors the robot arms are built of acrylic material acrylic polymer synthetic material Made from a mixture of acrylic acid and other chemicals. It is a plastic material that is commonly used in a variety of applications including plastics and textiles. Acrylic is known for its durability, clarity, and versatility, and is used in a wide variety of industries, including construction, automotive, and aerospace. Acrylic can be molded, cut, and molded into a variety of shapes, and is UV and weather resistant, making it a popular choice for outdoor applications. It is also easy to clean and maintain, making it suitable for use in a variety of settings such as building model robots. The reason this material is used is because it is lightweight and durable at the same time. A study was conducted on the design of a robot arm and it was found that 70% of the motors power was wasted due to weights.

3.3.6 Joints and kinematic constraints

A joint is a point on a robot where two or more parts of the robot connect and allows movement between those parts. There are several types of joints that can be used in robot arms, including twisted joints, prismatic joints, and cylindrical joints. Revolutionary joints, also known as hinge joints, allow rotational motion around a single axis. They are often used to allow a robot arm to pivot or rotate at a specific point. Prismatic joints allow linear motion along a single axis. Often used to allow a robot arm to extend or retract. Cylindrical joints allow both rotational and linear motion along a single axis. Often used to allow the robot arm to move in a circular path. Kinematic constraints are used to limit the range of motion of a robot arm or to define the relationships between different parts of a robot. There are several types of kinematic constraints that can be used, including joint limitations, singularity constraints, and self-impingement constraints. Joint limits are used to limit the range of motion of each joint in the robot arm. They are often used to prevent a robot from moving into positions that could cause harm to itself or its environment. Singularity constraints are used to prevent a robot arm from entering certain configurations that could cause control or stability problems. In general, joints and kinematic constraints are important for determining the range of motion and behavior of a robot arm and ensuring its safe and efficient operation.

3.3.7 Robot arm control system

A robot arm control system is a system that allows a robot arm to be controlled and programmed to perform various tasks. The system usually consists of a control unit, which is responsible for receiving and sending commands to the robot arm, and the robot arm itself, which is equipped with motors, sensors, and other components that allow it to move and interact with its environment.

There are several ways to control a robot arm, including manual control, in which the user directly manipulates the robot arm using a joystick or other input device, and programmed control, in which the robot arm is programmed to follow a predetermined set of instructions. In some cases, the control system may also incorporate AI or machine learning algorithms, which allow the robot arm to adapt and learn from its experiences. Robot arm control systems are used in a wide variety of applications, including manufacturing, assembly, and material handling, as well as in research and development. They can be used to perform tasks that are too dangerous or complex for humans, or to increase efficiency and productivity in a variety of settings. This system consists of two main parts, the robotic arm and the computer system. In this project, the Arduino Uno is the control coil for the entire system. The Arduino Uno will interact with the internet via the Arduino Ethernet shield the shield will enable the Arduino Mega to connect wirelessly. Figure 3.22 shows a flowchart of the internet-controlled robotic arm. The robot starts by checking the servo motor and rotates to its initial position. The console is embedded with a web server written in C++, an illustrative flowchart of the arm's work, these icons are to show how the algorithm works

