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A PROJECT REPORT ON

MiniMech - A Multifunctional Humanoid Robot

submitted in partial fulfilment of the requirements for the award of the degree of

Bachelor of Technology

in

Electronics and Communication Engineering

By

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BONAFIDE CERTIFICATE

This is to certify that the project titled **MiniMech - A Multifunctional Humanoid Robot** is a bonafide record of the work done by

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in partial fulfilment of the requirements for the award of the degree of Bachelor of Technology in Electronics and Communication Engineering of the INDIAN INSTITUTE OF INFORMATION TECHNOLOGY UNA, HIMACHAL PRADESH, during the year 2024-2025.

under the guidance of

Dr. Nikunj Goyal

Project viva-voce held on: __09/12/2024__

Internal Examiner External Examiner

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ABSTRACT

MiniMech is a multifunctional humanoid robot designed to perform basic human-like gestures and interact with its environment through various sensors. The robot is equipped with a **DHT11 sensor** to measure temperature and humidity, a **PIR sensor** for motion detection, an **ultrasonic sensor** for obstacle avoidance, and a **gas sensor** to monitor air quality. The robot's movements, powered by **7 servo motors**, allow it to perform gestures such as waving, pointing, and lifting. The **LCD display** shows real-time environmental data, making the robot informative and interactive. Bluetooth connectivity enables the robot to be controlled remotely via a smartphone, providing flexibility and ease of operation.

MiniMech is designed for practical applications such as personal assistance, home security, and educational demonstrations. Its ability to monitor environmental conditions, detect motion, and avoid obstacles makes it a useful tool for everyday tasks. The integration of dynamic arm gestures adds a human-like quality to the robot, enhancing user interaction. By combining these features into a single platform, MiniMech highlights the potential of robotics to assist in both household and professional environments, showcasing how humanoid robots can contribute to a safer, more efficient world.

Keywords: *Humanoid robot; gesture control; environmental monitoring; Bluetooth; obstacle detection; servo motors*

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TABLE OF CONTENTS

Title	Page No.

LIST OF ABBREVIATIONS

IoT	Internet of Things
MQ	Metal Oxide Semiconductor
DHT	Digital Humidity and Temperature
PIR	Passive Infrare

LIST OF TABLES

LIST OF FIGURES

Chapter 1

Introduction

The **MiniMech** project combines humanoid robotics with interactive features, focusing on environmental monitoring, gesture-based control, and obstacle detection. By integrating **DHT11** for temperature and humidity measurement, **PIR** motion detection, **ultrasonic** sensors for distance measuring, and a **gas sensor** for air quality, MiniMech provides a multifunctional solution. The robot's movement is powered by **7 servo motors** for dynamic arm gestures such as waving, pointing, and lifting. Controlled via Bluetooth, MiniMech is designed to be both a practical assistant and an educational tool, offering real-time sensor data displayed on an **LCD**. With the addition of **Bluetooth** connectivity for remote control, MiniMech presents a user-friendly and innovative approach to humanoid robotics for home and professional environments.

1.1 Background

- The field of humanoid robotics has rapidly advanced, allowing robots to perform tasks and interact with humans in increasingly sophisticated ways.
- By integrating sensors, microcontrollers, and actuators, humanoid robots like MiniMech are designed to mimic human movements and respond to environmental stimuli, bringing automation and interactivity to everyday life.
- With the integration of technologies such as DHT11 for environmental sensing, PIR and ultrasonic sensors for motion detection and navigation, and Bluetooth for remote control, MiniMech offers a comprehensive solution for automation and human-robot interaction. This project showcases how combining robotics with sensory feedback and control systems can enhance convenience, safety, and communication within home or workplace environments.

1.2 Motivation

- The growing interest in humanoid robots and automation has driven the need for advanced systems that can enhance human interaction, improve household efficiency, and ensure safety.
- MiniMech aims to empower individuals by integrating robotics with everyday tasks, offering advanced tools to assist in environmental monitoring, security, and human-robot interaction.

