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Theme

Pharmacy Assistant Robot

By :

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front of the jury:

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نسأله أن يرفع مقامنا في الدنيا والآخرة، ويبارك لنا في عملنا المتواضع الذي بين أيديكم، شاكرين الله على توفيقنا وسداد خطواتنا آملين درجات اكثر .

بعد شكر الله وحمده في المقام الأول، نشكر عائلاتنا التي كانت الداعم الأول جزاهم الله خيرا ووالدينا بصفة خاصة، فهذا بفضل تضحياتهم كان يكون نجاحنا. نعبر لهم عن أصدق الامتنان ونتقدم بشكر خاص لجميع الأساتذة والكوادرة الذين أشرفوا على نجاحنا قراءة، والأسرة الجامعية والطواقم والمؤسسات التي ساهمت في هذا العمل كفضاء الابتكار الذي كان العمل الأول، إلى مخبر البحث مواد الالكترولوجيا وأنظمة الطاقة والبيئة تحت إشراف الدكتور بلعور عبد الرحمان .

كما نوجه شكرا خاصا للمشرف الدكتور حسن ناصر الذي كان دعمه مصدرًا للإلهام والدفع نحو التميز. وأصدقائنا وزملائنا جزاهم الله خيرا ووفيرا من النجاح. وإلى صديقي زميلي في هذا العمل ألف شكر وألف إهداء وتحية.

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DEDICATION

With all love and appreciation, I dedicate these words to my dear parents:
To those who have been the light of my life every day, thank you for your constant presence, your limitless support, and your love that fills my heart with warmth and happiness.
In times of doubt and pain, as well as in moments of joy, you have always been by my side, faithful companions on my journey with your gentle words and unwavering support. You have inspired me, motivated me, and made me stronger and more loyal.
In your generous sharing and kind gestures, I find comfort, joy, and precious happiness. Thank you from the bottom of my heart for your endless support and invaluable love
And to my dear colleague who shared this work with me:

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Abstract

In the context of rapid technological evolution, pharmacies are facing increasing challenges, exacerbated by the COVID-19 pandemic. To address these challenges, our project proposes to modernize pharmacies using robots and artificial intelligence systems. These technologies allow for the automation of various tasks such as sales, monitoring, and data entry, thus reducing human effort and minimizing errors. The project relies on advanced technologies such as Optical Character Recognition (OCR) for reading prescriptions, database search for locating medications, and the automation of medication collection and payment. Added values include using the screen as advertising space, managing complaints through a connected platform, and regular stock monitoring. Additionally, a pharmacy assistant robot will be integrated to help with daily task management and customer interaction. In conclusion, this project radically transforms pharmacy operations by combining technological innovation and artificial intelligence to enhance efficiency and service quality.

Keywords: Smart pharmacies, artificial intelligence, robotics, pharmacy automation, OCR

Résumé

Dans un contexte d'évolution technologique rapide, les pharmacies font face à des défis accrus, exacerbés par la pandémie de COVID-19. Pour répondre à ces défis, notre projet propose de moderniser les pharmacies à l'aide de robots et de systèmes d'intelligence artificielle. Ces technologies permettent d'automatiser des tâches variées comme la vente, la surveillance et la saisie de données personnelles, réduisant ainsi les efforts humains et minimisant les erreurs. Le projet repose sur des technologies avancées telles que l'OCR pour lire les ordonnances, la recherche dans une base de données pour localiser les médicaments, et l'automatisation de la collecte et du paiement des médicaments. Les valeurs ajoutées incluent l'utilisation de l'écran comme espace publicitaire, la gestion des plaintes via une plateforme connectée, et un suivi régulier des stocks. En outre, un robot pharmacien assistant sera intégré pour aider à la gestion quotidienne des tâches et à l'interaction avec les clients. En conclusion, ce projet transforme radicalement les opérations pharmaceutiques en alliant innovation technologique et intelligence artificielle pour améliorer l'efficacité et la qualité des services.

Mots-clés : Pharmacies intelligentes, intelligence artificielle, robots, automatisation des pharmacies, reconnaissance optique de caractères

ملخص

في سياق التطور التكنولوجي السريع، تواجه الصيدليات تحديات متزايدة تفاقمت بسبب جائحة .COVID-19للاستجابة لهذه التحديات، يقترح مشروعنا تحديث الصيدليات باستخدام الروبوتات وأنظمة الذكاء الاصطناعي. تتيح هذه التقنيات أتمتة المهام المختلفة مثل البيع، والمراقبة، وإدخال البيانات الشخصية، مما يقلل من الجهود البشرية ويقلل من الأخطاء. يعتمد المشروع على تقنيات متقدمة مثل التعرف البصري على الحروف ((OCR لقراءة الوصفات الطبية، والبحث في قاعدة البيانات لتحديد مواقع الأدوية، وأتمتة جمع الأدوية والدفع. تشمل القيم المضافة استخدام الشاشة كمساحة إعلانية، وإدارة الشكاوى عبر منصة متصلة، ومتابعة دورية للمخزون. بالإضافة إلى ذلك، سيتم دمج روبوت صيدلي مساعد للمساعدة في إدارة المهام اليومية والتفاعل مع العملاء. في الختام، يُحدث هذا المشروع تحولاً جذرياً في عمليات الصيدليات من خلال الجمع بين الابتكار التكنولوجي والذكاء الاصطناعي لتحسين الكفاءة وجودة الخدمات.

الكلمات المفتاحية: صيدليات ذكية، الذكاء الاصطناعي، الروبوتات، أتمتة الصيدليات، التعرف البصري على الحروف

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List of Abbreviations

OCR: Optical Character Recognition

NLP: Natural Language Processing

AI: Artificial Intelligence

ROS: Robot Operating System

DOF: Degrees of Freedom

IR: Infrared

RFID: Radio-Frequency Identification

ML: Machine Learning

DL : Deep Learning

NLP : Natural Language Processing

General Introduction

Introduction:

In recent years, the pharmaceutical sector has witnessed a remarkable technological boom, with advanced systems becoming indispensable in daily operations, significantly improving efficiency, accuracy, and safety. Automation is one of the key pillars of this transformation, enhancing pharmaceutical processes by reducing human errors, increasing efficiency, reinforcing safety standards, and improving customer experience by reducing waiting times and ensuring precise medication dispensing. These advanced systems include robots for preparing prescriptions, pharmacy management systems that enable pharmacists to efficiently track medications and inventory, and electronic verificationsystems that ensure the correct medication is provided to the correct patient. Thanks to artificial intelligence, these technologies have become integrated into all sectors, offering new opportunities to enhance performance and quality.In Algeria, there is a strong drive for leadership in the pharmaceutical field through the introduction of these advancedtechnologies. The goal is to transform pharmacies from traditional stores into modern and efficient centers, which requires significant investments in time and resources. Although adopting these systems entails substantial investments, the resulting benefits justify these investments and make them necessary. These technologies can significantly improve the quality of healthcare and increase customer satisfaction by providing more accurate and efficient services.

Project Objectives

The project aims to develop the pharmacy sector in Algeria by introducing and adopting advanced technology and smart systems in pharmaceutical operations. The main objectivesinclude

1. **Enhancing healthcare quality**: By improving accuracy andsafety in medicationdistribution and reducing human errors.
2. .**Improving customer experience**: Through reducing waittimes and increasingaccuracy in providing the required medications.
3. **Enhancing operational efficiency**: By utilizing technology to improve inventorymanagement and expedite packaging and distribution processes.

4. Transforming pharmacies into modern and efficientcenters: By updating technological infrastructure and enhancing pharmaceutical capabilities.

The project aims to elevate the level of pharmaceutical services and increase customer satisfaction, thereby contributing to improving public health and enhancing the efficiency of the healthcare sector in the country.

- **Organization of the Thesis**

The thesis is organized as follows:

Chapter 1 : Discusses the evolution of pharmacy technologies and the modern applications of robotics and AI in enhancing pharmaceutical processes.

Chapter 2 : : Explains the proposed design of a pharmacy robot, integrating line-following and robotic arm technologies for precise medicationhandling.

Chapter 3 : Details the individual mechanical and electrical components used in assembling the pharmacy robot prototype and their specific roles.

Chapter 4 : Outlines the process of building, assembling, and programming the pharmacy robot, including the challenges faced and solutions implemented.

Chapter 5: Explores the integration of AI components such as machinelearning, NLP, and computer vision in the pharmacy robot to enhance operational efficiency.

Chapter 6 :Summarizes the project's achievements, future work, challenges encountered, and the potential impact of the pharmacy robot on improving pharmaceutical operations.

Chapter1 :

Applications of Modern Pharmaceutical Technologies

1.1 Introduction

In this chapter, we review the evolution of modern pharmacy technologies and their role in improving drug manufacturing, storage, and distribution processes, focusing on the use of robotics and artificial intelligence. We discuss the efforts made by specialized companies to develop advanced pharmacy systems that enhance efficiency and reduce human errors, thereby promoting patient safety. Additionally, we present prominent examples of these technologies, such as drug dispensing robots, and analyze the benefits and challenges facing this fiel

1.2 What is pharmacy Robots?

Pharmacy robots are advanced mechanical systems designed to enhance efficiency and accuracy in various pharmaceutical operations. These robots play a vital role in facilitating a variety of tasks within pharmacies, including prescription preparation, customer interaction, inventory management, as well as safer and more effective medication collection and distribution methods .

1.3 Types of Pharmacy technology :

There are many different types of robots. We can distinguish tree families :

1.3.1 Automated packaging and distribution systems

The automated systems used in pharmacies aim to enhance efficiency and accuracy in the processes of filling and dispensing medications. These systems rely on robots and artificial intelligence technologies to manage inventory, fill prescriptions, and distribute medications in a safe and efficient manner. This advanced technology helps reduce human errors, increase service speed, and ensure the continuous availability of necessary medications. Additionally, these systems free up pharmacists' time, allowing them to provide better consultative services to patients. [1]

- **PILLPICK**

The PillPick system accurately and quickly packages, stores, and distributes individual doses. It transfers medications from large containers to smart packages equipped with RFID technology. Each pill is placed in a separate bag after being inspected for quality. The bags are stored in storage units, and robots prepare medication orders and determine the appropriate doses, with patient labels being printed and verified using scanners. Multiple robots efficiently and systematically distribute the medications. [2]

Figure 1.1 : Integrated unit dose system [28]

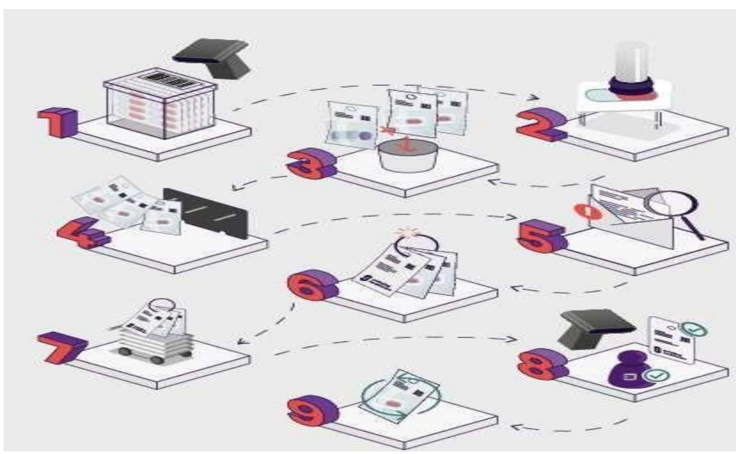

Figure 1.2: PillPick — Functions [29]

- **CONSIS robotic systems**

CONSIS robotic systems are advanced automated warehouses designed to manage and distribute pharmaceutical inventory, thereby improving pharmacy efficiency. These systems include intelligent robots capable of storing and distributing over 2,000 drug packages per hour automatically and quickly in response to patient demands. The system ensures accurate fulfillment of individual orders, with the required packages swiftly delivered to the pharmacist for patient delivery. This automation enhances medication safety, improves the efficiency of pharmacy operations, and allows pharmacists to spend more time providing consultation and care to patientsand customers.. [3]

Figure 1.3 : consis Robotics systems [30]

- **Pharma SIS**

One of the latest innovations by the Changi General Hospital (**CGH**) pharmacy team in Singapore, which is dedicated to developing technological solutions and automating all aspects ofdrug storage, packaging, and purchasing, is the Pharmasis vending machine. This machine offerscustomers a convenient and easy way to purchase medications at any time, allowing them to manage their own health. A pharmacist is available for remote consultations at specific times, providing support and advice on the proper use of medications. The machine dispenses medications for minor ailments such as coughs, colds, and mild skin allergies..[4]

Figure 1.4 : PharmaSIS vending machine [31]

1.3.2 Smart Robots for drug identification

Smart robots designed for drug identification utilize advanced techniques like artificial intelligence and machine learning to examine medication samples.The robot analyzes the chemical and molecular data of the provided sample to ascertain if it contains the correct substances in the appropriate quantities. These robots are also capable of detecting counterfeit or adulterated drugs.. [5]