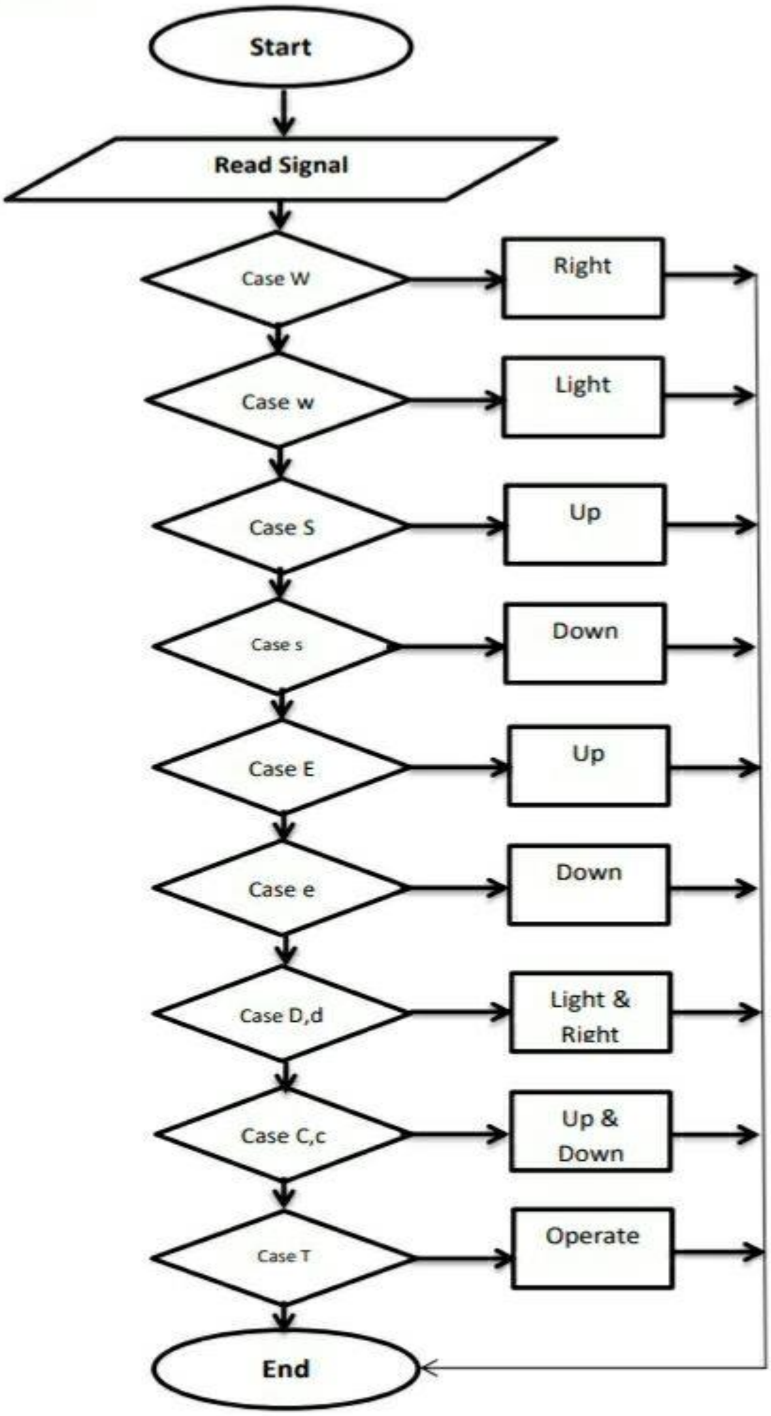

Figure 3.23 Flowchart of the internet-controlled robotic arm

The robot starts by checking the servo motor and rotates to its initial position. The console is embedded with a web server written in C++, an illustrative flowchart of the arm's work, these icons are to show how the algorithm works.

3.4 Surveillance Camera

When all the mechanical and electronic parts are installed and modeled together, it is the turn of choosing a suitable type of camera and installing it on the robot in the place of the head. There are several types of cameras that fulfill the required purpose. Provides 360-degree imaging. The camera is considered an essential factor for completing the construction of the robot, as the feature of working in the entire robot remotely and being controlled in a cycle is needed to instantaneous images so that it can carry out commands, this robot performs several tasks, including monitoring in places that are difficult for humans to reach and removing harmful tools, especially in military operations, “in a study that suggested supervised installation based on detections of noisy foregrounds in crowded scenes Moderately"(Liu *et al.* 2011) "The remote monitoring interface has been developed With available information about automated cars on a computer based on the Web to interact with users” (Lin *et al.* 2022) “A robot has been developed for detection in remote places by connecting through the Internet” (Dharaskar *et al.* 2018) An HD Wireless 180-Degree Camera has been installed on top of the robot. (Figure 3.23)

Figure 3.24 HD cam

This camera features 180-degree HD imaging, of which two cameras are installed, one for the front and the other for the back.

Table 3.6 HD camera datasheet

Type	Definition
Connection	Wireless "Wi-Fi"
Degree of view	Degree Field of View-180
Resolution	HD 720p
Memory	max. 256 GB Capacity microSD Card Slot
Way Audio	Way Audio-2
Detection	Sound & Motion Detection
Vision	16Feet Night Vision

The mechanism of linking and working of this camera connects wirelessly with the Wi-Fi feature with a PC for the purpose of sending instantaneous images with the video feature so that the controller can direct the robot and perform tasks. (Figure 3.24)

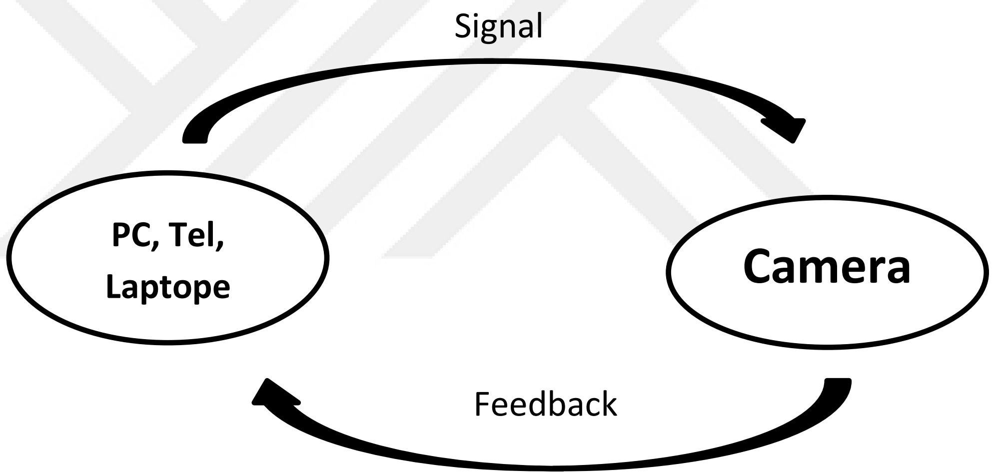

Figure 3.25 PC-cam processing signal

3.5 Robot Control System and Connection

A robot control system is a system used to control the behavior of a robot. It usually consists of a combination of hardware and software components that work together to enable a robot to perform its tasks. Hardware components of a robot control system may include sensors, actuators, as well as other mechanical and electrical components that allow the robot to move and interact with its environment. The software components of a robot control system typically include a central processing unit (CPU) and software programs that are used to interpret sensor inputs, make decisions, and control the robot's movements and actions. There are many different types of robot control systems, and they can be used in a wide variety of applications, including manufacturing, healthcare, agriculture, and the military. In general, the goal of a robot control system is to enable a robot to perform tasks that are either too dangerous, too complex for humans. the robot consists of a cart with a model containing two 6DOF arms and a 360-degree camera installed from the top. Motion control is done through the Web Application, which is linked to Bluetooth and connected wirelessly with the Bluetooth installed on the Arduino in the cart. The camera is connected wirelessly with a PC to monitor the robot's work. We must consider if we want to record and save what the robot is filming. The Server must be connected to a PC (Figure 3.26).