- The project fosters innovation in the field of robotics, showcasing how integrating gesture-based control, sensor feedback, and Bluetooth communication can transform the way humans interact with machines.
- By providing a humanoid robot capable of interacting with its surroundings and responding to user commands, MiniMech seeks to shape the future of intelligent living spaces, making them more efficient, secure, and user-friendly.

1.3 Objectives

- Develop a multifunctional humanoid robot, MiniMech, that integrates advanced sensors, actuators, and communication technologies for dynamic interaction and task automation.
- Utilize cutting-edge sensors such as DHT11, PIR, ultrasonic, and gas sensors, along with the Arduino Mega 2560 and Bluetooth for seamless control and data management, creating an adaptable and efficient system for real-world applications.
- Implement interactive features like gesture-based control and environmental monitoring to enhance user experience and improve home or workplace safety, with the ability to customize behavior through Bluetooth connectivity.
- Optimize firmware and user interfaces to ensure smooth operation, easy control, and real-time feedback on environmental conditions via the LCD display.
- Conduct comprehensive testing to assess performance, sensor accuracy, and robotic interaction under various scenarios, ensuring reliability and scalability for practical use.
- Provide recommendations for future enhancements, including potential integration with AI for advanced human-robot interactions, contributing to the ongoing development of humanoid robotics and automation..

1.4 Significance

- MiniMech aims to revolutionize humanoid robotics by creating an intelligent and interactive system that enhances user experience, safety, and convenience in various environments, including homes and workplaces.
- The project contributes to the advancement of robotics technology, demonstrating the potential for adaptable, multifunctional robots that can seamlessly integrate into everyday tasks such as environmental monitoring, security, and automation.

- By combining gesture-based control, real-time environmental sensing, and Bluetooth connectivity, MiniMech enables new opportunities for innovation in areas like human-robot interaction, data analysis, and robotic autonomy, advancing the field of robotics and smart living.
- The project also serves as an inspiration for future engineers, researchers, and innovators to explore and contribute to the ongoing development of robotics, shaping the future of interactive and intelligent technologies.

1.5 Scope

- Design, develop, and implement MiniMech, a sophisticated humanoid robot that integrates advanced sensor technologies, robotic actuators, and communication systems to enhance user interaction, environmental monitoring, and security.
- Focus on creating a modular and extensible architecture that can adapt to a variety of sensors and actuators, allowing the system to evolve with future technologies and user needs.
- Explore innovative approaches to user interaction and gesture-based control, improving user experience by offering intuitive, real-time control and feedback via Bluetooth connectivity and an interactive LCD display.
- Collaborate with industry experts, academic researchers, and community stakeholders to test and refine the robot's capabilities, gather user feedback, and identify opportunities for enhancement and further integration.
- Document the project's findings, insights, and recommendations through academic publications, technical reports, and public demonstrations to contribute to the ongoing development of humanoid robotics and influence future research and innovations in smart robotics applications.

Chapter 2
Review of Literature

2.1 Introduction to MiniMech Technology

- MiniMech is a humanoid robot designed to walk, perform gestures, and potentially recognize voice commands.
- It utilizes components like Arduino Mega AT, servos, and wireless communication modules for its functionalities.
- The project aims to explore advancements in robotics and AI, with scope for future enhancements in automation.

2.1.1 IoT Technologies in MiniMech

- Introduction to MiniMech and its integration with IoT for enhanced functionality and remote control.
- Explanation of IoT components used in MiniMech, such as sensors, actuators, and communication modules for movement and voice recognition.
- Overview of communication protocols (e.g., Bluetooth, Wi-Fi) used for controlling MiniMech and enabling interaction with other devices.

2.1.2 MiniMech Automation and Security

- Importance of MiniMech automation in enhancing user control through wireless communication and voice commands.
- Discussion on automation technologies used in MiniMech, including servo motors for gestures and Arduino Mega AT for controlling movements.

- Overview of security features in MiniMech, focusing on secure Bluetooth communication for remote access and control.

2.2 User Interaction in MiniMech

- Integration with Bluetooth modules for communication and potential expansion with virtual assistants.
- Evaluation of user interaction methods for MiniMech, gestures, and remote control via mobile apps.