- **Scriptpro**

In 1994, ScriptPro transformed pharmacy operations by introducing the first automated prescription dispensing system, establishing a benchmark for reliability and efficiency. These systems manage prescription entry, verification, medication selection, and dispensing through theuse of robots, enhancing safety and minimizing errors. They provide faster prescription processingand cater to pharmacies of all sizes, thanks to their adaptable and diverse designs.. [6]

Figure 1.5 : scriptpro robot [32]

1.3.3 Robots specialized in inventory management

- **Omnicell system**

The Omnicell system provides a comprehensive solution for inventory and medication management in pharmacies and hospitals. This system stands out for its ability to detect the need for replenishment, then automatically and accurately receive data and dispense medications. Following this, the quality of the packages is verified before distributing the medications to the appropriate locations within the hospital or pharmacy. This process enhances inventory management efficiency and ensures the smooth and secure availability of medications..[7]

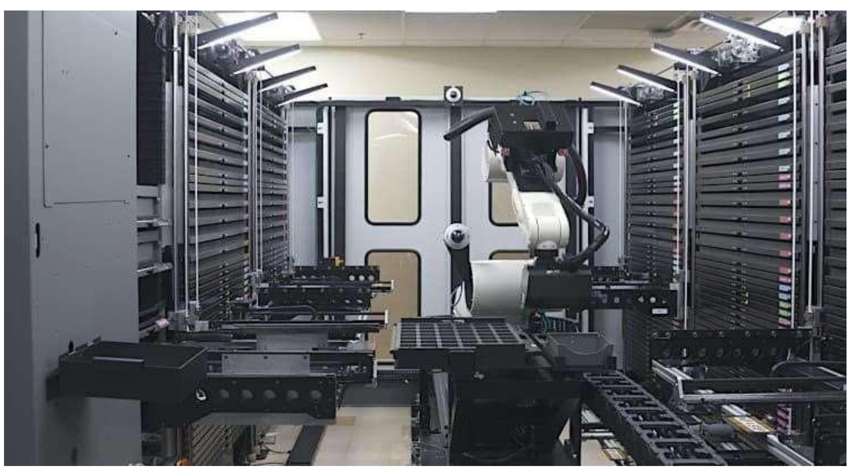

Figure 1.6: Omnicell XR2 automated central pharmacy robot [33]

There are also many other innovations and modern technologies such as IBM Watson Health, RoboPharma, and Parata, which aim to improve and modernize pharmacy operations and keep up with technological advancements in various fields. These projects contribute to enhancing accuracy, efficiency, and safety in medication distribution, significantly improving healthcare and customer experience.

1.4 Conclusion

Based on the above, it is clear that innovations and modern technologies in the pharmacy sector play a crucial role in enhancing efficiency, accuracy, and safety, which significantly improve healthcare and customer experience. However, these projects face major challenges related to cost and space, hindering their widespread adoption. This raises the question: How can the implementation of modern technologies in community pharmacies be enhanced to align with cost and space constraints? And how can these challenges be addressed to ensure the effective and affordable provision of pharmaceutical services across all communities? Effectively addressing these issues is essential for achieving the necessary balance and making technology accessible to everyone.

Chapter 2:

Conceptualizing the Development of a Pharmacy Robot

2.1 Introduction

In this chapter, we will discuss the overall conceptualization of developing a pharmacy robot designed to address the challenges and obstacles hindering the implementation of modern pharmaceutical technologies and robotics in pharmacies. Our aim with this design is to provide a comprehensive solution that meets the needs of all pharmacies and communities, thereby contributing to the automation and enhancement of the pharmaceutical system's efficiency. We will review the robot's overall design, its main components, and the innovations integrated into it. Additionally, we will explain the reasons behind choosing this design as an ideal solution to overcome spatial and financial constraints, with a focus on providing efficient and affordable pharmaceutical services, thus enhancing patient and community satisfaction.

2.2 The general design of the proposed pharmacist robot

The proposed design of the pharmacy robot consists of two main components: a line- following robot and a robotic arm with six degrees of freedom, programmed using Raspberry Pi Pico. The line-following robot ensures precise navigation within the pharmacy using sensors to detect paths on the floor, allowing smooth and safe movement between the shelves. Meanwhile, the robotic arm handles and dispenses medications with high precision due to its flexible design and ability to move in six different directions. The robot is integrated with the Robot Operating System (ROS)to facilitate communication between its components and develop advanced behaviors, enabling seamless integration between software and hardware, and simplifying maintenance and updates. The design includes sensor systems such as infrared sensors and cameras to ensure efficient navigation and obstacle avoidance. The robot is connected to an artificial intelligence system that scans medical prescriptions accurately, identifies the required medications, and directs the robot to collect them quickly, making it adaptable to various pharmacy layouts.

2.2.1 What is a line follower car robot?

A line follower car robot is an autonomous robot that follows a predefined line on the ground. It uses sensors to detect the line and adjusts its path accordingly. This type of robot is commonly used in industrial applicationsfor material handling and transportation.

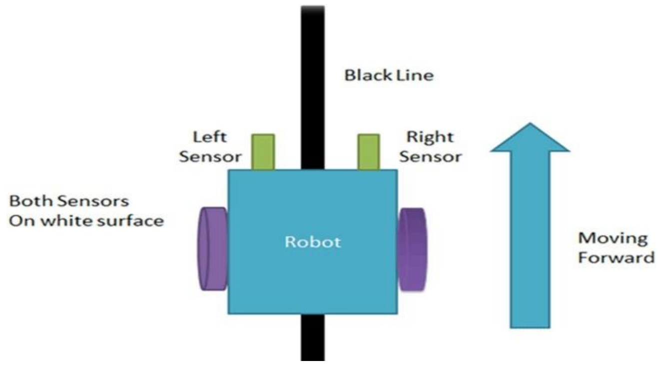

Figure2.1 : Line Follower Car Robot Diagram

. 2.2.1.1 Types of line follower car robots

There are different types of line follower car robots, distinguished by various technologiesfor detecting lines and controlling movement, including:

- **Robots using Infrared (IR) Sensors**:
  - The most common and least expensive.
- **Robots using Color Sensors**:
  - Can distinguish between multiple colors to follow colored lines.
- **Robots using Cameras and Image Processing:**
  - Provide higher accuracy for following complex lines.
- **Robots using Magnetic Sensors**
  - Used in industrial applications with magnetic lines.
- **Robots with Machine Learning and Artificial Intelligence**:
  - Adapt to new environments and improve tracking capability.

2.2.1.2 line follower car robots programming

Programming robots involves giving them specific instructions to control their movementsand actions. Various programming methods include:

- **Teach Pendant Programming:** Using a joystick or potentiometer to movethe robot and savepositions.
- **Offline Programming:** Writing code to control the robot without manual intervention.
- **Task-Level Programming**: High-level instructions for complex tasks.

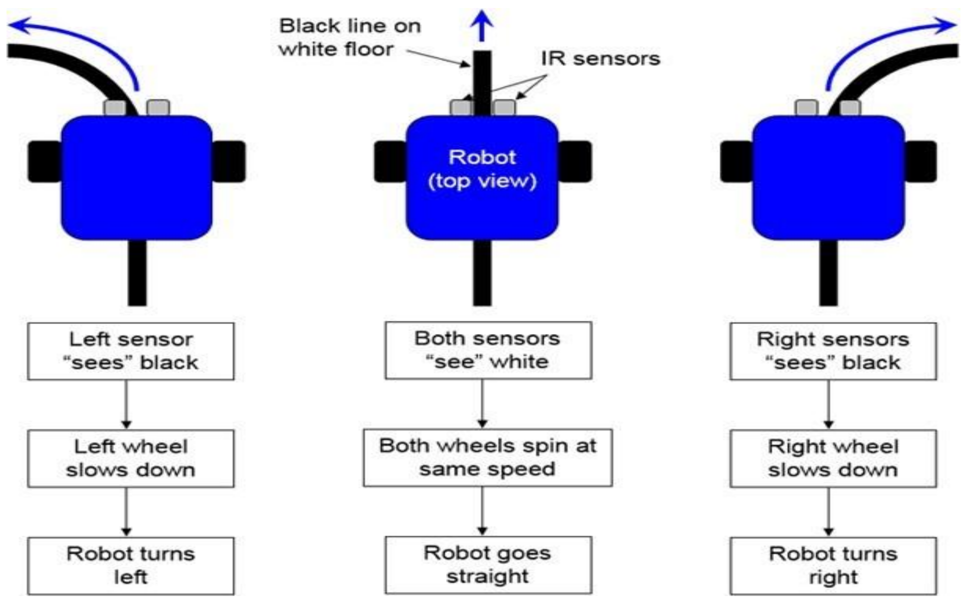

Figure 2.2: Diagram of Robot Programming Methods

2.2.2 What is a 6 DOF Arm Robot?

A 6 DOF (Degrees of Freedom) arm robot is a robotic arm with six joints,allowing it to move in six different directions. This configuration provides high flexibility and precision, makingit suitable for complex tasks such as assembly, welding, and handling delicate objects.[8]

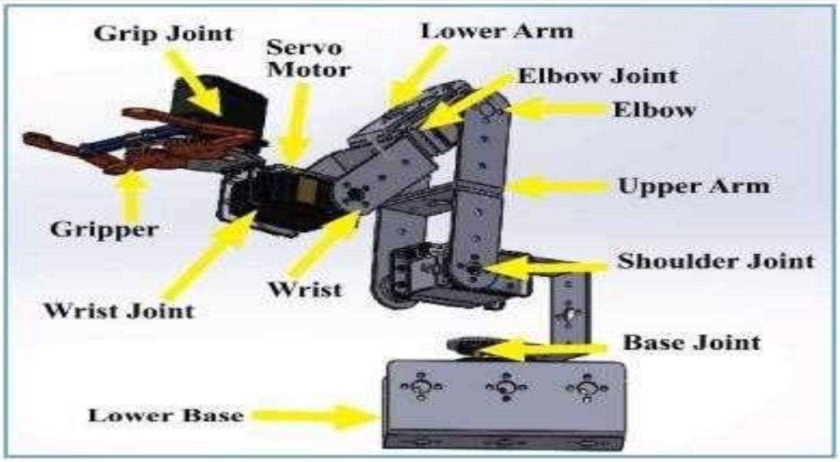

Figure 2.3: 6 DOF Arm Robot Diagram

2.2.2.1 Types of Robot Arms

Robotic arms can be classified into various types based on their architecture andfunctionality. Some common types of robotic arms include:

- **Cartesian Robots:** These have three prismatic joints forming aCartesian coordinatesystem.
- **Cylindrical Robots:** These use a cylindrical coordinate system, allowing the arm to movein radial, rotational, and axial directions.
- **Spherical Robots:** These rely on a polar coordinate system, enablingrotational and radialmovement.
- **SCARA Robots (Selectively Compliant Articulated Robot Arm):** These feature twoparallel rotary joints, making them suitable for pick-and-place and assembly tasks.

2.2.2.2 6 DOF Arm Robot Modeling :

To use robotic manipulators in practical applications, the first step is to obtain an accurate kinematic and dynamic model. Forward kinematics deals with the relationship between the individual joints of the robot and the position and orientation of the tool or end-effector. Formally, forward kinematics aims to determine the position and orientation of the end-effector based on the joint variables. Joint variables are the angles between the links in the case of revolute joints, and the link extension in the case of prismatic joints.

- **Kinematic Model**: The kinematic model describes the relationship between the joint angles and the position and orientation of the end-effector. The Denavit-Hartenberg (DH) parameters are used to represent the kinematic chain of the robot. Each joint is defined by four parameters: link length, link twist, link offset, and joint angle. [9]

- **Forward Kinematics** : When considering a set of rigid bodies connected by joints, the pose of this kinematic model is specified by the orientation of the joints. Suppose we have a robot with *n* links numbered from zero, starting from the robot's base to the end-effector, with the base being link 0, and all joints are numbered from 1 to *n*. In 1955, Denavit and Hartenberg (DH) proposed a system for assigning reference frames to each link in an open kinematic chain of links. Once these link-attached coordinate frames are assigned, the transformation between adjacent coordinate frames can be represented by a standard 4×4 homogeneous transformation matrix.

- **DH Parameters** ; DH parameters describe the spatial relationships between a joint axis and its two neighboring joint axes. After assigning the link-attached coordinate frames, the transformation between adjacent coordinate frames can be represented by a standard 4×4 homogeneous transformation matrix.

  - d_i: Distance between z_{i-1} and z_i along x_{i-1}.
  - α_i: Angle between z_{i-1} and z_i along x_{i-1}.
  - a_i: Link length between x_{i-1} and x_i along z_i.
  - θ_i: Angle between x_{i-1} and x_i along z_i.

- **DH Transformations** : The four transformations include
  1. Rotation of θ_i around the z_{i-1} axis.
  2. Translation of d_i along the z_{i-1} axis.
  3. Translation of a_i along the x_i axis.