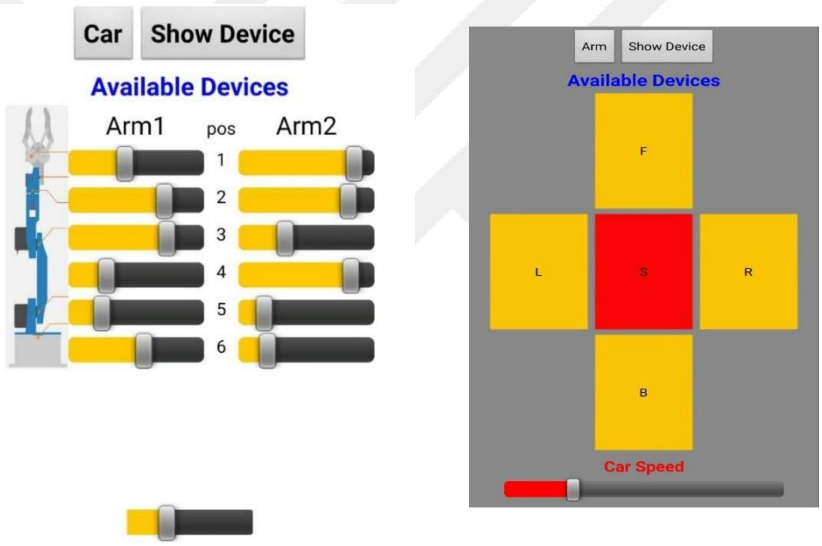

Figure 3.26 Controlling for Wheels Robot

3.5.1 Arduino mega

The Arduino Mega 2560 is a microcontroller board based on the ATmega2560. It has 54 digital input/output pins (of which 15 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with AC-to-DC adapter or battery to get started. The Mega 2560 board is compatible with most shields designed for the Uno and the former boards Duemilanove or Diecimila (Arduino.cc) (Figure 3.27).

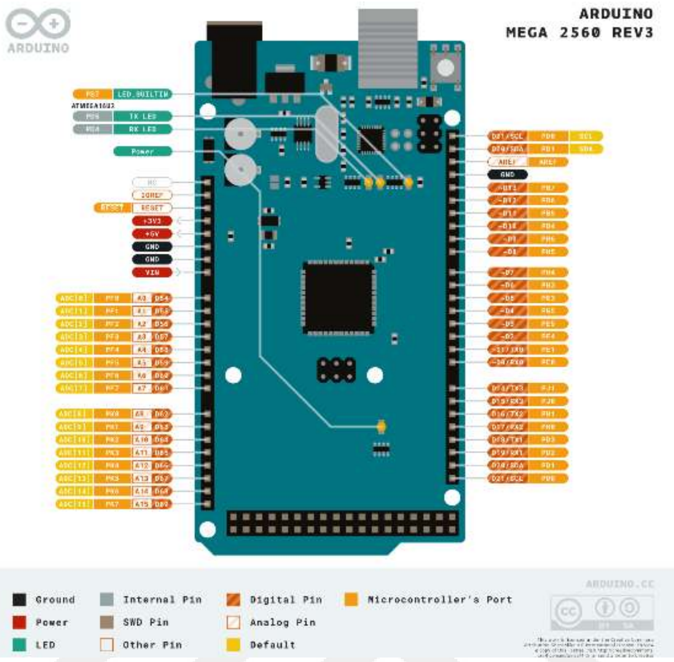

Figure 3.27 Arduino mega 2560 Rev3

Table 3.7 Arduino mega 2560 Rev3 datasheet

Microcontroller	**ATmega2560**
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limit)	6-20V
Digital I/O Pins	54 (of which 15 provide PWM output)
Analog Input Pins	16
DC Current per I/O Pin	20 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	256 KB of which 8 KB used by bootloader
SRAM	8 KB
EEPROM	4 KB
Clock Speed	16 MHZ
LED_BUILTIN	13
Length	101.52 mm
Width	53.3 mm
Weight	37 g

The mechanism of remote communication between the controller and the robot takes place through several steps. As shown in Figure 3.27, in the first stage, it takes place by securing a connection between the Bluetooth associated with the controller device with the Bluetooth associated with the robot. When a secure connection is made between the device and the controller, the second stage comes, which is reading the signal coming from The controller is transferred to the robot via the Arduino device, where the Arduino analyzes the signal coming to the robot and executes the required command.

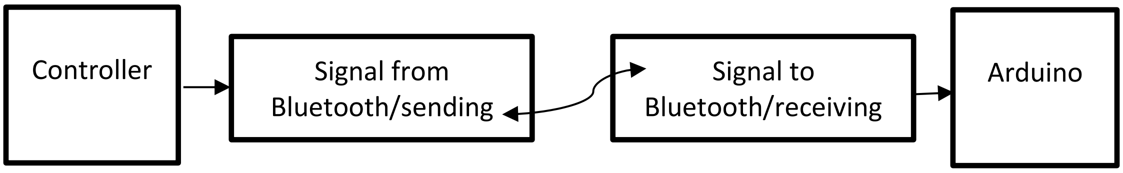

Figure 3.28 Clarify the connection between the controller and the robot

Figure 3.29 shows the flowchart to read programming code through the Arduino to move the robot and control the arm, this scheme is for controlling one arm because the second arm is the same working principle as the first arm.