2.2.1 Cloud Connectivity and Remote Monitoring in MiniMech

- Role of cloud computing in MiniMech for data storage, processing, and enabling remote control via IoT modules.
- Overview of cloud-based platforms like IoT cloud services used for managing MiniMech's connectivity and functionality.
- Discussion on remote monitoring capabilities for MiniMech, enabling real-time control and status updates through mobile apps or cloud interfaces.

2.2.2 User Experience and Design Considerations for MiniMech

- Importance of user-centric design principles in MiniMech, ensuring ease of use and accessibility for controlling the robot.
- Overview of user interface design for MiniMech, focusing on intuitive voice control and mobile app interfaces for seamless interaction.
- Evaluation of UX design strategies for MiniMech, focusing on responsiveness, accessibility, and ensuring a smooth user experience with voice and gesture controls

2.3 Currently Available Solutions for MiniMech

- Review of existing robotic systems similar to MiniMech, focusing on humanoid robots and their functionalities for automation and interaction.
- Analysis of popular platforms for controlling robots like MiniMech, including integration with IoT cloud platforms and mobile apps for seamless control.
- Comparison of MiniMech's features with other leading robotics solutions, focusing on automation, mobility, and voice control capabilities.

2.3.1 Integration of Sensors and Actuators in MiniMech

- Overview of sensor types used in MiniMech, such as motion sensors and proximity sensors, for enhancing automation and interactivity.
- Evaluation of sensor fusion techniques and data analytics methods to improve MiniMech's movement, recognition, and response accuracy.
- Discussion on integrating sensors and actuators for advanced functionalities in MiniMech, such as gesture recognition and wireless communication.
- Exploration of the role of actuators in MiniMech, focusing on how servo motors and other mechanical components enable precise movements and gestures.

2.4 Emerging Trends and Future Directions for MiniMech

- Exploration of emerging trends in robotics and automation, focusing on humanoid robots like MiniMech and their integration with AI and IoT for enhanced functionalities.
- Discussion on the potential integration of artificial intelligence (AI) and machine learning (ML) in MiniMech for improved voice recognition, decision-making, and adaptive behavior.

- Future directions for MiniMech, including advancements in AI-driven gesture recognition, enhanced mobility, and the development of smarter, more autonomous features.

2.5 Research Papers

Some of the research papers are as follows:

Table 1: Table of literature of Research Papers

TITLE	YEAR	KEY FINDINGS	REFERENCE NO.
Toward interactive humanoid robots: Synthetic approach for understanding human communication	2004	The development of **interactive humanoid robots** has significantly advanced, allowing for more natural human-robot communication..	[2]
A universal stability criterion of the foot contact of legged robots - Adios ZMP	2006	The research presents a universal stability criterion for legged robots, focusing on balance and stability.	[3]
Development of a Bluetooth-based communication system for small robot control	2008	Development of a Bluetooth-based communication system for small robot control	[4]
Sensor fusion for detecting human activities with wearable sensors	2018	Highlighted the effectiveness of combining multiple sensors to detect activities.	[5]

2.6 CONCLUSION for MiniMech

In conclusion, the review of literature has provided valuable insights into the evolution and current state of robotics and automation, emphasizing the significant role of IoT integration, voice control, and Arduino-based systems in enhancing the functionalities of humanoid robots like MiniMech. By synthesizing key findings from various sources, this review sets the stage for the development of MiniMech as a comprehensive solution, poised to improve user interaction, automation, and security while paving the way for future advancements in AI and machine learning.

Chapter 3

Methodology

3.1 System Architecture

The system architecture of MiniMech integrates an Arduino Mega 2560 microcontroller with sensors like DHT11, PIR, ultrasonic, and MQ2 for environmental monitoring and obstacle detection. 7 servo motors enable dynamic arm gestures, while DC motors provide mobility. A Bluetooth module (HC-05) allows remote control, and an LCD display shows real-time data, creating a seamless and interactive system

3.1.1 Arduino Mega 2560

The **Arduino Mega 2560** serves as the central controller for **MiniMech**, interfacing with various sensors and actuators. It processes data from the **DHT11**, **PIR**, **ultrasonic**, and **MQ2 sensors**, controlling the **7 servo motors** for arm gestures and **DC motors** for movement

Additionally, it integrates with the **HC-05 Bluetooth module** for remote commands and the **LCD display** for real-time feedback, ensuring seamless operation and functionality.