4. Rotation of αi around the xi axis.

- **Dynamic Model**: The dynamic model includes the mass and inertia of each link, as well as the forces and torques generated by the actuators.[10]
- **Applying the Model to a Real Robot:** To illustrate the method, it will be applied to a robot with five articulated joints, resembling the anatomy of a human arm. The robot consists of a fixed link (L0) and four movable links (L1, L2, L3, and L4). All joints are revolute. At the final link, known as the end-effector, two movements (elevation and rotation) are observed. [11]

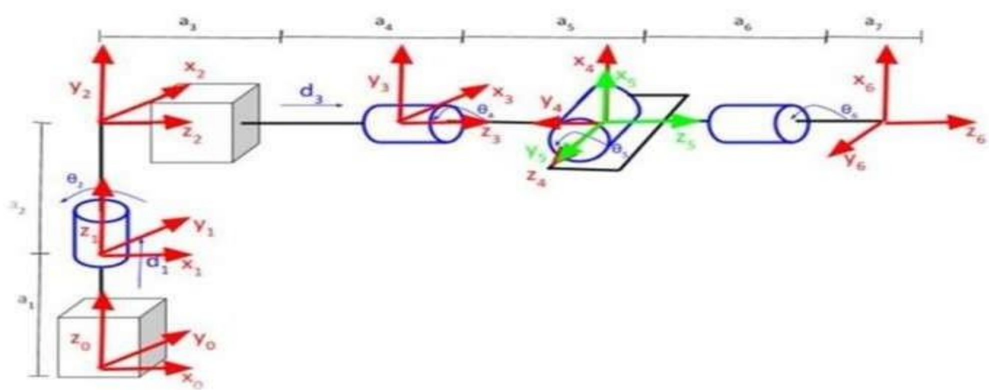

Figure 2.4: Diagram of 6 DOF Arm Robot Kinematics and Dynamics [34]

- **Verifying the Forward Kinematic Model:** The forward kinematic model was verified using the Robotics Toolbox in MATLAB. Numerical results were compared with the graphical representation of the robot's position and orientation in the MATLAB environment. When inputting the joint angle set [0 0 0 0 0], the position and orientation of the end-effector were calculated using the '**fkine'** command in MATLAB's Robotics Toolbox, yielding:

$$T_{0^5} = \begin{bmatrix} 1 & 0 & 0 & 43 \\ 0 & -1 & 0 & 0 \\ 0 & 0 & -1 & 13 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

When using another set of joint angles [π/2 -π/2π/4 0 0], the result was:

$$T_{0^5} = \begin{bmatrix} 0 & 1 & 0 & 0 \\ 0.7071 & 0 & 0.7071 & 21.21 \\ 0.7071 & 0 & -0.7071 & 44.33 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

The forward kinematic model of the robot can be verified using software tools like MATLAB, providing a clear insight into the robot's kinematic behavior based on a given set of joint angles. The dynamic model includes the mass and inertia of each link, as well as the forces and torques generated by the actuators.

2.2.3 What is ROS System ?

The Robot Operating System (ROS) is an open-source framework for developing robotic applications. It provides a collection of tools, libraries, and conventions to simplify the task of creating complex and robust robot behavior across a wide variety of robotic platforms. ROS is widely used in both academiaand industry due to its flexibility and extensive community support

2.2.3.1 Benefits of Using ROS :

- **Modularity:** ROS allows for the creation of modular softwarecomponents that can bereused across different projects.
- **Scalabilit**y: It supports the development of scalable systems that canhandle increasingcomplexity.
- **Community Support**: A large community of developers and researchers contributes toROS, providing extensive resources andsupport.
- **Interoperability**: ROS enables the integration of various hardware and softwarecomponents, facilitating communication between differentparts of the robotic system.

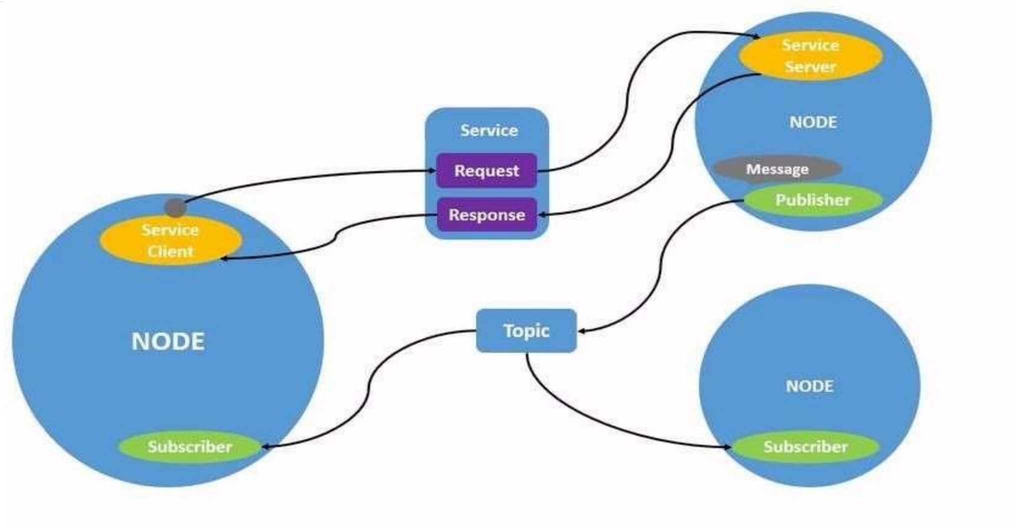

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Figure 2.5 : Ros2 Graph [35]

2.2.4 Introduction to Raspberry Pi Pico :

Raspberry Pi Pico is a miniature development platform used for developing interactive projects. It features numerous GPIO pins and an integrated microcontroller unit, making it suitable for controlling robotic systems and small electronic devices.

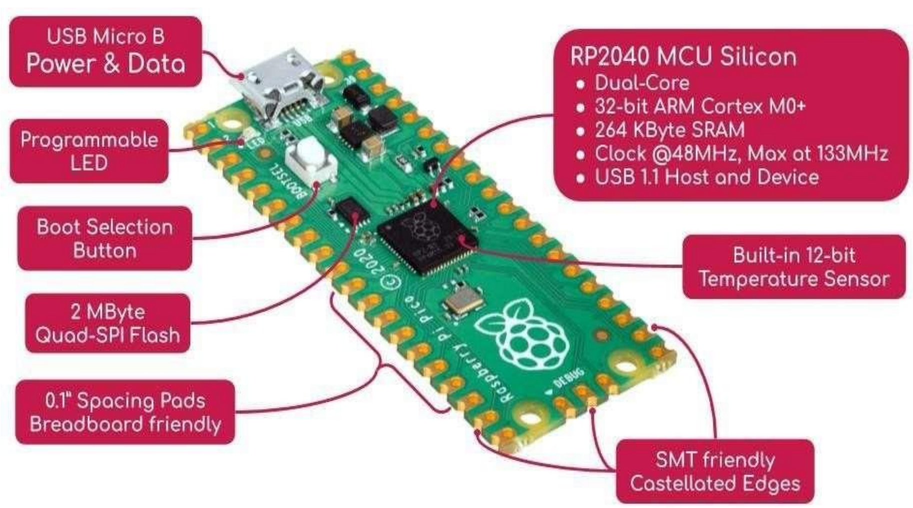


Figure 2.6 : Raspberry pi Pico Microcontroller Board [36]

Raspberry Pi Pico can be programmed using MicroPython or C/C++.

2.2.4.1 What is MicroPython ?

MicroPython is a re-implementation of Python 3 for microcontrollers and integrated systems, providing some of the benefits of Python but adapted for specific situations. It includes a limited number of standard libraries and modules for simple control and interaction with GPIOs.

2.3 The innovative aspects of the proposed design:

- **Integration with the ROS System:**

ROS allows robots to communicate effectively and synchronously, enhancing their capabilities to perform complex tasks efficiently. This integration also facilitates the updating and development of robots over time without the need to rebuild the system from scratch.

- **Embedded Artificial Intelligence System**

The robot's ability to scan and understand medical prescriptions autonomously allows it to identify the required medications quickly and accurately. This system reduces human errors and enhances the speed and efficiency of the medication dispensing process, improving user experience and satisfaction.

- **Flexible and Versatile Design**

The robot is designed to be adjustable in size, shape, and internal configurations to fit the available spaces in various pharmacies. This makes it a comprehensive solution that can be used in both small and large pharmacies, increasing its flexibility and value to different users

- **Precise and Efficient Navigation**

The robot is equipped with advanced movement control algorithms and sensing technologies to avoid obstacles and ensure safe and precise navigation. This reduces the chances of collisions or errors in movement, enhancing the safety and operational efficiency within the pharmacy.

These innovative ideas were chosen in the design of the pharmacy robot with the aim of improving efficiency and reducing the cost and space used in pharmacies.

This is achieved through:

- Integration with the ROS system reduces costs related to maintenance and frequent updates,as existing systems can be improved rather than replaced entirely.
- The embedded artificial intelligence system enhances operationalefficiency and saves timeand resources.
- The flexible and versatile design can expand its capabilities to meetlarger needs. Thisflexibility reduces the costs of modifications and reconstruction for different spaces.
- Precise and efficient navigation reduces costs associated with potential damage andmaintains the safety of equipment and personnel within thepharmacy.

These innovations in the design of the pharmacy robot were chosen to reduce costs and improve space efficiency, thereby enhancing the competitiveness of pharmacies and the quality of service..

2.4 Conclusion

This chapter provided a comprehensive overview of the proposed pharmacy robot design, highlighting the integration of the Robot Operating System (ROS) and artificial intelligence to improve the accuracy of pharmaceutical operations and reduce human errors. It also addressed the design's flexibility to adapt to different pharmacy sizes and enhance operational safety through precise navigation and obstacle avoidance, contributing to achieving operational and economic objectives.

***Chapter 3*:**

Components Of The prototype

3.1 Introduction

Developing the prototype is a crucial step in engineering design, allowing for the verification of concepts, function testing, and identifying improvements before final production. This chapter describes the essential components of the prototype, including raw materials, mechanical parts, and electronic components, emphasizing the importance and role of each component in ensuring the prototype's efficient operation. It also discusses potential challenges associated with each component, aiming to provide a precise understanding of the fundamental elements that form the prototype's structure, paving the way for the project's next phase.

3.2 Division of the Robot into Two Main Parts

The robot in our project consists of two main parts: the line-following robot and the robotic arm. Each part has specific functions that contribute to the overall systemof the robot. In this project, the line-following robot will be responsible for navigation and movement within the pharmacy, while the robotic arm will be responsible for handling and dispensing medications.

3.2.1 Components of the Line-Following Robot

The line-following robot relies on several essential components that enable it to move accurately and efficiently within the pharmacy. Below is a detailed explanationof the key components that make up the line-following robot:

3.2.1.1 UNO R3 Board and USB Cable

- **What is Arduino ?**

Arduino is an open-source electronic platform comprising hardware and software used to develop interactive applications. Arduino provides a flexible and user-friendlyplatform that allows developers and hobbyists to design and build their electronic projects with ease. Arduino features a wide range of boards and additional modules that can be used to program and control various electronic devices. [12]

- **Types of Arduino**

There are many types of Arduino boards, such as :Arduino Uno, Arduino Mega, Arduino Nano, Arduino Leonardo, and others. Each type has different characteristics and specifications that suit various project requirements

Arduino Uno R3

Arduino Uno R3 is one of the most popular and widely used Arduino boards. It is based onthe ATmega328P microcontroller and includes:

- 14 digital input/output pins (6 of which can be used as PWM outputs)
- analog input pins
- 16 MHz crystal oscillator
- USB connection
- Power jack
- ICSP header
- Reset button

This board is known for its flexibility and ease of use, making it an ideal choice forbeginners and hobbyists in the field of electronics and robotics.

- **Importance of Using Arduino Uno R3**

Arduino Uno R3 was chosen for our project for several reasons:

- **Ease of Use:** It provides a straightforward and simple programming environment,facilitating the development process.
- **Wide Support Community:** There are many resources and support available fromthe Arduino community, making it easier to find solutions to problems.
- **Connectivity Flexibility**: It offers multiple input/output pins, allowing easy connection of various components.
- ost Efficiency: It is a low-cost board compared to its features and capabilities.

- **USB Cable:**

The USB cable is used to connect the Arduino Uno R3 board to the computer. This cableserves two main functions:

- **Programming**: Transferring the program code from the computer to the board.
- **Power Supply**: Providing power to the Arduino board during development and testing.