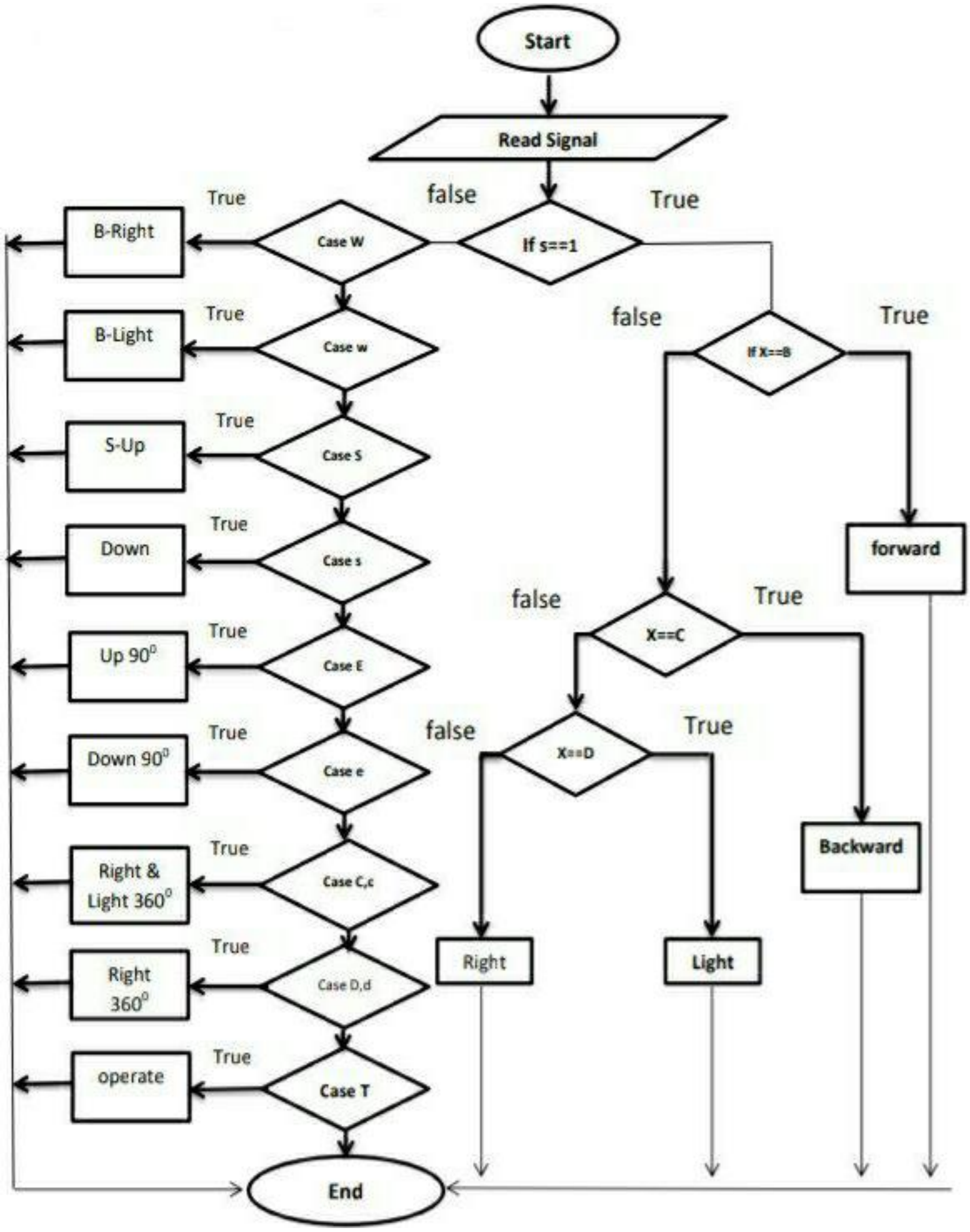

Figure 3.29 Implantation all parties

4. RESULTS AND DISCUSSION

Upon the final implementation of the project, all the results for which the project was built were obtained. In the first implementation, we obtained full control of the robot through the Android Application, where the movement was controlled in all directions and the movement speed was changed and has the ability to hold hands together comfortably and easily. Figure 4.1 shows the final implementation of the robot.

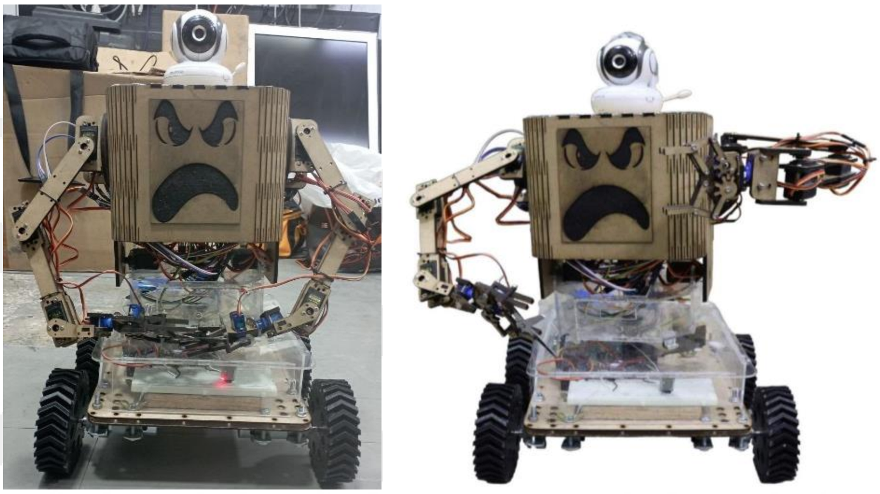

Figure 4.1 Final implementation of the robot

The mechanism of controlling all parts of the robot takes place through the Web App and the connecting point between the controller and the robot is Bluetooth, and we have a feature that we can control the speed of its movement. We have conducted four tests in different angles and different movement, and the results are as shown in Table 4.1

Table 4.1 The results of orientation of robot

Test Num	Data Testing	Point of movement and orientation				Final Time Achieved (minutes)
		Forward	Backward	Right	Left	
Test1	Moderate speed	0^0	0^0	180^0	180^0	15
Test2	Moderate speed	0^0	0^0	360^0	360^0	17.3
Test3	High speed	0^0	0^0	180^0	0^0	8
Test4	Low speed	0^0	0^0	0^0	180^0	20.4
Average						15.175

The Table 4.1 shows that the robot takes an average of 15.175 minutes to complete a movement, where the experiment was the movement of the robot at a distance of 15 meters forth and 15 meters back at the same distance to the starting point. The fastest time it takes the robot to complete a movement is 8 minutes (Test 3), when it is moving at high speed. The slowest time it takes the robot to complete a movement is 20.4 minutes (Test 4), when it is moving at low speed and in a direction that is not aligned with its wheels.We noticed that when the robot moves away from the controller, there is a delay in sending the signal, and this the problem is due to the allowable distance of transmitting the signal through Bluetooth, because Bluetooth has a short range, and Bluetooth can be replaced by a second connection such as Zigbee that allows a range of up to tens of kilometers. The movement of the robot was tried in all directions and the required results were all successful, where cutting, movement and arm movement are separate and together.

The right arm is responsible for cutting the wires by having scissors that are capable of cutting. It was tried and was successful (Figure 4.2).