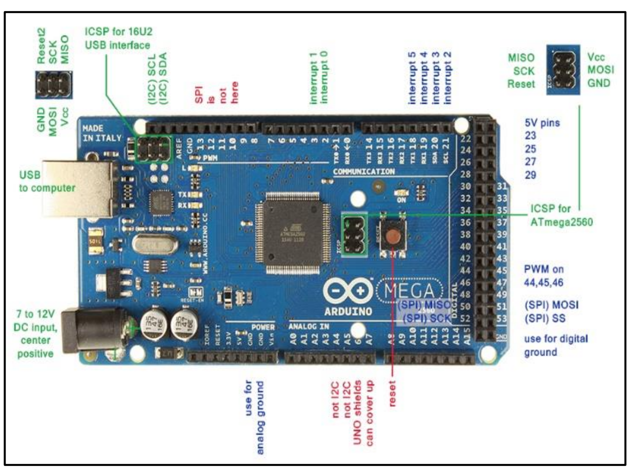

Figure 1:Arduino Mega

3.1.2 Bluetooth Module (HC-05)

The HC-05 Bluetooth module is a reliable communication interface that allows MiniMech to connect wirelessly to a smartphone or other Bluetooth-enabled devices. It facilitates remote control of the robot's functions, including movement, gestures, and sensor data monitoring. The module's simplicity and compatibility with the Arduino Mega 2560 make it an essential component for ensuring seamless interaction and user control.

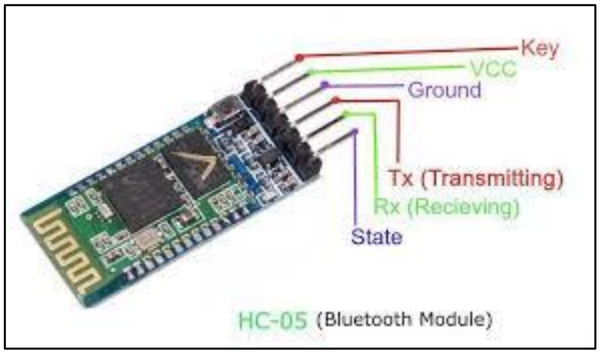

Figure 2: Bluetooth Module (HC-05)

3.1.3 MQ2 Sensor

The MQ2 sensor is a popular gas sensor widely used for detecting various gases such as methane, propane, and smoke. It operates on the principle of resistance changes in the presence of target gases, providing reliable detection in diverse environments.

Figure 3:MQ2 Sensor

3.1.4 DHT11 Sensor

The DHT11 sensor accurately measures the ambient temperature in its surroundings. Additionally, the sensor determines the relative humidity, providing insights into the moisture content of the air.

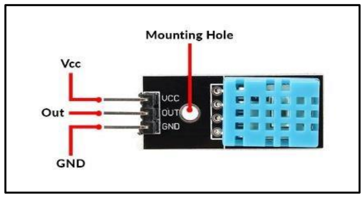

Figure 4:DHT11 sensor

3.1.5 PIR Motion Sensor

The PIR (Passive Infrared) motion sensor detects movement by sensing changes in infrared radiation emitted by objects in its field of view. It is commonly used in security systems and lighting controls to trigger actions, such as turning on lights or sounding alarms, when motion is detected.

Figure 5:PIR Motion Sensor

3.1.6 Ultrasonic Sensor

The ultrasonic sensor detects distance by emitting sound waves and measuring their reflection, finding applications in robotics, automotive, and industrial systems for accurate object detection and ranging.

