EMBEDDED TESTING

AN INDUSTRIAL TRAINING REPORT

Submitted by

MANIMARAN V 513121106302

DEPARTMENT OF

ELECTRONICS AND COMMUNICATION ENGINEERING

in complete fulfilment for the award of the certificate

of

COURSE COMPLETION
IN THE AREA OF

"AGNI"

VAAYUSASTRA AEROSPACE PRIVATE LIMITED
IITM Research Park, Chennai.

VAAYUSASTRA AEROSPACE PRIVATE LIMITED
IITM Research Park, Chennai.

BONAFIDE CERTIFICATE

Certified that this industrial training report **"EMBEDDED TESTING"** is the bonafide work of **"MANIMARAN V (513121106302)"** who carried out of the Industrial Training & Project Work under my supervision.

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MANIMARAN V (513121106302)

INTERNSHIP REPORT

EMBEDDED TESTING

Submitted by

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ABSTRACT

This embedded systems course offers an extensive overview of microprocessors and microcontrollers, which are key components in today's electronic devices. The course begins by thoroughly examining the architecture and roles of microprocessors and microcontrollers, demonstrating their importance in a wide range of applications, from consumer gadgets to industrial control systems.

Next, students dwell into chip-level testing, where they learn various methods to verify the integrity and functionality of individual chips. The course then advances to module-level testing, focusing on the assessment of specific functional units within the embedded system, using tools such as debuggers and simulators.

The course covers the integration of these modules, guiding students through the complexities and strategies necessary to ensure smooth communication and cooperation among different system components. System-level testing is then introduced, underscoring the importance of verifying the entire system's performance under real-time conditions.

The course concludes with a practical project phase, allowing students to apply their knowledge by designing, implementing, and testing a complete embedded system, thus preparing them for the practical challenges they will encounter in the field

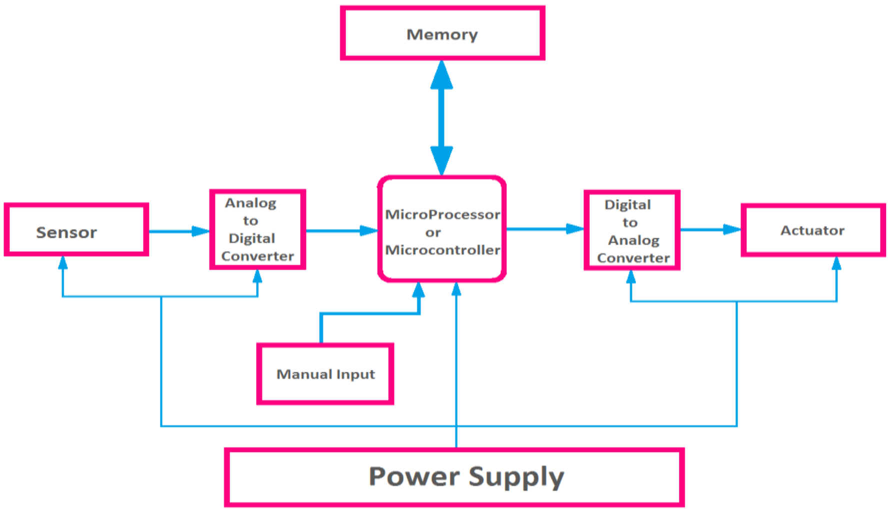
OVERVIEW OF EMBEDDED SYSTEMS

Embedded systems are specialized computing systems that perform dedicated functions within larger mechanical or electrical systems. These systems are integral to modern technology, powering a wide range of devices from everyday household appliances to complex industrial machinery.

1.1 Embedded System Components:

Embedded systems are typically built around microprocessors and microcontrollers, which serve as the "brains" of the operation. These components manage the execution of specific tasks within a device, ensuring that the system operates smoothly and efficiently. Other essential components include memory, input/output interfaces, and communication protocols, all working together to support the system's overall functionality.