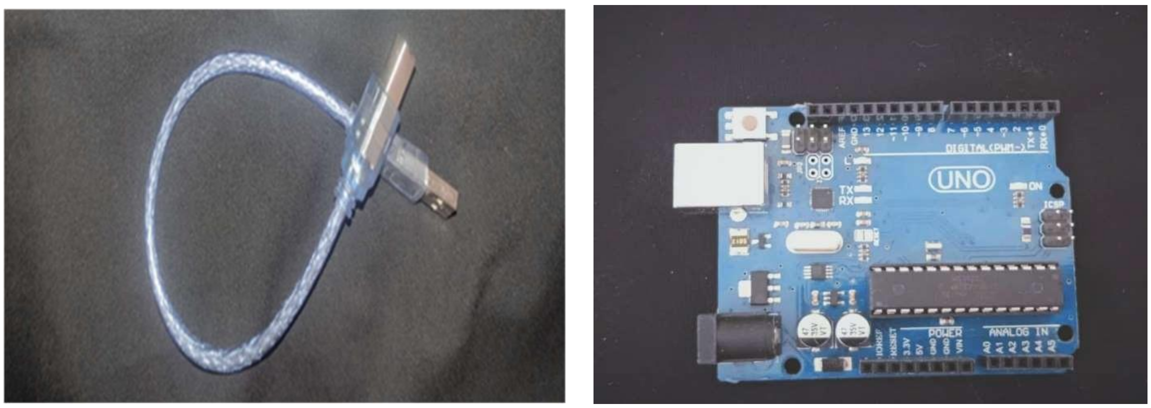


Figure 3.1 : UNO R3 Board and USB Cable

3.2.1.2 L293d Motor Driver Shield for Uno R3

The L293d Motor Driver Shield is a vital component for controlling robot motors, enabling the operation of DC motors and stepper motors using low-power control signals from the UNO R3 board. According to Michael Margolis in his book "Arduino Cookbook," the L293d shield is one of the most popular motor control shields due to itsability to provide simple and effective control.[13]

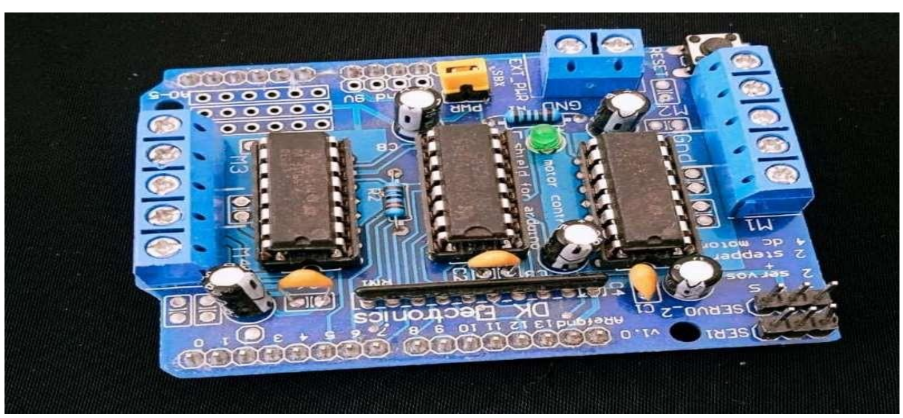


Figure 3.2 : L293d Motor Driver Shield

- **Technical Specifications of the L293d Shield:**

- **Number of Channels:** The shield has four channels, allowing independent control of two motors.
- **Maximum Current:** The shield can supply up to 600mA per channel, with apeak current capacity of 1.2A per channel.
- **Voltage Range:** It supports an operating voltage range of 4.5V to 36V, makingit suitable for a wide variety of motors.
- **Thermal Protection:** The shield includes built-in thermal protection to preventoverheating during intensive operation.
- **Direction Control:** It allows easy control of motor direction by changing the digital control signals, providing great flexibility in robot movement control.

- **Reasons for Choosing the L293d Shield for Our Project:**

1-**Flexible Motor Control:** The shield offers high flexibility in controlling DC motors and stepper motors, facilitating precise adjustments to the robot's movements.

2-**Ease of Connection and Programming:** It integrates seamlessly with the UNO R3 board, making the connection and programming process straightforward using thestandard Arduino library.

3- **Compact Size:** The shield's small and compact size helps save space when designing the prototype and assembling other components.

4- **Built-in Protection:** The built-in thermal protection enhances system reliability and protects components from damage due to overheating.

5- **Cost-Effective:** The L293d shield is an economical choice, making it ideal for student and hobbyist projects that require high-quality components at an affordablecost.

By using the L293d shield in our project, we can achieve precise and effective control of the robot's movements, enhancing the prototype's performance and ensuring the desired project outcomes.

3.2.1.3 Infrared Sensors (IR)

Infrared sensors (IR) are vital tools in the field of robotics for path tracking. These sensors work by emitting and receiving infrared signals, which are used to distinguishbetween different lines and surfaces over which the robot moves. Their mechanismrelies on measuring the reflection of infrared signals from various surfaces, allowing them to accurately determine the robot's position relative to the desired path.[14]

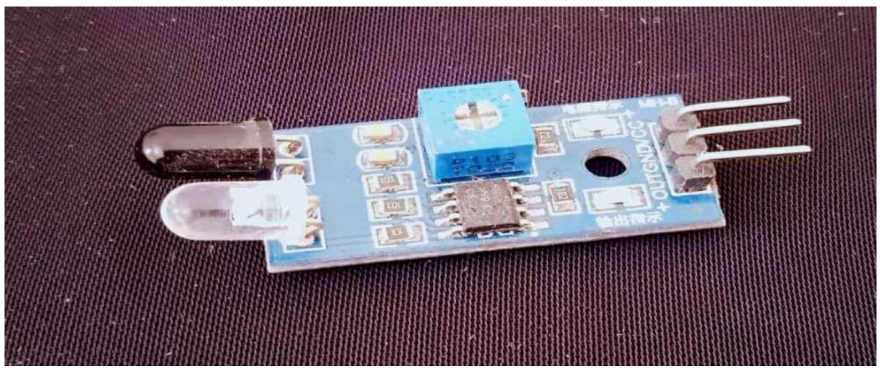


Figure3.3 : Infrared Sensors

- **Reasons for selecting IR sensors in our project :**

- High accuracy in detecting lines and contrasting colors, making them ideal fortracking defined paths.
- Quick response time and efficiency in different environments, ensuring reliableperformance in most operational conditions.
- Cost-effective and easy to install, making them suitable for prototype projects and educational applications

3.2.1.4 DC Motors

DC motors are used to move the wheels and thus drive the robot. These motors are capable of generating sufficient torque to propel the robot across various surfaces. The speed and direction of the motors are controlled by a motor driver shield, such as the L293d.

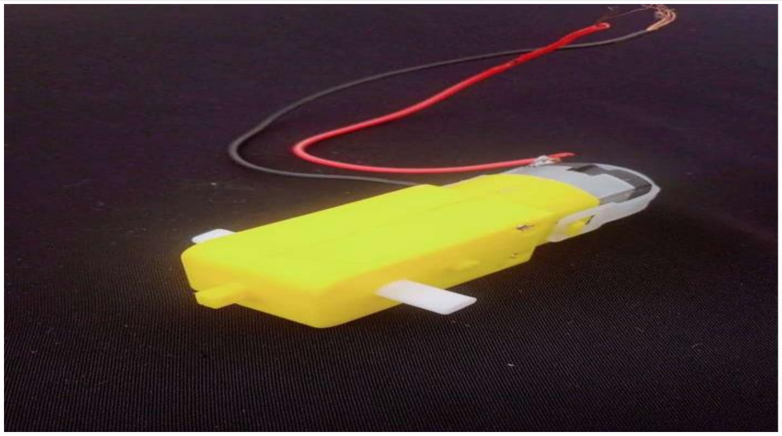


Figure 3.4 : DC Motors

3.2.1.5 Wheels

Wheels are a fundamental component for movement. They must be durable and made of materials that provide good traction with the ground, such as rubber. The wheelsare mounted directly onto the motor shafts, allowing the transfer of kinetic force from themotors to the ground.

Figure 3.5 : Wheels

3.2.1.6 AA Battery Holder with ON-OFF Switch

The battery holder is used to power the robot with four AA batteries. The ON-OFFswitch provides an easy way to control the robot's power, making it simple to manage energy and test the system.

Figure 3.6 : AA Battery Holder with 4 battery’s

3.2.1.7 Female Jumper Wires

Female jumper wires are used to connect various components of the robot. They are easy to use and connect, making them ideal for engineering and robotics projects, as theyallow for quick and efficient connections.

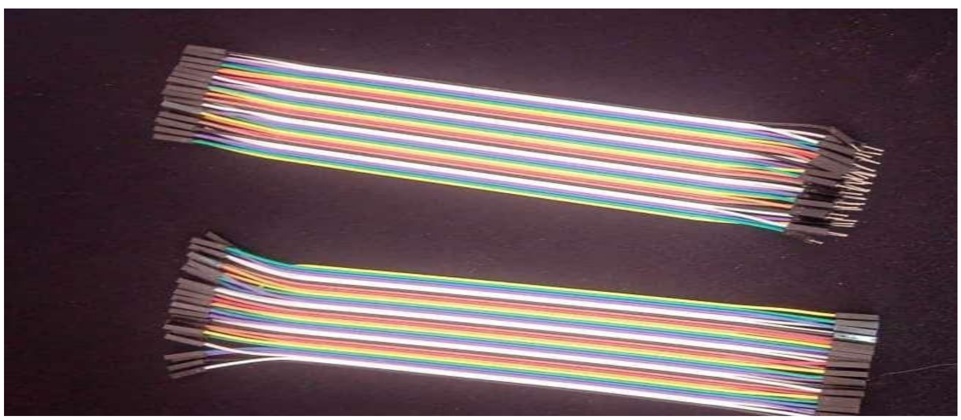


Figure 3.7 : Female Jumper Wires

With this, we have concluded the explanation of the components of the line-followingrobot and their uses.

3.1.1 Components of the Robot Arm

3 .2.2.1 Arduino Uno or Mega

The Arduino Uno and Mega boards are among the most popular control boards used in robotics. The Mega board offers a larger number of ports compared to the Uno, making it suitable for projects that require multiple connections. [15]

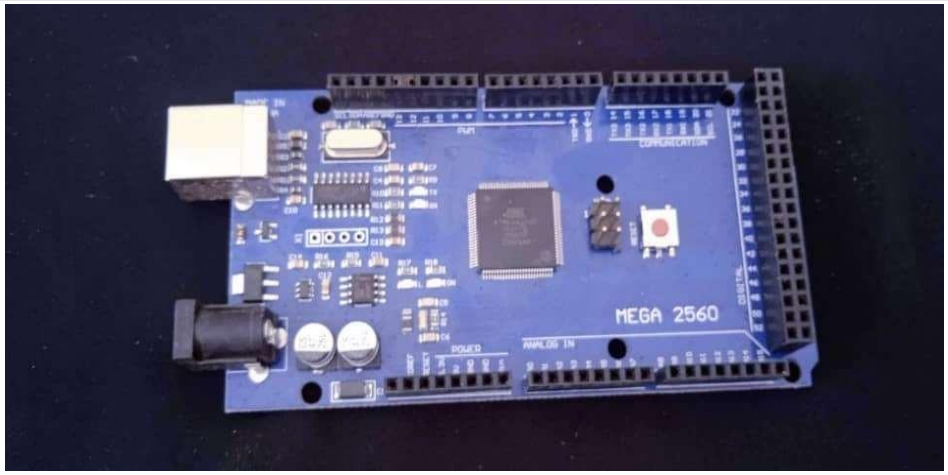


Figure 3.8 : Arduino Mega

3 .2.2.2 3 Servo Motors MG996 and 3 Servo Motors MG90S

Servo motors are used to control the movement of the robotic arm. MG996 motors are known for their high torque, making them suitable for heavier parts. MG90S motorsare smaller and lighter, ideal for precise movement . [16]

We chose these motors to provide accurate and powerful control for the robotic arm in our project.

Figure 3.9 : Servo Motors MG996 and Servo Motors MG90S

3.2.2.3 Mechanical Structure for the Arm (Using Plastic Components)

We chose to build the mechanical structure of the arm using plastic components. We selected plastic because it provides the required strength and durability, and it is easy to shape, giving a better overall form. Additionally, the lightweight nature of plastic makes the arm suitable for prototyping and allows the line-following robot to carry the arm effortlessly

Figure 3.10 : Mechanical Structure for the Arm

3.2.2.4 Suitable Power Supply

We have tried to choose a suitable power supply to provide the necessary power for the robotic arm. This source can be either batteries or power adapters, depending on the project's requirements.

3.2.2.5 Cables and Connectors

Cables and connectors are used to link the various components of the robotic arm,ensuring efficient flow of power and signals between them.

We used a breadboard in the prototype to facilitate the electrical assembly and connect various components without the need for soldering, allowing us to test the circuits easily and effectively.