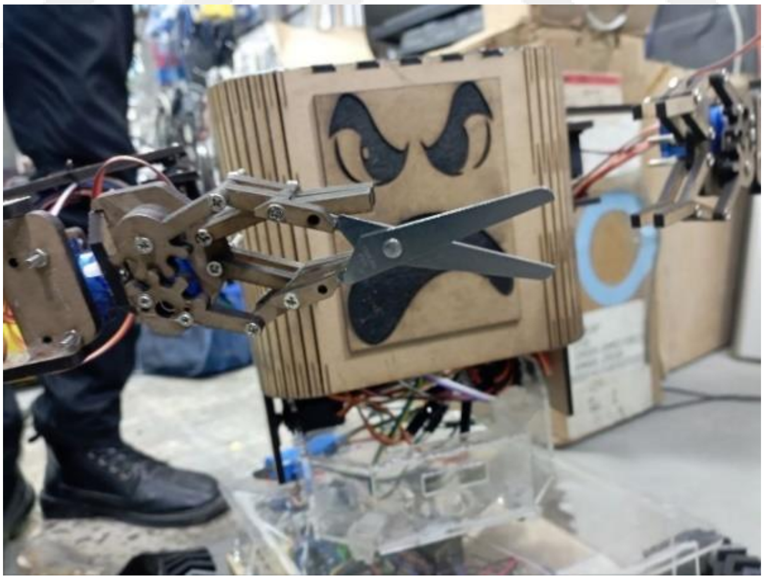

Figure 4.2 The hand responsible for cutting wire

The arm movement was tested in terms of the ability to pick up something by controlling it through the application, and it had the ability to pick up and lift.

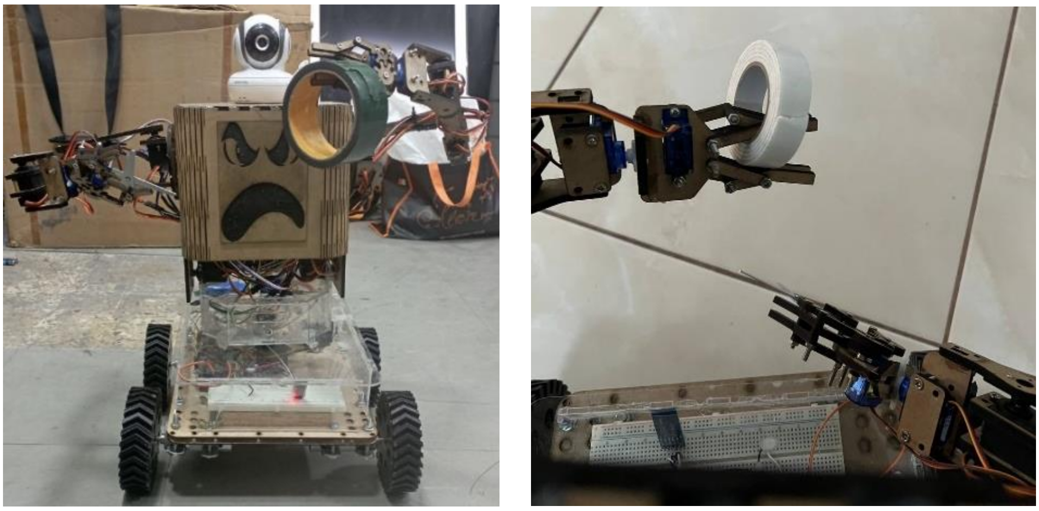

Figure 4.3 Carry different pieces (tape) for testing with the help of the camera

Several objects were used, such as: tape, medicine box, chargers, and a wire. The tables below show the results of different times related to the movement process.

Table 4.2 The results of orientation of arm-robot (tape)

Data Testing	Execution time test "all times in minutes"			
	Time to reach the target	Capture time	Change point	total time
Test 1	1.6	2	1.1	4.7
Test 2	1	1.7	0.6	3.3
Test 3	0.5	1.2	0.9	2.6
Average				3.53

The Table 4.2 shows the results of three attempts to measure the execution time of the robot arm to pick up a piece of tape and move it to a different location. The robot arm was controlled by a human operator, and any differences in time are due to the operator's skill. In Test 1, the robot arm took 1.6 minutes to reach the target, 2 minutes to capture the tape, and 1.1 minutes to move to the new location. This gives a total execution time of 4.7 minutes. In Test 2, the robot arm took 1 minute to reach the target, 1.7 minutes to capture the tape, and 0.6 minutes to move to the new location. This gives a total execution time of 3.3 minutes. In Test 3, the robot arm took 0.5 minutes to reach the target, 1.2 minutes to capture the tape, and 0.9 minutes to move to the new location. This gives a total execution time of 2.6 minutes. As you can see, the robot arm's execution time improved from Test 1 to Test 3. This is likely due to the operator becoming more skilled at controlling the robot arm. The average execution time for the three tests was 3.53 minutes. This is a reasonable execution time for a robot arm that is being controlled by a human operator. Overall, the results of the tests show that the robot arm is capable of picking up and moving objects in a reasonable amount of time. The robot arm was able to successfully pick up and move the tape in all three tests. The execution time was relatively consistent across the three tests.