Block diagram of Embedded Systems:



1.2 Unit Level Testing:

Unit testing simulation in an embedded public transport system project involves verifying the functionality of individual modules, such as the GPS, RFID reader, sensors, and communication interfaces, in a controlled environment. By using simulation tools like Proteus or Keil u Vision, and unit testing frameworks like Unity, developers can create mock objects to simulate hardware components, allowing for the thorough testing of each module's behavior. This approach ensures that each component works correctly on its own before integration, enabling early detection of issues and contributing to a more reliable and efficient overall system.

Design and Development of Embedded Systems:

Designing an Embedded system involves selecting the appropriate hardware and software components to meet specific performance requirements. This process includes defining system specifications, choosing microcontrollers or microprocessors, and developing the embedded software. Testing and validation are crucial stages, ensuring that the system meets performance standards and operates reliably under real-world conditions.

Challenges in Embedded Systems:

Developing embedded systems presents several challenges, including the need for low power consumption, limited processing power, and memory constraints. Additionally, embedded systems must often operate in real-time environments, requiring precise timing and fast response. Addressing these challenges requires careful design, efficient coding practices, and rigorous testing to ensure the system's reliability and effectiveness.

COMPONENT LEVEL TESTING

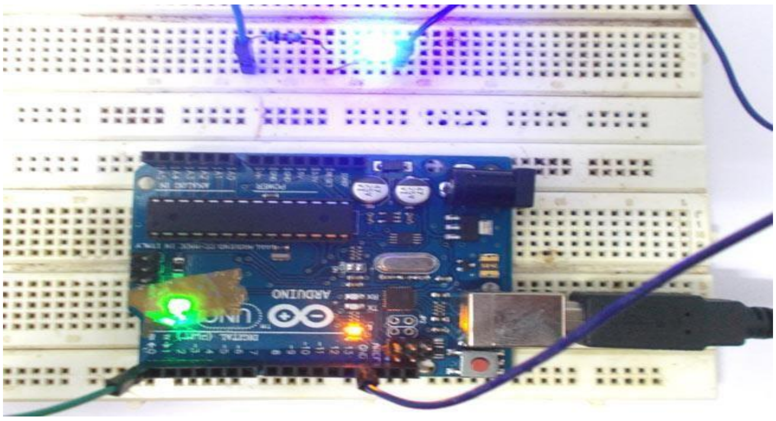
2.1 ACTIVE AND PASSIVE COMPONENTS:

Active Components: These are components in an embedded system that need an external power source to operate and can control the flow of electricity, like transistors and integrated circuits.

Passive Components: These components don't need an external power source and can't control the flow of electricity on their own. They include resistors, capacitors, and inductors.

2.2 PROGRAMMING EXERCISE:

LED BLINKING:



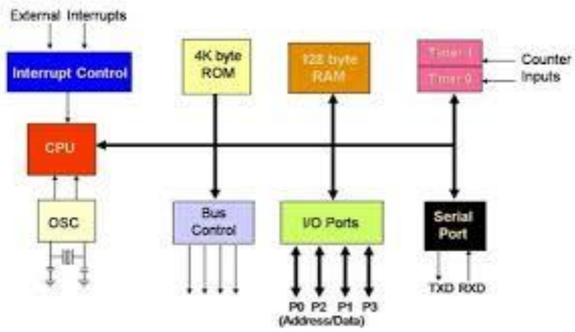
CHIP LEVEL TESTING

3.1 MICROCONTROLLER AND MICROOPROCESSOR:

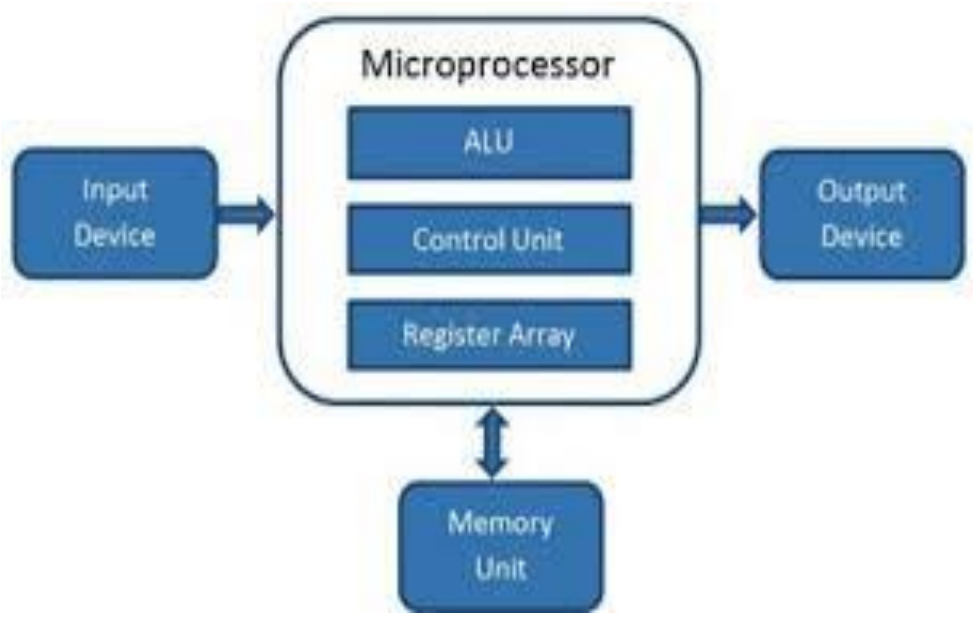
A microcontroller (MCU) is a small computer on a single integrated circuit that is designed to control specific tasks within electronic systems. It combines the functions of a central processing unit (CPU), memory, and input/output interfaces, all on a single chip. Microcontrollers are widely used in embedded systems, such as home appliances, automotive systems, medical devices, and industrial control systems.

The core elements of a microcontroller are:

1. The processor (CPU) – A processor can be thought of as the brain of the device. It processes and responds to various instructions that direct the microcontroller’s function. It also performs data transfer operations, which communicate commands to other components in the larger embedded system.
2. Memory – A microcontroller’s memory is used to store the data that the processor receives and uses to respond to instructions that it’s been program.



A Microprocessor is an important part of a computer architecture without which you will not be able to perform anything on your computer. It is a programmable device that takes in input performs some arithmetic and logical operations over it and produces the desired output. In simple words, a Microprocessor is a digital device on a chip that can fetch instructions from memory, decode and execute them, and give results.



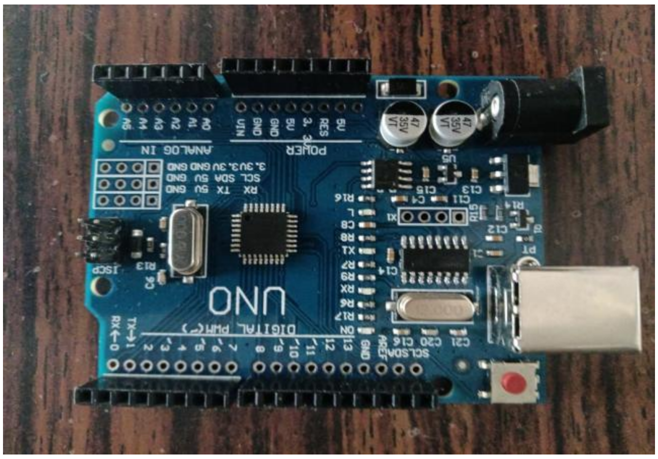
3.2 ARDUINO HARDWARE AND SOFTWARE:

The Arduino IDE (Integrated Development Environment) is a software application used for programming Arduino boards. It allows you to write, edit, and upload code to your Arduino hardware. Here are some key features:

1. **Code Editor:** Provides syntax highlighting and basic code editing features to help write your Arduino programs (sketches).
2. **Compilation:** Translates your code into a format that the Arduino board can understand.
3. **Uploading:** Sends the compiled code to the Arduino board via USB or other connections.
4. **Serial Monitor:** Allows you to view data sent from the Arduino board and interact with it in real-time.