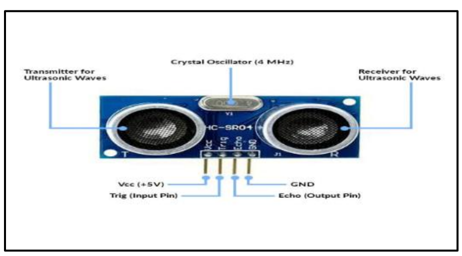

Figure 6:Ultrasonic Sensor

3.1.7 Servo Motor

The **7 servo motors** control the robot's upper body and arm movements. They enable gestures like waving, pointing, and lifting, making **MiniMech** capable of performing dynamic and interactive actions that mimic human behavior.

Figure 7:4 servo motor

3.1.8 DC Motors

The **DC motors** power the wheels of **MiniMech**, enabling forward, backward, left, and right movements. Controlled by the **Arduino Mega 2560**, these motors provide precise and smooth navigation.

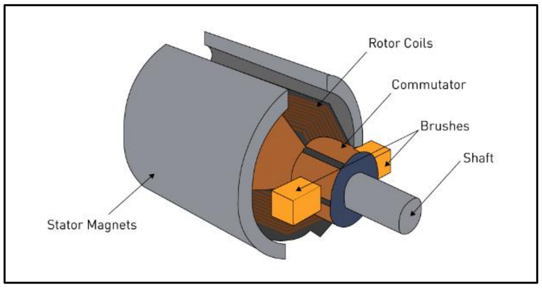

Figure 8:DC Motors

3.1.9 LCD Display

The 16x2 LCD display provides real-time feedback by showing sensor readings such as temperature, humidity, and gas levels, along with system status or alerts. This feature makes MiniMech user-friendly and informative.

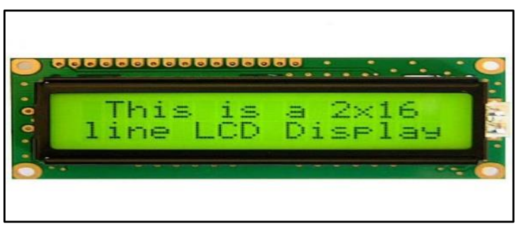

Figure 9:LCD Display

3.1.10 Power Supply

The power supply ensures uninterrupted operation of the robot by powering the microcontroller, sensors, motors, and other components. It can be configured with a battery or an external adapter to meet the robot's power requirements.

3.2 System Interface

The system interface of the **MiniMech humanoid robot** is a multifaceted framework meticulously designed to provide users with an intuitive and interactive experience. It seamlessly integrates environmental monitoring, gesture-based interaction, and navigation functionalities into a cohesive system. With a focus on accessibility, convenience, and efficiency, the system interface incorporates a comprehensive array of components, each contributing to the overall functionality and user engagement of the robot.

3.2.1 Mobile Application Interface:

- The mobile application interface serves as the central control hub for MiniMech, providing users with the ability to interact with and command the humanoid robot effortlessly. Through a simple yet powerful interface, users can control movements, trigger gestures, and access real-time sensor data, ensuring complete control over the robot's functionalities.
- Leveraging the power of Bluetooth connectivity, the application allows users to remotely initiate commands such as arm gestures, obstacle detection, or environmental data display. With an intuitive layout and seamless navigation, the app ensures that interaction with MiniMech is engaging, accessible, and highly efficient.

3.2.2 Gesture-Based Control:

- Gesture-based control redefines user interaction by enabling **MiniMech** to respond dynamically with human-like movements. Gestures such as waving, pointing, or raising arms are initiated based on user commands or sensor inputs, creating an interactive and engaging experience.
- This functionality bridges the gap between traditional automation and human-robot interaction, offering unparalleled convenience and intuitiveness. By combining precise servo motor control with real-time feedback, **MiniMech** provides a seamless interface for communication and task execution.