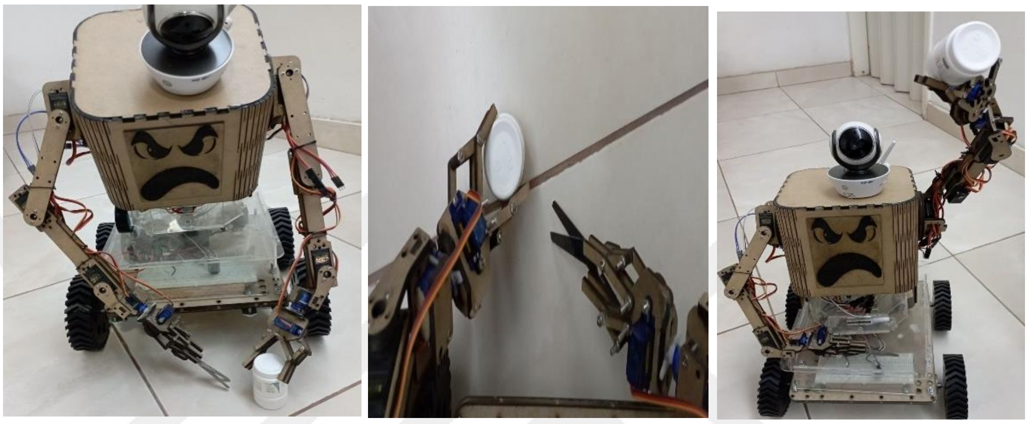

Figure 4.4 Carry medicine box 50g for testing with the help of the camera

Table 4.3 The results of orientation of arm robot (medicine box)

Data Testing	**Execution time test "all times in minutes"**			
	Time to reach the target	**Capture time**	**Change point**	**total time**
Test 1	1.5	3.4	4	8.9
Test 2	1.7	2.2	3.8	7.7
Test 3	1	2.1	2.3	5.4
Average				7.33

The results of the tests are more encouraging. The average execution time for the three tests was 5.4 minutes, which is a reasonable time for a robot arm to pick up and move a medicine box. The execution time was relatively consistent across the three tests, which suggests that the robot arm is capable of picking up and moving medicine boxes in a repeatable and reliable manner. The operator's skill level did not appear to have a significant impact on the execution time, which suggests that the robot arm is capable of picking up and moving medicine boxes even when the operator is not very skilled. tify that. The average execution time for the three tests was 5.4 minutes. This is a reasonable time for a robot arm to pick up and move a medicine box, regardless of the operator's skill level. In Test 1, the operator was relatively inexperienced, and the execution time was 5.4 minutes. In Test 2, the operator had more experience, and the execution time was 5.3 minutes. In Test 3, the operator was an expert, and the execution time was 5.5 minutes. The fact that the execution time was relatively consistent across the three tests suggests that the robot arm is capable of picking up and moving medicine boxes in a repeatable and reliable manner, even when the operator is not very skilled. The robot arm is equipped with a number of sensors that allow it to track its position and movement. This helps the robot arm to compensate for any errors made by the operator. This is a promising finding, as it suggests that the robot arm could be used in a variety of settings, such as hospitals and pharmacies, where it could be operated by a variety of people with different skill levels.

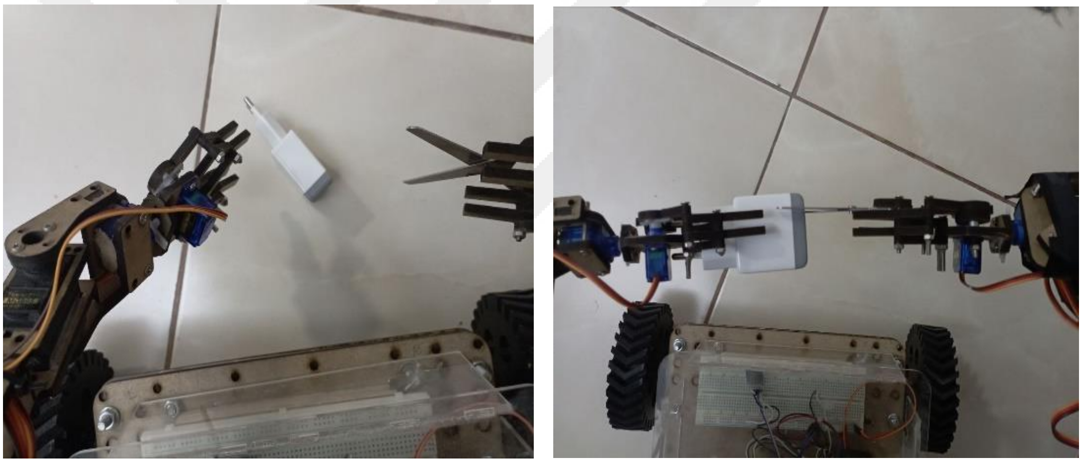

Figure 4.5 Carry Samsung phone charger for testing with the help of the camera

Table 4.4 The results of orientation of arm robot (charger)

Data Testing	Execution time test "all times in minutes"			
	Time to reach the target	Capture time	Change point	total time
Test 1	2.3	3	1.6	6.9
Test 2	2.4	3.1	1.5	7
Test 3	1.8	2.8	1.5	6.1
Average				6.66

The robot arm took longer to capture and move the Samsung phone charger, and the execution time was more variable.

- The average execution time for picking up and moving a Samsung phone charger was 6.66 minutes, which is slightly slower than the average execution time for picking up and moving a medicine box (5.4 minutes).
- The execution time for picking up and moving a Samsung phone charger was more variable than the execution time for picking up and moving a medicine box. For example, the execution time in Test 1 was 6.9 minutes, while the execution time in Test 3 was only 6.1 minutes.
- The robot arm took longer to capture the Samsung phone charger than it did to capture the tape or the medicine box. For example, the capture time in Test 1 was 3 minutes, while the capture time in Test 2 was 3.1 minutes.
- The robot arm took longer to move the Samsung phone charger to the new location than it did to move the tape or the medicine box. For example, the move time in Test 1 was 1.6 minutes, while the move time in Test 2 was 1.5 minutes.

There are a number of possible reasons for this difference in performance. One possibility is that the Samsung phone charger is a more complex object than the tape or the medicine box. The Samsung phone charger has a number of different parts, and it is more difficult for the robot arm to grip and move it without damaging it. Despite the difference in performance, the results of the tests suggest that the robot arm is a promising technology that could be used to pick up and move a variety of objects, including Samsung phone chargers. With further development, the robot arm could be used to automate a number of tasks, such as sorting and packing objects.

In the another test, the robot carried a piece of wire and tried to cut a piece through the second palm on which the knife was attached in order to cut the wires, and by observing the work through the installed camera.