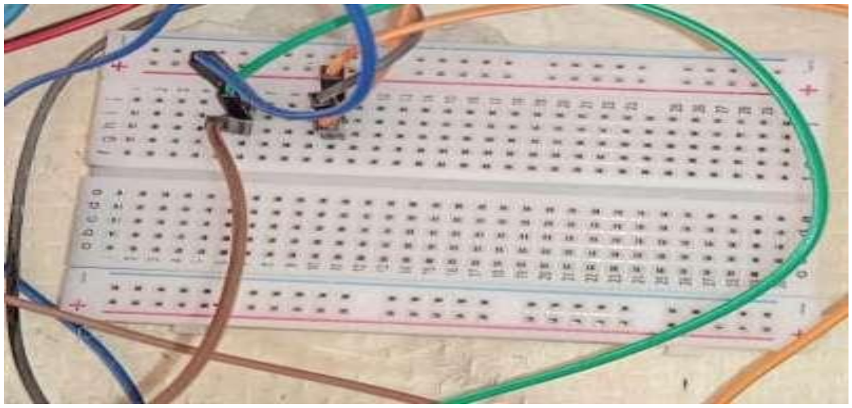


Figure 3.11 : breadboard

3.3 Conclusion

In this chapter, we attempted to list and explain all the components used in assembling the robot prototype, along with the reasons for choosing each component. This explanationaims to provide a comprehensive understanding of the individual elements, thereby offering a solid foundation and a clear picture for transitioning to the next phase of the project. In the next chapter, we will detail the process and stages of assembling the robot

Chapter 4:

Implementation

4.1 Introduction

In this chapter, we detail the implementation and assembly of the pharmacy robot prototype, starting from planning and design, through mechanical and electrical assembly, to programming and testing. We outline the time periods for each stage, focusing on challenges and solutions within the limited timeframe. We explain the results achieved so far and the future steps necessary for the final design. We cover the process of building and assembling the robot, installing sensors and electrical components, and programming the robot to ensure its efficiency, along with performance evaluation through tests and necessary improvements. The aim of this chapter is to provide a comprehensive analysis of the pharmacy robot development process, highlighting technical and practical aspects to ensure an effective prototype and future steps to complete the final design..

4.2 process of building the mobile robot :

4.2.1 Initial Planning and Design

In early February, we embarked on the initial planning and design phase for the pharmacyrobot we aim to develop. This phase included the following activities:

- **Brainstorming and Goal Setting**:

- We began with intensive brainstorming sessions to generate ideas regarding therobot's functions and to define the main objectives of the project
- We discussed potential scenarios for the robot's use in a real pharmacy environment.

- **Initial Sketches and Diagrams**:

- We created initial sketches and diagrams using basic design tools to visualizethe overall design of the robot.
- The diagrams included details about the general structure, potential locations for the motors, wheels, and sensor placements

- **Preparing the Components and Materials List**:

- We precisely identified the components and materials needed to build the robot.
- A comprehensive list was prepared, including all required items for construction, and it was submitted to the college administration for procurement.

4.2.2 Research and Preparations

During the two-week waiting period for the components to arrive, we engaged in the following activities to enhance our knowledge and prepare for the implementation process:

- **Researching Assembly and Programming Methods**:

- We watched educational videos on YouTube covering various aspects of assembling and programming robots.
- We read specialized books and references in the field of robotics to gain a deeper understanding of the required technical steps.

- **Planning the Assembly Process**:

- We devised a detailed plan for the assembly process, including task distribution among team members and setting a timeline for each phase.
- We discussed potential challenges and formulated strategies to effectively address them.

After approximately two weeks of waiting, the necessary components were provided, and we began working on the first part of the project, which is developing a line-following robot as a fundamental component of the overall project.

4.3 Hardware Implementation for a Line-Following Robot :

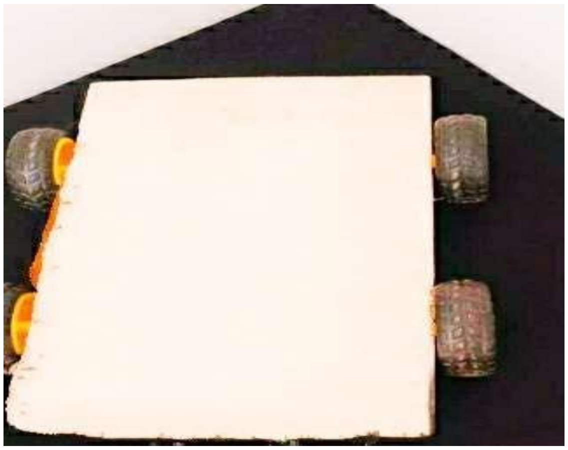
4.3.1 Mechanical Assembly

1 **- Chassis Construction:** after carefully studying the load capacity of the selected wheels, we decided to use wood as the main structure for the robot. We determined the appropriate size of the chassis to ensure it is suitable as a

preliminary model that allowsfor precise and easy work.

2 - **Motor Installation:** We installed motors in four designated areas of the woodenchassis to ensure balanced power distribution and movement..

3 - Wheel Attachment: After securing the motors, we attached the wheels and verified theirability to support and efficiently move the wooden chassis



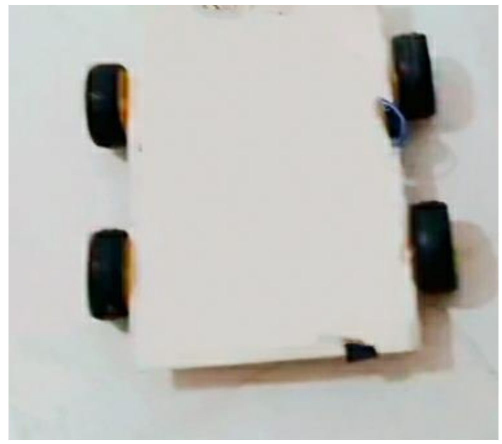


Figure 4.1 : the initial mechanical chassis of the line-following robot

4.3.2 Electrical Integration

After completing the mechanical assembly, and in the same third week of February when thecomponents arrived, we moved on to the initial electrical integration of the robot as follows:

1- **Controller Connection:** After researching the properties and uses of cc, we first tested it andthen connected it with the Arduino Uno to ensure control over the motors.

2- **Sensor Installation:** After verifying that the IR sensors were functioning correctly and hadno defects, we connected them to the Arduino and Motor Driver using female jumper wires to ensure accurate connections.

3- Power Supply: We connected the power supply consisting of four batteries linked together toensure full

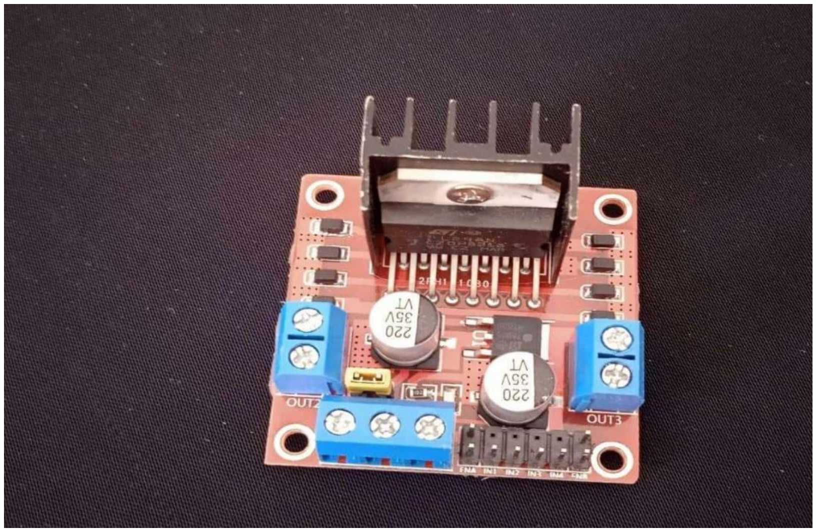


Figure 4.2 : the Motor Driver L298N

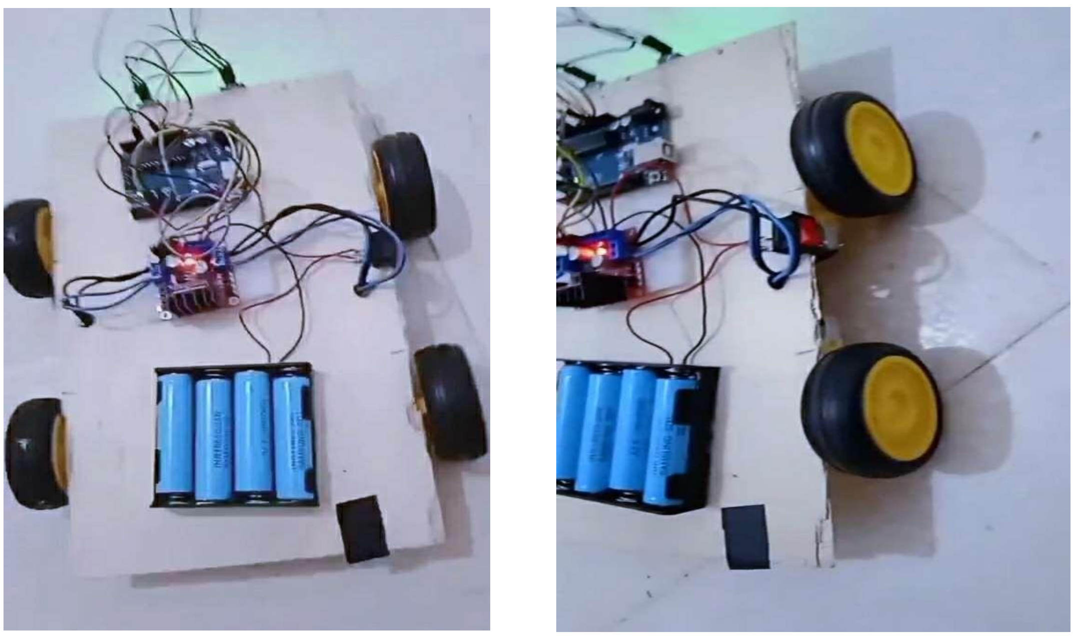


Figure 4.3 : the initial electrical integration of the line-following robot

4.4 Software Implementation for a Line-Following Robot

After completing the electrical integration of the robot and ensuring the electrical connections were correct, we began working on the Arduino code to match the robot's electrical components. We researched and wrote the appropriate algorithms necessary for navigation, obstacle avoidance, and executing the required tasks.

1. **Initializing Sensors and Motors:**

We correctly connected the motors and sensors and used the necessary Arduino libraries to operate them. Some of these libraries included:

- **Servo.h** for controlling the motors.
- **IRremote.h** for managing the IR sensors.

2. **Reading Data from Sensors:**

We wrote a function to read data from the sensors and detect obstacles using analog values. For instance, we used the **analogRead()** function to read values from the IRsensors.

3. **Determining Behavior Upon Obstacle Detection:**

We developed an algorithm to determine the robot's response when an obstacle is detected, such as stopping or changing direction. We used **'' if-else''** conditions to checkthe read values and take appropriate actions.

4. **Main Program Loop:**

We integrated all functions into the **'loop'** function to continuously control the robot, allowing it to interact with the environment and perform the required tasks. Functions such as '**digitalWrite()'** and ' '**analogWrite()'** were used to control motor movementsbased on sensor readings.

4.5 Initial Testing and Debugging

During the initial testing and debugging of the robot, we encountered several challenges that hindered achieving the expected performance. Below is a summary of the steps taken during the testing and debugging process, starting from verifying the robot's basic movements to identifying the issue with the L298N motor driver.

1. **Testing Basic Movements:**

When testing the robot's ability to move forward, backward, and turn, we observed that the robot was unable to perform these actions correctly, as the rear wheels did not rotateas required.

2. **Testing Basic Movements:**

When testing the robot's ability to move forward, backward, and turn, we observed that the robot was unable to perform these actions correctly, as the rear wheels did not rotateas required.

3. **Verifying Sensor Response:**

We checked that the sensors were functioning correctly and responding to the commandsprogrammed in the Arduino code.

4.Debugging Process:

After three days of continuous trials and rechecking the Arduino code and the integrity ofthe electrical components, we discovered that the L298N motor driver was not delivering adequate power to all the motors. This discovery was made by measuring the output voltage from the driver using a voltmeter, which confirmed that the driver was not operating efficiently.

4.5.1 Solution

To solve the problem, we replaced the L298N motor driver with the L293D motor driver. After that, we completely redesigned the robot's hardware and software system byfollowing these steps, which took approximately five days:

1. **Studied the Compatibility of the L293D with the Robot's Requirements**

We examined how well the L293D motor driver met the robot's requirements and ensuredit could provide the necessary power and control.

2. **Redesigned the Electrical Circuits Based on L293D Specifications**

We redesigned the robot's electrical circuits to align with the specifications of the L293Dmotor driver, updating the connections between various components.

3. **Updated the Robot's Programming to Align with L293D:**

We modified the robot's code to be compatible with the L293D motor driver, includingupdating commands and instructions for motor movements and sensor responses.