3.2.3 Sensor Data Monitoring and Alerts:

- At the core of MiniMech lies robust sensor data monitoring and alert capabilities, ensuring users remain informed of their surroundings. Through advanced algorithms, the system processes inputs from sensors like DHT11, PIR, ultrasonic, and gas sensors, detecting anomalies and triggering actions or alerts.
- Users receive instant feedback on the LCD display, such as temperature, humidity, gas levels, or motion detection. The robot also uses gestures or a buzzer to provide additional alerts, ensuring proactive and responsive system behavior.
- With seamless integration of multiple sensors, MiniMech empowers users to monitor their environment confidently, making it an essential tool for automation and safety..

3.2.4 Sensor Data Monitoring and Alerts:

- The real-time navigation system enables MiniMech to move autonomously while avoiding obstacles. Powered by ultrasonic sensors, the robot detects objects in its path and adjusts its movement dynamically to ensure a smooth and collision-free operation.
- This feature enhances the robot's mobility and expands its use cases, making it suitable for tasks like patrolling or interacting in confined spaces. Combined with precise control of DC motors, MiniMech offers a reliable and efficient navigation system.

3.2.5 Dynamic LCD Feedback:

- The 16x2 LCD display acts as a user-friendly interface for real-time feedback, displaying data such as sensor readings, current actions, and system status.
- The display ensures transparency in MiniMech's operation, making it easier for users to understand and interact with the robot's functionalities. With updates triggered by sensor inputs and user commands, the LCD enhances the robot's accessibility and interactivity.

In essence, the system interface of the **MiniMech humanoid robot** represents a harmonious convergence of advanced robotics and user-centric design principles, redefining human-robot interaction and setting new benchmarks for innovation, usability, and efficiency. Through its seamless integration of sensors, actuators, and intuitive controls, the system interface empowers users to unlock the full potential of **MiniMech**, transforming the way they monitor, interact with, and optimize their environments.

3.3 CIRCUIT DIAGRAM

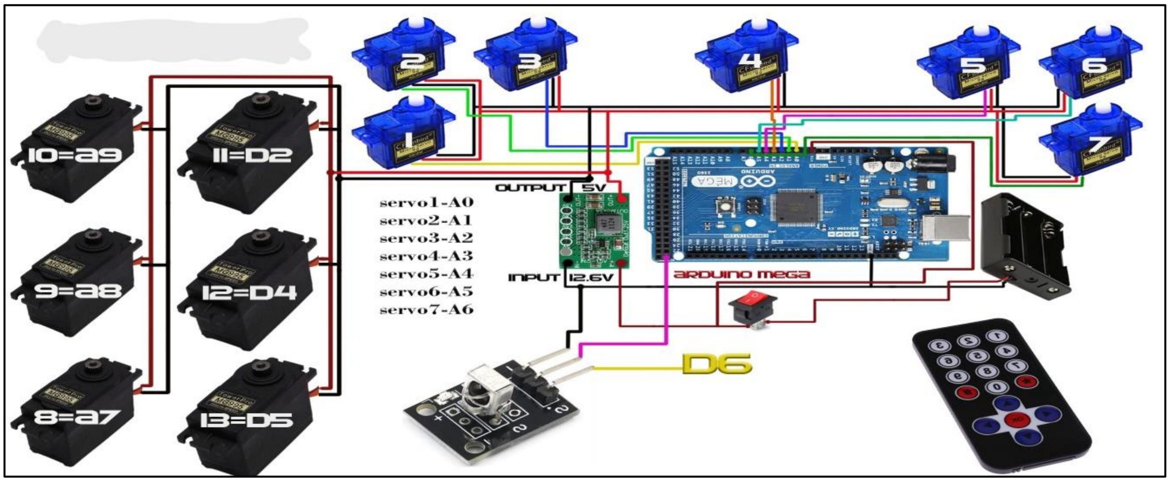

Figure 10:Schematic Diagram of MIniMech

Figure 11:Flow Chart of MiniMech

Chapter 4
Result and Conclusion

4.1 Result:

Seamless integration of IoT devices and sensors for advanced home automation and security.
Enhanced user experience with intuitive interfaces and robust functionalities.