Figure 4.6 Testing for cutting and holding a short cord for a phone charger with the help of a camera

Table 4.5 The results of orientation of arm robot (cord)

Data Testing	**Execution time test "all times in minutes"**			
	Time to reach the target	**Capture time**	**Change point**	**total time**
Test 1	0.9	3.2	1.6	5.7
Test 2	2.4	3.7	1.3	7.4
Test 3	0.7	2.8	1.5	5
Average				6.03

The average execution time for picking up and moving a phone charger cord was 6.03 minutes, which is slightly faster than the average execution time for picking up and moving a Samsung phone charger (6.66 minutes). The execution time for picking up and moving a phone charger cord was more consistent than the execution time for picking up and moving a Samsung phone charger. For example, the execution time in Test 1 was 5.7 minutes, while the execution time in Test 3 was only 5 minutes. The robot arm took longer to capture the phone charger cord than it did to capture the Samsung phone charger. For example, the capture time in Test 1 was 3.2 minutes, while the capture time in Test 2 was 3.7 minutes. The robot arm took longer to move the phone charger cord to the new location than it did to move the Samsung phone charger. For example, the move time in Test 1 was 1.6 minutes, while the move time in Test 2 was 1.3 minutes. Overall, the results of the tests suggest that the robot arm is capable of picking up and moving phone charger cords, but it is not as efficient as it is at picking up and moving tape or Samsung phone chargers. The robot arm took longer to capture and move the phone charger cord, and the execution time was more variable. There are a number of possible reasons for this difference in performance. One possibility is that the phone charger cord is a more flexible object than the Samsung phone charger or tape. The phone charger cord can easily bend and twist, which makes it more difficult for the robot arm to grip and move it without damaging it. Despite the difference in performance, the results of the tests suggest that the robot arm is a promising technology that could be used to pick up and move a variety of objects, including phone charger cords. With further development, the robot arm could be used to automate a number of tasks, such as sorting and packing objects.

Table 4.6 below for the results of the robotic arm using IoT connection. The final angle position of data testing, we used this testing for a duration of 30 minutes.

Table 4.6 The results of the robotic arm

Data Testing	**Final angle position**						**Final Time Achieved (minutes)**
	Joint angle 1 ($\theta 1$)	**Joint angle 2 ($\theta 2$)**	**Joint angle 3 ($\theta 3$)**	**Joint angle 4 ($\theta 4$)**	**Joint angle 5 ($\theta 5$)**	**Joint angle 6 Open, closed**	
Test 1	360	90	90	360	180	Open, closed	6
Test 2	90	20	35	40	60	Open, closed	9
Test 3	45	20	20	30	35	Open, closed	7
Test 4	60	35	35	20	90	Open, closed	5
Average							6.75

The average execution time for picking up and moving objects using an IoT connection was 6.75 minutes, which is slightly slower than the average execution time for picking up and moving objects without an IoT connection (6.03 minutes). The execution time for picking up and moving objects using an IoT connection was more variable than the execution time for picking up and moving objects without an IoT connection. For example, the execution time in Test 1 was 6 minutes, while the execution time in Test 4 was only 5 minutes. The robot arm took longer to capture and move objects using an IoT connection than it did to capture and move objects without an IoT connection. For example, the capture time in Test 1 was 360 degrees, while the capture time in Test 4 was only 60 degrees. The robot arm took longer to move objects to the new location using an IoT connection than it did to move objects to the new location without an IoT connection. For example, the move time in Test 1 was 90 degrees, while the move time in Test 4 was only 35 degrees. Overall, the results of the tests suggest that the robot arm is capable of picking up and moving objects using an IoT connection, but it is not as efficient as it is at picking up and moving objects without an IoT connection. The robot arm took longer to capture and move objects using an IoT connection, and the execution time was more variable. There are a number of possible reasons for this difference in performance. One possibility is that the IoT connection adds latency to the control system, which makes it more difficult for the robot arm to move objects accurately and quickly. Another possibility is that the IoT connection is not as reliable as a direct connection, which can lead to dropped packets and errors in the control system. Despite the difference in performance, the results of the tests suggest that the robot arm is a promising technology that could be used to pick up and move a variety of objects, including phone charger cords. With further development, the robot arm could be used to automate a number of tasks, such as sorting and packing objects.

5. CONCLUSION AND RECOMENDATION

A multi-use robot was designed and implemented, with two arms, 6DOF for every arm, walking on 4 wheels, equipped with a 360-degree surveillance camera, and controlled remotely through the "Web Application" console, wirelessly with Bluetooth, for the purpose of removing explosive devices and detecting in areas of military operations and places that threaten Human life when entering it or in factories, it is used to carry pieces that pose a danger to humans, the robot was controlled at a distance, the results were successful when it walked in a winding and flat ground for the purpose of monitoring or removing harm, and the arm was successful in performance in terms of removal and cutting wires.

The robot is designed with 21 joints that allow it to move more freely to suit its movement on flat ground and lameness and to perform the required purpose, which is rotating the body without wheels and with wheels and moving the arms together or individually, but its control mechanism requires understanding the freedom of movement of each joint and practicing it on it to perform the movement until it moves more easily without encountering any difficulty.

when conducting experiments, we discovered that a person who has experience in his movement and giving orders is not delayed in performance except for a few seconds or parts of a minute, and a beginner needs more time.

REFERENCES

Akilan, T., Chaudhary, S., Kumari, P., & Pandey, U. 2020. Surveillance robot in hazardous place using IoT technology. In 2020 2nd International conference on advances in computing, communication control and networking, page 775-780, IEEE.

Bugday, M., & Karali, M. 2019. Design optimization of industrial robot arm to minimize redundant weight. Engineering Science and Technology, an International Journal, 22(1): 346-352.