4. **Tested the Updated Circuits and Software to Ensure Proper Performance**

We tested the updated electrical circuits and software to ensure they functioned correctlyand met performance requirements

5. **Reassembled the Robot According to the New Design:**

After validating the new design, we reassembled the robot according to the updateddesign, ensuring all components were correctly position

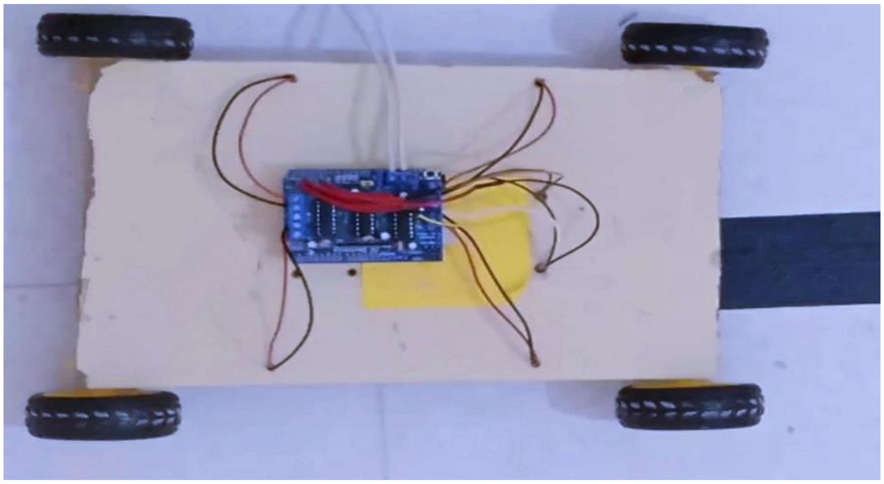


Figure 4.4 : The New Assembly of the Line-Following Robot

We conducted comprehensive final tests to ensure the system operated efficiently andmet the expected performance, including verifying the robot's movement, sensor response, and obstacle avoidance.

4.5.2 New Challenges

Even after following these steps and powering up the robot, we encountered new issues

- **Path Tracking:** The robot did not follow the designated path accurately.
- **Sensor Response Delay:** There was a noticeable delay in sensor responses.
- **Turning Delay:** The robot took longer to turn than expected.
- **Wheel Synchronization:** The four wheels did not rotate in coordination.

4.5.3 Proposed Solutions for New Challenges

1. Reconnecting Electrical Components:

- **Action:** We used a breadboard to reconnect the components.
- **Objective:** Ensure more stable and reliable connections to enhance the performance of the electrical circuits.

2. Modifying Arduino Code:

- **Action:** We revised and corrected the Arduino code to match the new connections.
- **Objective:** Ensure that sensors and motors receive accurate commands based onthe robot's current configuration.

3. Adjusting Power Supply:

- **Action:** We changed the type of batteries used.
- **Objective:** Provide sufficient and stable power to the components to prevent issues affecting the robot's performance.

4. Switching Between Arduino Mega and Arduino Uno:

- **Action:** We switched between Arduino Mega and Arduino Uno to ensure the issuewas not with the Arduino board itself.
- **Objective:** Verify that the control unit (Arduino) was functioning correctly andnot causing any of the mentioned issues.

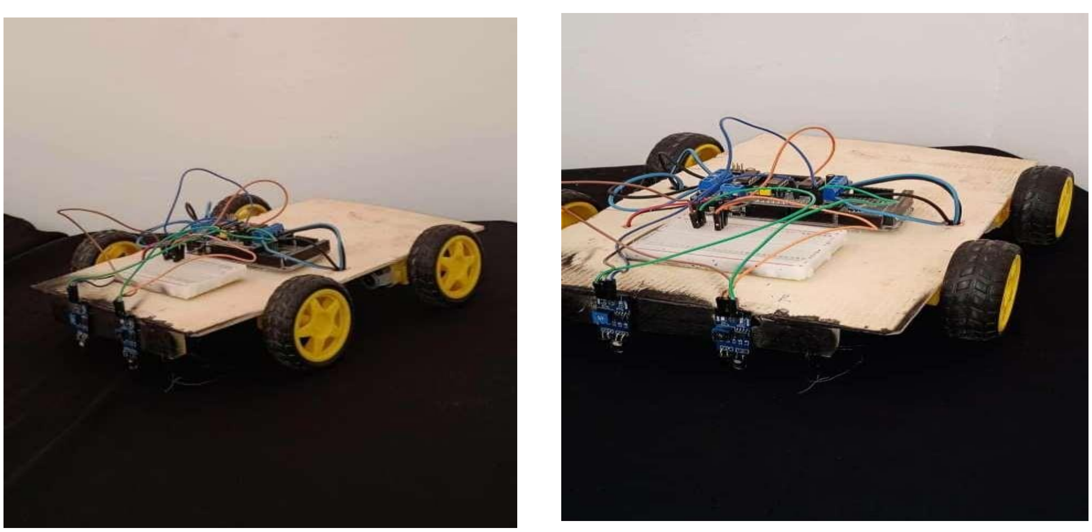


Figure 4.5 : The Final Assembly of the Line-Following Robot

4.5.4 Final Results

After four days of intensive experiments and adjustments, these additional steps successfully addressed the challenges. The line-following robot was able to function correctly, demonstrating improved path tracking, timely sensor responses, efficient turning capabilities, and synchronized wheel movements. These enhancements led to a stable and reliable robot capable of accurately following the designated path.

4.6 Hardware Implementation for a Robot Arm

4.6.1 Mechanical Design :

1. Modifying the Design Using SolidWorks

Instead of designing the arm from scratch, we modified an existing design to ensure itmet our size and requirement specifications. This modification process took about three days due to our limited experience with the software

2. 3D Printing of Parts

After completing the modifications, we sent the modified 3D model to a specializedcompany for printing. It took approximately two months to receive the printed parts.

4.6.2 Assembly of the Robotic Arm:

1- **Assembling the Base**: The first motor was attached to the base using the screwsprovided in its package.

2- **Assembling the Upper Parts** :The upper parts were attached to the motor usingscrews.

3- **Assembling Subsequent Motors**: The same process was repeated for the subsequentmotors and parts

4- **Supporting the Shoulder Axis :** A rubber band was used to support the motor at theshoulder axis to ensure structural stability

1- **Assembling the Gripper Mechanism** : The gripper mechanism was assembled usingbolts and nuts

2- **Completing the Arm Assembly** : After attaching the gripper mechanism, theassembly of the robotic arm was completed.

Figure 4.6 : Stages of Assembling the Arm

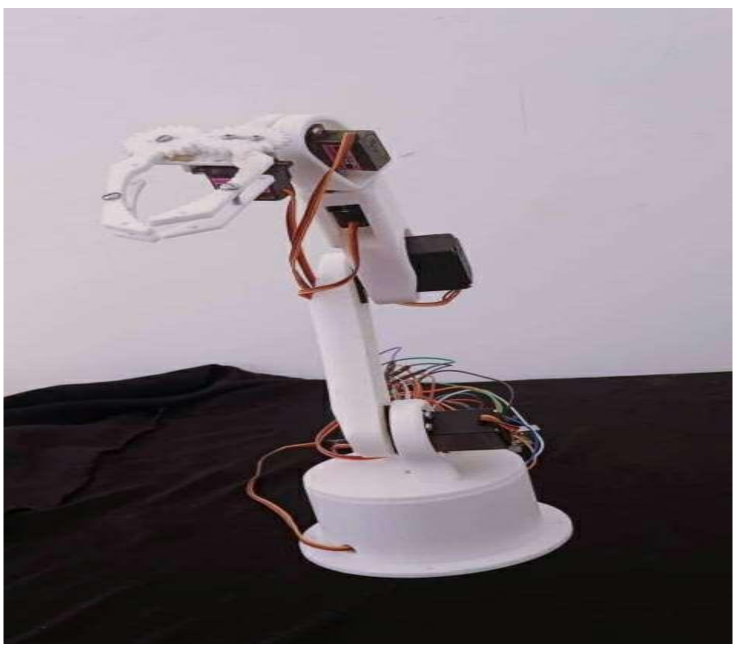


Figure 4.7 : The Arm after the assembling

4.6.3 Electrical Connections for the Robotic Arm

1- **Connecting the Arduino to the Motors** : Signal wires from the motors were connected to theappropriate pins on the Arduino.

2- Connecting the Power Supply: The positive and negative lines of the power supply wereconnected, and the power wires from the motors were connected accordingly.

3- Grounding Between Arduino and Power Supply: The ground (GND) on the Arduino was connected to the ground rail on the breadboard to ensure a stable commonground.

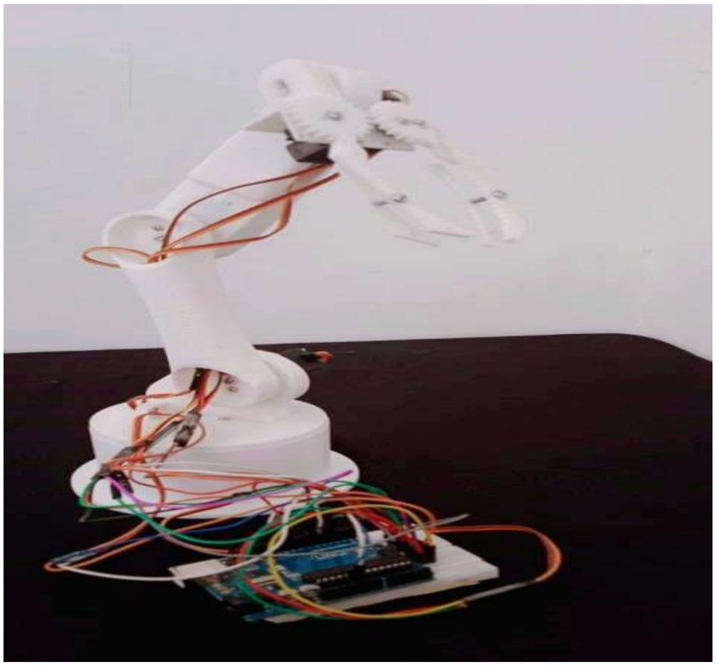


Figure 4.8 : the final form of The Arm

4.7 Software Implementation for the Robotic Arm

1. **Writing the Initial Arduino Code**:

The initial code was written to test the arm and ensure the motors functioned correctly.

2. **Including the Servo Library**:

The Servo library was included at the beginning of the code.

3. **Defining Variables and Motors**:

Necessary variables to store the positions of the motors were defined.

4. **Setting Up Motors in the setup Function**:

Motors were set up and connected to the appropriate pins in the setup function.

5. **Writing the loop Function**:

The code was written in the loop function to update the motor positions based on new inputs.

4.8 Final Results of the Robotic Arm

Despite following an organized process in assembling the robotic arm, connecting the electrical circuits, and implementing the programming, we were unable to achieve the desired result due to the poor quality of the 3D printed parts. This significantly affected thearm's ability to perform the required tasks.

4.9 How do we combine a line-following robot with a robotic arm?

In these steps, we will explain the method we will use to combine a line-following robot with a robotic arm using Raspberry Pi Pico and the Robot Operating System (ROS) to achieve an advanced robot. This integration allows us to leverage the flexibility and control power of ROS with the capabilities of Raspberry Pi Pico, providing a comprehensive and efficient solution.

- **Setting Up Raspberry Pi Pico**:

1. Installing MicroPython:

- Download the latest version of MicroPython.
- Connect the Raspberry Pi Pico to the computer via USB while holding the BOOTSEL button.
- Copy the MicroPython firmware file to the Raspberry Pi Pico storage.

2. Setting Up ROS Workspace:

- Install ROS following the official documentation.
- Create a ROS workspace.
- Source the setup file.

- **Converting Arduino Code to MicroPython for Raspberry Pi Pico**

1. Understanding Arduino Cod

- Review the logic and functions used in the code.

2. Rewriting the Code in MicroPython:

- Create a new script in Thonny IDE
- Translate Arduino functions to MicroPython, ensuring compatibility with Raspberry Pi Pico's GPIO pins.

1.Testing the MicroPython Code

- Run the script and test its functionality.

- **Integrating with ROS**

1. Creating ROS Node for Communication:

- Create the project package in the ROS workspace.
- Write a ROS node in Python to handle serial communication.

2. Setting Up Serial Communication:

- Ensure the correct serial port is used.
- Modify the MicroPython script to send data.

3. Running and Testing the Integration:

- Run the MicroPython script on the Raspberry Pi Pico.
- Run the ROS node.
- Verify the communication between Raspberry Pi Pico and ROS.

By following these steps, you can convert Arduino code to work on a Raspberry Pi Picoand integrate it with ROS, enabling better robot development, improved control, and enhanced results.

4.10 Conclusion

Despite facing numerous challenges and encountering several negative results throughout the project, our diligent efforts and in-depth research into problem-solving strategies have led us to achieve acceptable initial results. These results represent a promising start in developing the pharmacy robot, especially for us as beginners in this field. Future steps will focus on enhancing both hardware and software components to ensure the robot operates with high efficiency and accuracy. With these improvements, the pharmacy robot will be capable of performing complex tasks reliably and efficiently, contributing to better pharmacy operations and improved patient service.