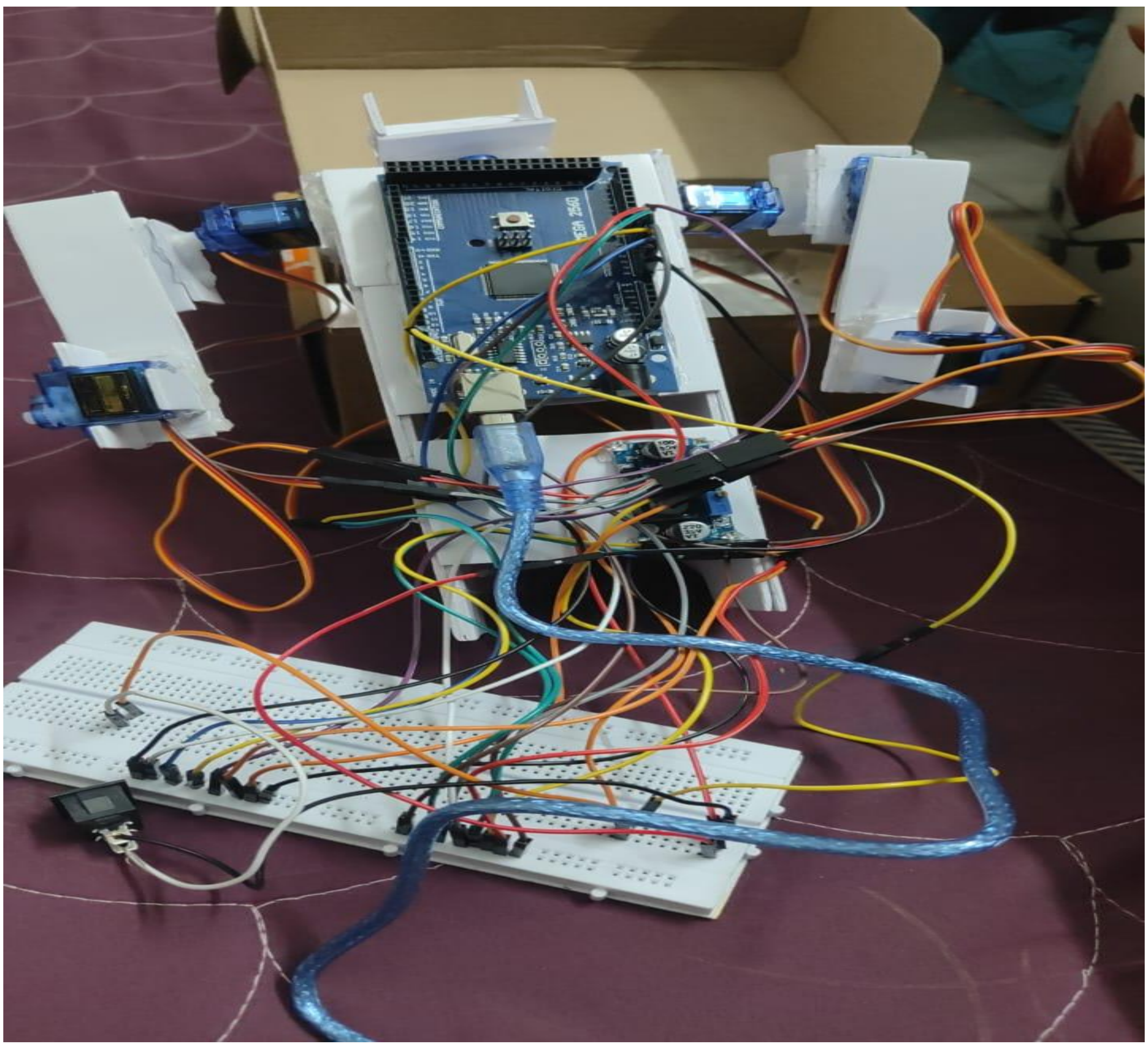

Figure 12: Circuit Connection

4.2 Conclusion:

The MiniMech humanoid robot project has successfully met its objectives by integrating advanced robotics, sensors, and intuitive control systems to enhance user interaction, environmental monitoring, and security. By combining components like the Arduino Mega 2560, servo motors, Bluetooth connectivity, and various sensors, MiniMech offers a dynamic and interactive solution that empowers users to control and monitor their environment with ease. This project highlights the potential of humanoid robotics in enhancing daily life through automation, security, and convenience. As the project evolves, future enhancements and the integration of more advanced technologies will continue to expand MiniMech's capabilities, solidifying its role as an innovative tool in robotics and smart living environments.