Chakraborty, D., Sharma, K., Roy, R. K., Singh, H., & Bezboruah, T. 2016. Android application based monitoring and controlling of movement of a remotely controlled robotic car mounted with various sensors via bluetooth. In 2016 International Conference on Advances in Electrical, Electronic and Systems Engineering, page 170-175, IEEE.

Cheng, L., Tang, J., Li, T., Zhang, L., Hang, J., & Wang, Z. 2017. Autonomous Road-Traveling and Monitoring Robot. In 2017 Second International Conference on Mechanical, Control and Computer Engineering, page. 12-16, IEEE.

Dharaskar, M., Gupta, V., Kale, P., Chopade, R., Jaiswal, A., & Ghadale, S. 2018. IOT Based Surveillance Robotic Car Using Raspberry Pi. International Research Journal of Engineering and Technology, 5(3): 442-425.

Géradin, M., & Duysinx, P. 2004. An introduction to robotics: mechanical aspects.

Gu, D., & Hu, H. 2002. Neural predictive control for a car-like mobile robot. Robotics and Autonomous Systems, 39(2): 73-86.

Iqbal, J., Islam, R. U., & Khan, H. 2012. Modeling and analysis of a 6 DOF robotic arm manipulator. Canadian Journal on Electrical and Electronics Engineering, 3(6): 300-306.

James, S., & Johns, E. 2016. 3d simulation for robot arm control with deep q-learning. arXiv preprint arXiv:1609.03759.

Juang, J. G., Tsai, Y. J., & Fan, Y. W. 2015. Visual recognition and its application to robot arm control. Applied Sciences, 5(4): 851-880.

Kadir, W. M. H. W., Samin, R. E., & Ibrahim, B. S. K. 2012. Internet controlled robotic arm. Procedia Engineering, 41: 1065-1071.

Kumar, A., & Kumari, M. 2021. Design and implementation of AI Based Robotic Car for Surveillance and transportation. In IOP Conference Series: Materials Science and Engineering 1116(1): 012123

Lee, S., Kim, M., Youm, Y., & Chung, W. 1999. Control of a car-like mobile robot for parking problem. In Proceedings 1999 IEEE International Conference on Robotics and Automation, page1-6, IEEE.

Li, T. H., & Chang, S. J. 2003. Autonomous fuzzy parking control of a car-like mobile robot. IEEE Transactions on Systems, Man, and Cybernetics-Part A: Systems and Humans, 33(4): 451-465.

Li, T. H., Chang, S. J., & Chen, Y. X. 2003. Implementation of human-like driving skills by autonomous fuzzy behavior control on an FPGA-based car-like mobile robot. IEEE Transactions on Industrial Electronics, 50(5): 867-880.

Lin, Y., Huang, M. L., Lin, C. H., & Chiang, H. H. 2022. Navigation Autonomy with Web-Based Remote Monitoring for Robotic Cars in Indoor Scenario. In 2022 IEEE International Conference on Consumer Electronics-Taiwan, page 417-418. IEEE.

Liu, J., Collins, R. T., & Liu, Y. 2011. Surveillance camera autocalibration based on pedestrian height distributions. In Proceedings of the British Machine Vision Conference page 144.

Maity, A., Paul, A., Goswami, P., & Bhattacharya, A. 2017. Android application based bluetooth controlled robotic car. Int. J. Intell. Inf. Syst, 6(5): 62.

Meteab, W. K., ALRikabi, H. T. S., Al Sultani, S. A. H., & Aljazaery, I. A. 2021, February). Controlling and monitoring a robot-car based on smart phone applications. In IOP conference series: Materials science and engineering 1094(1): 012096).

Okatan, A. 2001. Control of a robot car through Web. IFAC Proceedings Volumes, 34(3): 121-124.

Pane, M. A. S., Ehkan, P., Saleh, K., & Irwanto, M. 2018. A Mobile Surveillance Robot Over The Wifi Network Using Atmega 8.

Paolillo, A., Gergondet, P., Cherubini, A., Vendittelli, M., & Kheddar, A. 2018. Autonomous car driving by a humanoid robot. Journal of Field Robotics, 35(2), 169-186.

Pooja S. Kulkarni1 , G. T. Chavan, 2018. Android Application based Wi-Fi Controlled Robot Car. ResearchGate Impact Factor 2018: 0.28

Riazollah Firoozian. 2008. Servo Motors and Industrial Control Theory. Springer; 1st edition

Shekhawat, R. S., Sain, A., & Bhardwaj, G. 2016. Automatic intelligence car robot. Dimensions, 43(43): 26.

Shekhawat, R. S., Sain, A., & Bhardwaj, G. 2016. Automatic intelligence car robot.Dimensions,43(43): 26.

Shekhawat, R. S., Sain, A., & Bhardwaj, G. 2016. Automatic intelligence car robot. Dimensions, 43(43): 26.

Sowmya, K. V., Jamedar, H., & Godavarthi, P. 2020. Remote Monitoring System of Robotic Car Based on Internet of Things Using Raspberry Pi. Journal of Computational and Theoretical Nanoscience, 17(5): 2288-2295.

Taha, I. A., & Marhoon, H. M. 2018. Implementation of controlled robot for fire detection and extinguish to closed areas based on Arduino. TELKOMNIKA (Telecommunication Computing Electronics and Control), 16(2): 654-664.

Tarn, T. J., Bejczy, A. K., Yun, X., & Li, Z. 1991. Effect of motor dynamics on nonlinear feedback robot arm control. IEEE transactions on robotics and automation, 7(1): 114-122.

Ullah, S., Mumtaz, Z., Liu, S., Abubaqr, M., Mahboob, A., & Madni, H. A. 2019. An Automated Robot-Car Control System with Hand-Gestures and Mobile Application Using Arduino.

Vijayalakshmi, S. (2019). Robotic Car Using Arduino with Bluetooth Controller.

Werneck, H. L., & Junior, L. A. C. Project and Development of an Autonomous Robot Car.

Williamson, M. M. 1999. Robot arm control exploiting natural dynamics (Doctoral dissertation, Massachusetts Institute of Technology).

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