Chapter 5:

Pharmacy Robot and Artificial Intelligence

5.1 Introduction

In this chapter, we will provide a comprehensive and detailed study of artificial intelligence and its fundamental components, with a specific focus on its application in developing a pharmacy assistant robot. We will review the main components of artificial intelligence, such as machine learning, natural language processing, and computer vision, and explain how these technologies integrate to enhance the efficiency and accuracy of pharmaceutical operations. We will identify the specific requirements for using artificial intelligence in the pharmacy robot system and discuss the anticipated benefits of applying these technologies in this context. We will delve into the various practical applications of artificial intelligence in our pharmacy robot project and illustrate how these technologies can be effectively implemented to achieve the desired goals. Finally, we will summarize the overall benefits of using artificial intelligence in developing pharmacy technology, including improving operational efficiency, increasing the accuracy of processes, reducing human errors, and enhancing customer experience.

5.2 Artificial Intelligence and Its Main Components

Artificial Intelligence (AI) is a field in computer science focused on developing systems capable of performing tasks that require human intelligence. These tasks include learning, understanding, interacting, and adapting to new data. AI can be divided into several main components [17], including:

5.2.1 Machine Learning (ML) :

Machine learning is a branch of AI that relies on developing algorithms that enable systems to learn from data and discover patterns. It includes several approaches such as:

- **Supervised Learning**: In supervised learning, the model is trained using labeled data. The model learns from this data and makes predictions based on

- **Unsupervised Learning**: In unsupervised learning, the model is trained on unlabeled data, where it tries to discover patterns and relationships in the data without human supervision.[19]
- **Reinforcement Learning**: Reinforcement learning relies on training systems through trial and error, where the model learns by interacting with the environment and receiving rewards or penalties based on its actions.[20]
- **Deep Learning (DL)**: Deep learning is a subset of machine learning that uses deep neural networks with many layers to analyze and learn from large amounts of data. It excels in discovering intricate patterns and representations in the data.[21]

5.2.2 Natural Language Processing (NLP)

Natural Language Processing aims to enable machines to understand and generate humanlanguage. NLP applications include:

- **Linguistic Analysis**: Linguistic analysis involves parsing texts to extract linguisticinformation such as sentence structure and meaning analysis. [22]
- **Machine Translation**: Machine translation aims to translate texts from one language to another using machine learning techniques and deep neural networks. [23].
- **Question Answering**: This application enables machines to understand questions posed by humans and provide accurate and appropriate answers based on analyzingavailable texts.[24]

5.2.3 Computer Vision

Computer vision deals with enabling machines to understand and analyze images andvideos. Computer vision applications include:

- **Pattern Recognition**: Pattern recognition involves analyzing images to detect andidentify various patterns and shapes.[25]
- **Tracking**: Tracking is used to monitor the movement of objects in images or

videos, which is useful in applications such as surveillance and human interaction.[26]

- **Classification**: Classification involves identifying and categorizing objects in images into predefined categories. [27]

5.3 Most Prominent AI Applications in Pharmacy Technology Today

Pharmacy technology has seen significant advancements thanks to the use of artificial intelligence, leading to improved operational efficiency and accuracy in pharmaceutical services. Here, we will discuss three of the most prominent AI applications in pharmacy technology, providing a technical explanation for each

5.3.1 Intelligent Inventory Management Systems

Intelligent inventory management systems are vital applications in modern pharmacies, leveraging advanced AI techniques to enhance inventory management processes. These systems include the following technical elements:

- **Machine Learning**: Machine learning algorithms analyze historical data related to drug demand, enabling the system to accurately predict future needs. This technology helps improve storage processes and reduce drug wastage.
- **Computer Vision**: This technology uses cameras and sensors to monitor inventory levels in real-time. The system can analyze images and videos to determine the quantity of available drugs and automatically update the data, reducing the need forhuman intervention.
- **Big Data Analytics**: Analyzing large volumes of data related to pharmaceutical and health operations can uncover patterns and trends, aiding in better planning and data-driven decision-making. This analysis helps pharmacies better manage demand fluctuations and ensure the availability of essential drugs at all times.

5.3.2 Diagnostic and Drug Recommendation Systems

Diagnostic and drug recommendation systems use AI techniques to provide accurate and effective drug recommendations based on input symptoms and the patient's medical history. These systems include the following technical elements:

- **Natural Language Processing (NLP)**: This technology enables systems to analyze medical texts and health conversations to understand the medical context and provide evidence-based recommendations. NLP is used to interpret and understand textual or voice inputs from patients, guiding them towards appropriate medications.
- **Deep Neural Networks**: This technology relies on building deep learning models to analyze large health data sets and discover complex patterns that indicate appropriate medical diagnoses. These models help provide accurate drug recommendations based on a comprehensive analysis of available health information
- **Reinforcement Learning**: This technique trains models to continuously improve their recommendations by interacting with new data and user feedback. The systemenhances its performance over time by learning from past experiences and adjusting its strategies based on outcomes.

5.3.3 Automated Pharmacy Robots

Automated pharmacy robots are advanced applications in pharmacy technology, relyingon a combination of AI techniques to enhance the efficiency and accuracy of daily pharmaceutical operations. These systems include the following technical elements:

- **Computer Vision**: This technology enables robots to accurately identify drugs and pharmaceutical components by analyzing images and videos. Robots can use this data to perform tasks such as identifying the correct medications and preparing themfor dispensing.
- **Autonomous Robotics**: This involves designing robotic systems capable of

performing routine tasks such as drug filling and dispensing without human intervention. These systems enhance efficiency and reduce medication errors by automating processes.

- **Process Automation**: This technology uses AI to automate various pharmaceutical processes such as prescription preparation and quality monitoring. This contributes to improving the accuracy of operations and reducing the time required to complete tasks, thereby enhancing the quality of pharmaceutical services provided.

5.4 Applications of Artificial Intelligence in Our Project

In our project to develop an intelligent pharmacy robot, we aim to leverage artificial intelligence applications to enhance the efficiency and accuracy of pharmaceutical operations. The focus will be on using machine learning, natural language processing, and computer vision technologies to achieve effective integration between the different system components. This integration will contribute to improving inventory management, drug distribution, and providing accurate medical consultations. Below, we will outline the details of these applications and the methods of integrating them in a systematic and studied manner to achieve our goals efficiently

5.4.1 Scanning of the medical prescription

We aim to develop a system that scans handwritten medical prescriptions optically and analyzes their data accurately, using artificial intelligence techniques to enhance the efficiency and accuracy of pharmaceutical operations. This system will help convert handwritten texts into digital data that is analyzable and interpretable.

1. **Optical Character Recognition (OCR) :** Optical Character Recognition (OCR) technology is used to extract text from handwritten medical prescriptions with high accuracy, using advanced algorithms for image analysis. This technique handles complex texts or handwriting that is difficult to read.

2. **Natural Language Processing (NLP):**Natural Language Processing (NLP) techniques are used to understand and analyze the medical texts extracted from OCR, including identifying medical terms, interpreting medical sentences, and analyzing dosages and instructions. These texts are converted into digital data that can be processed efficiently.

3. **Deep Learning:**Deep Learning employs deep neural networks to analyze complexmedical texts, including handwritten ones. These networks are trained on large datasets to improve recognition accuracy and better understand medical contexts.

5.4.1.1 Training the System on Difficult Medical Texts:

Improving the system's understanding of medical texts written in diverse styles requires collecting and expanding diverse datasets. It is essential to gather a large set of medical prescriptions written in various fonts, totaling approximately 10,000 prescriptions, to train the system. Supervised Learning utilizes this extensive dataset to enhance text recognition accuracy and correctly classify medical terms and phrase This expansion of the dataset helps the system better understand and interpret medical texts, thereby enhancing its abilityto handle challenges related to diverse writing styles in the medical field.

5.4.2 Sorting medicines and determining their locations

We are utilizing artificial intelligence technologies to enhance the processes of organizing medications and identifying their locations after extracting data from medical prescriptions through optical scanning and analysis. This initiative aims to facilitate the selection and distribution of medications within pharmacy environments with high efficiency and increased accuracy.

1. **Data Collection** : Using data processing techniques, we collect comprehensive information about medications, such as names, therapeutic categories, expiration dates, andusage frequency from various databases and pharmaceutical systems.

1. **Pattern Analysis :** We employ machine learning algorithms to analyze the collected data. Models are trained on historical medication data to identify usage patterns and predictdemand, focusing on medications frequently used together.
2. **Medication Arrangement Optimization** : Clustering algorithms are applied to organize and classify medications into homogeneous groups based on identified patterns. Algorithms like K-means help group medications with similar characteristics together, classifying them by medical importance and usage frequency.
3. **Shelf Space Allocation :** Operations optimization algorithms are used to allocate specific shelf locations for each group of medications. The genetic algorithm is employed to analyze available shelf space and assign locations based on analysis and demand prediction results, facilitating access and improving efficiency.
4. **Determining Medication Locations After Prescription Analysis:** We use search and classification algorithms to determine the exact locations of medications after analyzing a prescription. The system references the database to locate each medication. Binary Search or Decision Trees algorithms are applied to identify the correct shelf and precise location for each medication.
5. **Continuous Database Updating:** Iterative learning is applied to continuously update the database with new data and actual medication usage, helping to improve prediction accuracy and adapt to ongoing changes.

5.4.3 Guiding the Automated Robot for Medication Dispensing

After analyzing the prescription and identifying the required medications and their locations on the shelves, commands are sent to the mobile automated robot. The robot uses internal navigation systems to reach the specified locations of the medications on the shelves. Upon reaching the designated location, the robot verifies the correct medications using verification techniques such as barcode scanning or RFID reading.

After collecting the required medications and verifying them, the robot delivers the medications to the designated dispensing point for the customer, either directly handing over the medications to the customer or placing them in a special container for pickup, ensuring the dispensing process is documented in the system

5.4.4 Inventory Management

Managing medication inventory effectively is crucial to ensure the availability of essential drugs and prevent stockouts. Artificial intelligence can be used to achieve this goal by periodically analyzing inventory data and providing alerts when inventory levels reach critical thresholds. This is done through the following steps:

1- Data Collection: Inventory data is continuously collected, including quantities, daily usage rates, expiration dates, and supply data, using sensors and inventory management systems to automatically update and ensure accuracy.

2. Predictive Data Analysis : Analyze the collected data using machine learning algorithms such as neural networks and decision trees to identify patterns in medication usage and predict future demand, improving forecast accuracy.

3. Forecasting Future Needs: Use predictive models to estimate the required quantitiesof medications based on current and historical usage, updating these models periodically to ensure their accuracy and relevance to changes.

4. Inventory Alerts : Provide automatic alerts when inventory drops to 10% of the total quantity via system notifications, email, or text messages, alerting staff to take necessary actions.

5.5 Benefits of Using Artificial Intelligence in Developing P T

Using artificial intelligence in developing pharmacy technology offers numerous benefits, including:

- Reducing the Burden on Pharmacists
- Saving Time

- Enhancing Customer Experience
- Increasing Operational Efficiency and Accuracy
- Reducing Error Rates
- Fraud and Error Detection.

5.6 The website for our project

The HANYAPHARMA website is the main and only website for our project, "Pharmacy Robot Assistant," which we have named HANYAPHARMA. The website serves as a direct communication page between the customer and the pharmacy, offering innovative services using advanced artificial intelligence techniques. These services include prescription reading, medication identification, and linking to a database to provide precise advisory services regarding consumed medications.

- **Page 1 Home**

Welcome to HANYAPHARMA! We are here to provide comprehensive services for your medical and pharmaceutical needs.

- **Prescription Scanning**

You can now easily scan your prescription through our website, where the list of required medications will be sent to the robot to fetch them quickly and efficiently

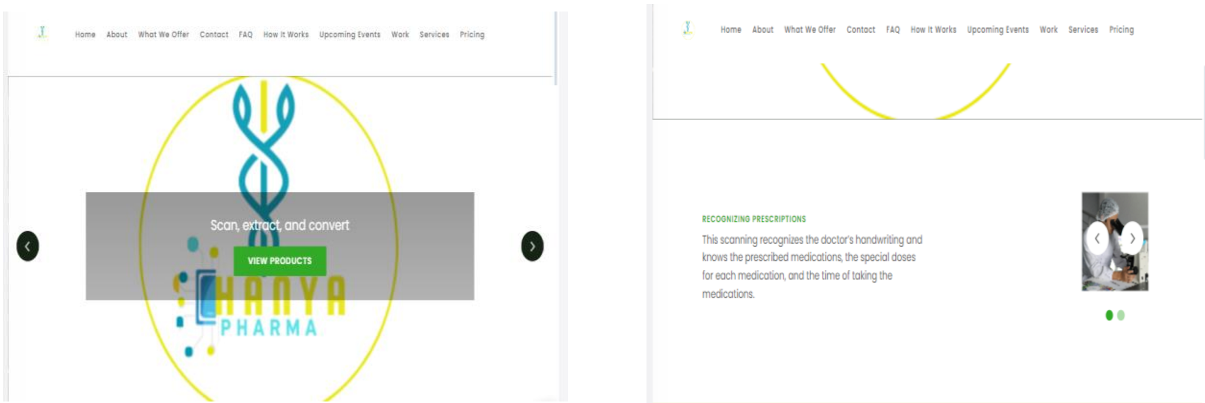


Figure 5.1 : Prescription Scanning

- **Medication Information and Usage Instructions**

  A comprehensive page containing detailed information about medications, appropriate dosages, and usage precautions to ensure safe and effective use.