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Appendices

Appendix A
Code Attachments

The following is the partial / subset of the code. Code of some module(s) have been wilfully supressed.

A.1 MiniMech: A multifunctional humanoid robot

```
#include <Servo.h>

#include <LiquidCrystal_I2C.h>

#include <DHT.h>


// Constants for DHT11 sensor and pins

#define DHTPIN 12

#define DHTTYPE DHT11

DHT dht(DHTPIN, DHTTYPE);


// Pin assignments

const int PIR_PIN = 3;

const int GAS_SENSOR_PIN = A0;

const int ULTRASONIC_TRIG = 4;

const int ULTRASONIC_ECHO = 5;

const int BUZZER_PIN = 6;

const int BLUETOOTH_RX = 10;
```

```
const int BLUETOOTH_TX = 11;

// Servo motors for arm movement
Servo shoulder1, elbow1, wrist1; // Left arm
Servo shoulder2, elbow2, wrist2; // Right arm

// LCD Display
LiquidCrystal_I2C lcd(0x27, 16, 2);

void setup() {
  // Pin Mode Setup
  pinMode(PIR_PIN, INPUT);
  pinMode(GAS_SENSOR_PIN, INPUT);
  pinMode(BUZZER_PIN, OUTPUT);

  // Attach servos
  shoulder1.attach(7);
  elbow1.attach(8);
  wrist1.attach(9);
  shoulder2.attach(10);
  elbow2.attach(11);
  wrist2.attach(12);
```

```
  // Initialize LCD
  lcd.begin();
  lcd.backlight();
  lcd.setCursor(0, 0);
  lcd.print("MiniMech Ready");
  delay(2000);
}

void loop() {
  // Get sensor data
  float temp = dht.readTemperature();
  float humidity = dht.readHumidity();
  int gasLevel = analogRead(GAS_SENSOR_PIN);

  // Display environmental data on LCD
  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("Temp: " + String(temp) + "C");
  lcd.setCursor(0, 1);
  lcd.print("Hum: " + String(humidity) + "%");

  // PIR Sensor (Motion Detection)
  if (digitalRead(PIR_PIN) == HIGH) {
```

```
  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("Motion Detected");
  waveGesture();
}

// Gas detection
if (gasLevel > 300) {
  digitalWrite(BUZZER_PIN, HIGH); // Activate buzzer
  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("Gas Alert!");
  liftHands();
} else {
  digitalWrite(BUZZER_PIN, LOW); // Deactivate buzzer
}

// Ultrasonic Sensor (Obstacle detection)
long duration, distance;
digitalWrite(ULTRASONIC_TRIG, LOW);
delayMicroseconds(2);
digitalWrite(ULTRASONIC_TRIG, HIGH);
delayMicroseconds(10);
```

```
  digitalWrite(ULTRASONIC_TRIG, LOW);
  duration = pulseIn(ULTRASONIC_ECHO, HIGH);
  distance = (duration * 0.034 / 2);

  if (distance < 10) {
    lcd.clear();
    lcd.setCursor(0, 0);
    lcd.print("Obstacle Ahead!");
    pointGesture();
  }

  delay(1000);
}

void waveGesture() {
  // Waving gesture
  for (int i = 0; i < 3; i++) {
    shoulder1.write(90);
    delay(500);
    shoulder1.write(0);
    delay(500);
  }
}
```

```
void pointGesture() {
  // Pointing gesture
  shoulder1.write(90);
  delay(1000);
  shoulder1.write(0);
}

void liftHands() {
  // Hands-up gesture for alert
  shoulder1.write(90);
  shoulder2.write(90);
  delay(1000);
  shoulder1.write(0);
  shoulder2.write(0);
}
```