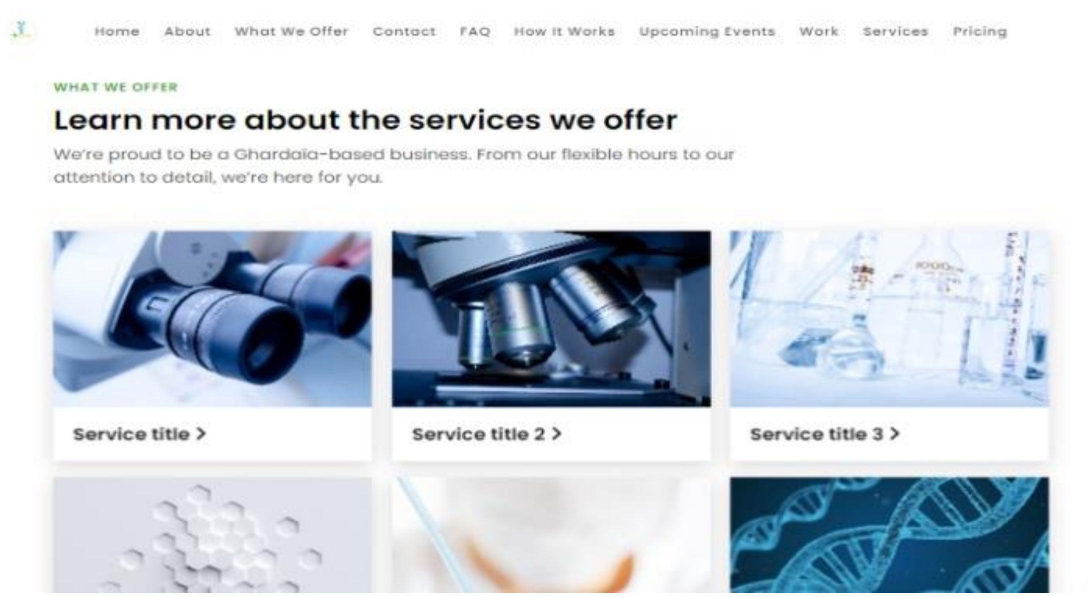


Figure 5. 2: Safe Medication Guide

- **Advisory Space for Medications and Dosages**

  Comprehensive advisory services for medications, dosages, usage precautions, and contraindications, connecting the consumer directly with the pharmacy or HANYAPHARMA.

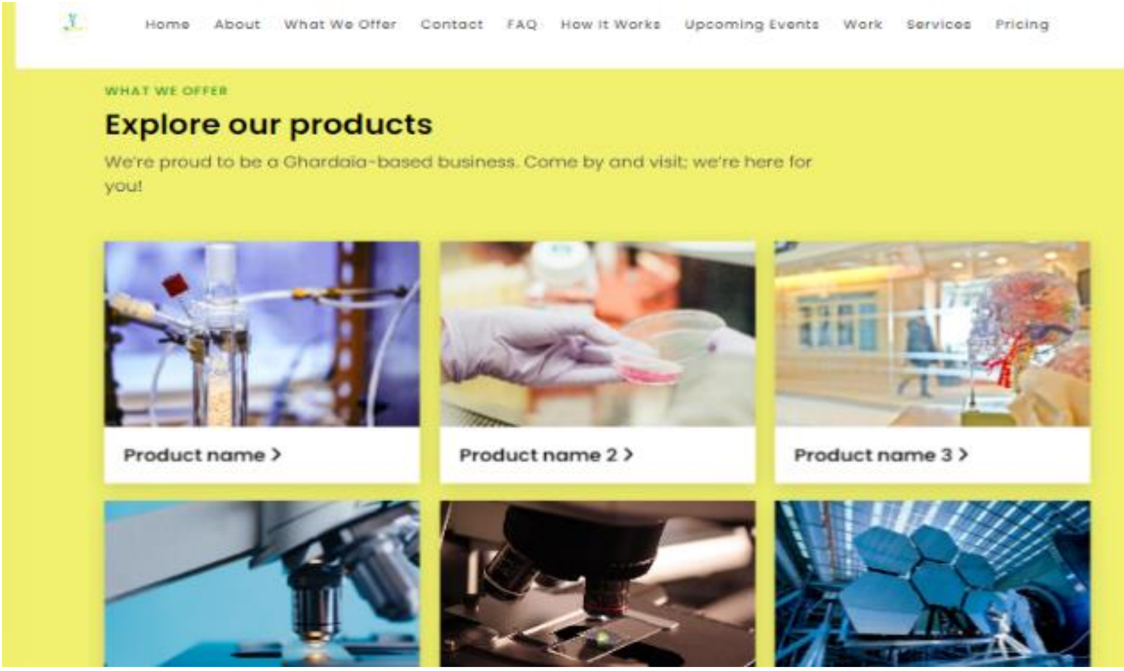


Figure 5.3 : Exploration product

We also in the same page can :

- **Advertising Space for Parapharmaceuticals**

We offer a wide range of parapharmaceutical products. Browse our products and get the best deals.

- Users can communicate with the pharmacist through the advisory section that connects the pharmacy, the customer, the consumer, and the company

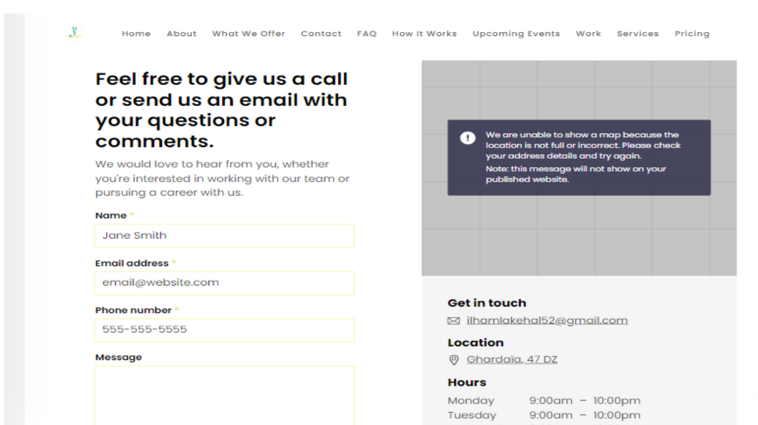


Figure 5 4.: **Customer Service**

5.7 Conclusion

In conclusion, the integration of artificial intelligence into pharmacy technology significantly enhances the efficiency and accuracy of pharmaceutical operations. By leveraging advanced techniques such as machine learning, natural language processing, and computer vision, AI-driven systems can streamline inventory management, optimize medication dispensing, and improve patient consultation services. These advancements not only reduce the operational burden on pharmacists but also enhance the overall customer experience by minimizing errors and ensuring the availability of essential medications. Thus, the application of AI in pharmacy represents a critical step towards more efficient, accurate, and patient-centric pharmaceutical services.

General Conclusion

General Conclusion

In the context of rapid technological evolution, pharmacies are facing increasing challenges, exacerbated by the COVID-19 pandemic, which has highlighted enormous pressures and difficulties in managing the increased demand for medications. To alleviate this burden and ensure greater precision in daily operations, our project proposes to modernize pharmacies through the integration of robots and artificial intelligence systems. These technologies enable the automation of numerous tasks such as sales, monitoring, and data entry, reducing the human effort required, minimizing the risk of errors, and ensuring a high level of efficiency and productivity to meet customer needs.

The project relies on several advanced technologies:

- Optical Character Recognition (OCR): This technology is used to read the text of scanned prescriptions, employing various techniques such as segmentation, character recognition, and error checking. Natural Language Processing (NLP) technology is then applied to analyze the prescription and extract the necessary information, such as the name of the medication and the dosage.

- Database Search: Once the required medications are identified, the search is carried out directly in the system's database, which is updated periodically. This allows for the precise location of medications on the shelves, using search techniques such as Structured Query Language (SQL) and indexing.

- Medication Collection: After exactly locating the medications, the system sends instructions to the pharmacy robot to collect and package the necessary medications.

- Payment: This can be done using traditional methods such as cash payments, bank cards, insurance cards, and mobile payment applications. A transaction confirmation is then sent to the client.

Our project brings significant added value:

- Reading and analyzing prescriptions using OCR and artificial intelligence technology.

- Using the screen as advertising space for medications and parapharmaceutical products.

- Collecting and verifying medications by automatic robots.

- Developing the screen as a space for consumer complaints and a direct platform to connect citizens with the Ministry of Health and pharmaceutical and parapharmaceutical product distributors in terms of quality.

- The possibility of payment by all known methods.

- Developing the robot for segmentation tasks, such as organizing and arranging shelves.

- Regular monitoring of medication stock, between remaining and sold medications.

In conclusion, our project proposes a radical transformation of pharmaceutical operations by combining technological innovation and artificial intelligence to meet current and future challenges, while improving the efficiency and quality of services provided to clients.

Future Work

To optimize smart pharmacies, future work will include improving OCR algorithms through machine learning, developing sophisticated AI systems for personalized recommendations, integrating blockchain for data security, expanding robotic capabilities for stock management and client interaction, and using predictive analytics to anticipate medication demand trends. These advances aim to enhance the efficiency, precision, and quality of pharmaceutical services.

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Appendix

A. Project Timeline

February 2024 :

- **Week 1***:* Initiation of brainstorming sessions and defining the main objectives of the project, along with the preliminary designs of the robot and identifying and ordering the required components.
- **Week 2***:* Gathering information and researching assembly and programming methods.
- **Week 3**: Arrival of components and starting the assembly of the line-following robot. This includes assembling the chassis and installing the motors and wheels.
- **Week 4:** Connecting the electrical components and conducting initial tests. Problems were discovered with the L298N motor, which was replaced with an L293D motor, followed by redesigning the electrical circuits and reprogramming the robot.

March 2024 :

- **Week 1***:* Modifying the design of the robot arm using SolidWorks and sending the model for 3D printing.
- **Week 2***:* Beginning the development of the robot's scanning system.
- **Week 3***:* Working on the technical documentation of the project

April 2024 :

- **Weeks 1 and 2***:* Programming the Robot Operating System (ROS) and integrating the system with the robot components.

May 2024 :

- **Week 1***:* Arrival of the robot arm structure and beginning its assembly.
- **Week 2***:* Connecting the electrical components of the robot arm.
- **Week 3***:* Writing the initial code to test the robot arm and ensuring the functionalityof the motors.

B. Challenges

Challenges We Faced During the Project

1. Component Compatibility:

Ensuring compatibility between different mechanical, electrical, and software componentswas a major challenge. This required careful selection and testing of parts to ensure they worked together without causing system failures or performance issues. Identifying the best components and coordinating them required precise knowledge and additional time.

2. Time Management:

Balancing project requirements with time constraints was a significant challenge. Efficient time management to meet deadlines required meticulous planning and prioritization. Unforeseen problems necessitated rescheduling activities and reallocating tasks.

3. Financial Constraints:

Managing the project budget was challenging due to the high cost of some components.We had to find cost-effective alternatives without compromising the quality and performance of the robot. This required extensive research to select the most optimal components in terms of performance and cost.

4. Quality of Electrical Components:

We faced ongoing issues with the quality of available electrical components, in replacing faulty components and retesting the system.

5. Programming:

We encountered significant difficulties in writing the programs due to our inexperience with programming languages. This posed major challenges in researching, learning, and applying new knowledge to efficiently program the system. We had to invest a considerable amount of time in improving our programming skills to ensure the system operated as intended.

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Université de Ghardaïa

غرداية في: 2024/09/15

إذن بالطباعة (مذكرة ماستر)

بعد الاطلاع على التصحيحات المطلوبة على محتوى المذكرة المنجزة من طرف الطلبة التالية أسماؤهم:

1. الطالب (ة): الأكحل إلهام
2. الطالب (ة): ريغي مروة

تخصص: آلية وأنظمة

نمنح نحن أعضاء لجنة المناقشة:

الإسم واللقب	الرتبة	المؤسسة الأصلية	الصفة	الإمضاء
فيها خير أمين مهدي	MCB	جامعة غرداية	الممتحن 1	
/	/	/	الممتحن 2	/
حسن ناصر	MCA	جامعة غرداية	المؤطر	
بوخاري حامد	MCB	جامعة غرداية	رئيس اللجنة	

الإذن بطباعة النسخة النهائية لمذكرة الماستر الموسومة بعنوان:

Pharmacy Assistant Robot

إمضاء رئيس القسم

العلمي عبد اللطيف
رئيس قسم الآلية
و الكهروميكانيك

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