ARDUINO UNO:

Arduino Uno is a popular microcontroller board based on the ATmega328P microcontroller. It is part of the Arduino family, an open-source electronics platform designed for easy use in interactive projects. The Uno is widely used by hobbyists, students, and professionals for developing electronic projects due to its simplicity and versatility.



ARDUINO NANO:

Arduino Nano is a small, compact microcontroller board based on the ATmega328P or ATmega168 microcontroller. It is similar in functionality to the Arduino Uno but comes in a much smaller form factor, making it ideal for projects where space is limited.

BOARD LEVEL TESTING

4.1 SENSORS AND ACTUATORS:

Sensors and actuators are devices that convert physical activity or changes into signals. Sensors collect data from the environment and convert it into electrical signals, while actuators transform electrical signals into physical actions. They often work together, but they are essentially opposite devices. Sensors are placed at input points in a system, while actuators are placed at the output point.

Sensors have three main functions**:** sensing, conditioning, and communication. They can detect physical phenomena such as light, sound, temperature, pressure, or motion.

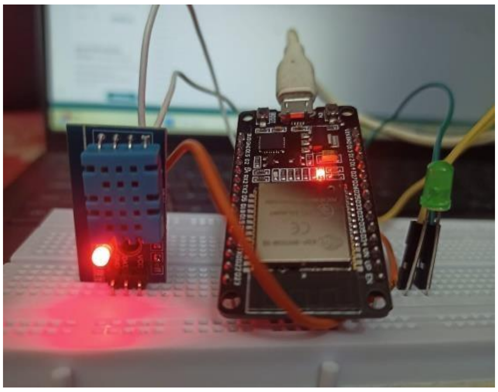
Actuators have two main functions**:** receiving and acting.

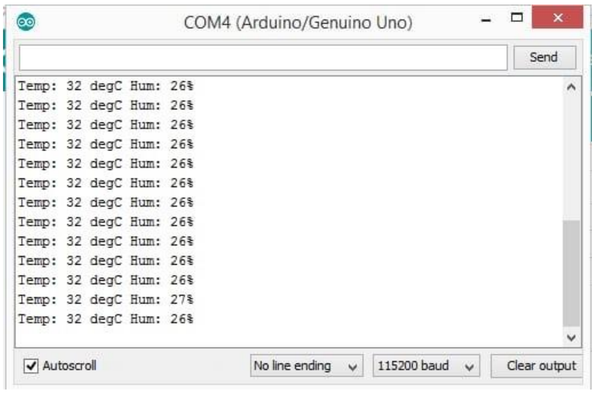
4.2 SENSOR TESTING:

DHT:

The DHT sensor, including the DHT11 and DHT22 models, measures temperature and humidity. The DHT11 is affordable but limited in range and accuracy, while the DHT22 offers wider range and better precision. Both are easily used with Arduino for various projects.

CONNECTIONS: OUTPUT:

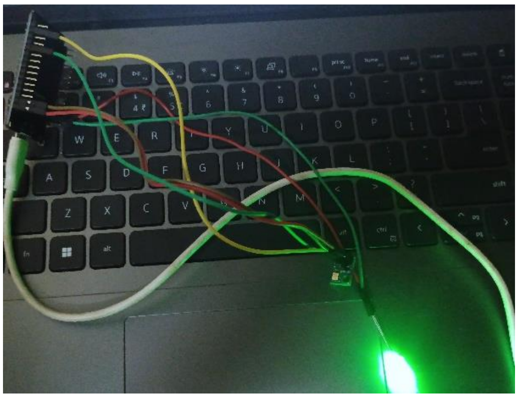


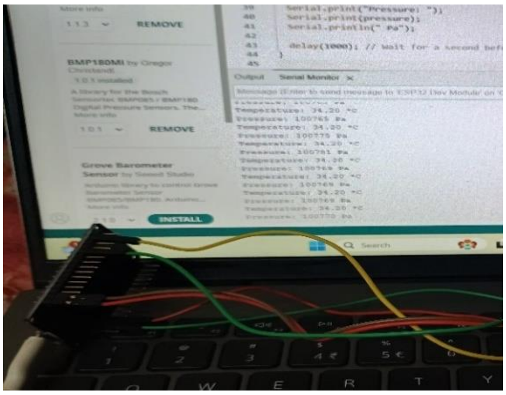


BAROMETRIC PRESSURE SENSOR:

BMP180 is a digital sensor used to measure atmospheric pressure and temperature. When connected to an ESP32 microcontroller via the I2C interface, the sensor allows the ESP32 to read pressure and temperature data.

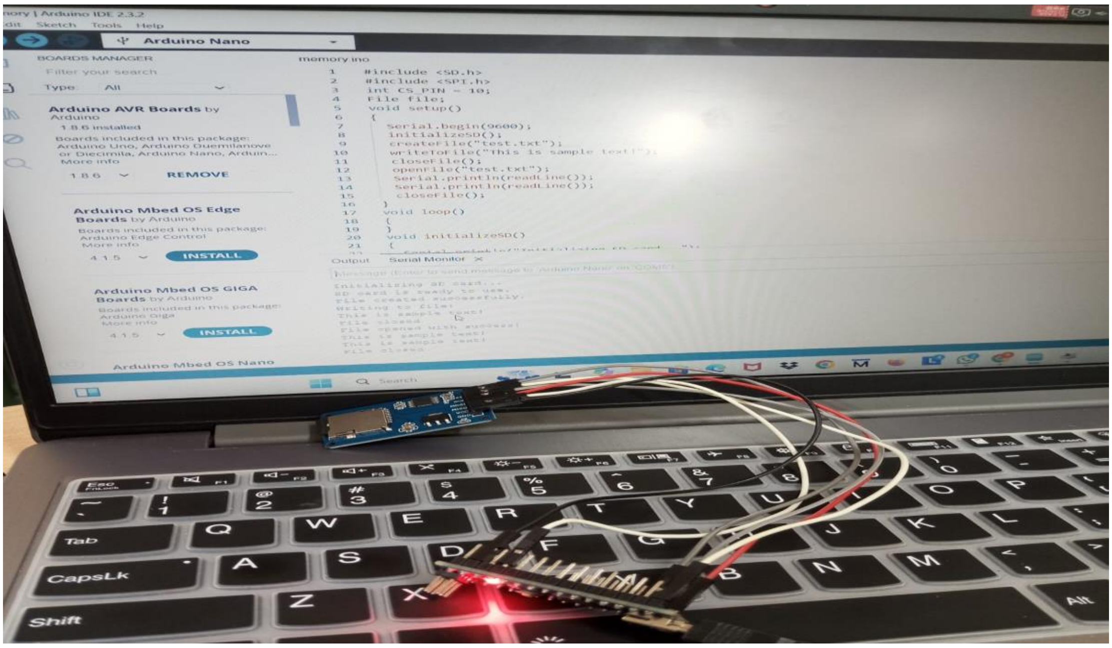
CONNECTIONS: OUTPUT:





WRITING DATA TO A SD CARD:

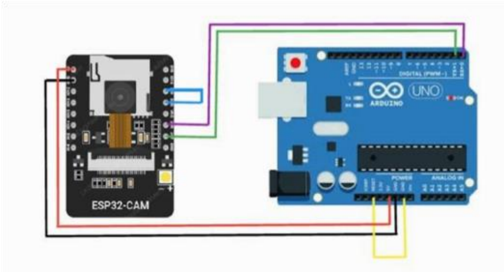
The Arduino Nano can be used to interface with an SD card module to read from and write data to an SD card. By using the Arduino SD library, you can program the Nano to create, write to, and read files on the SD card, making it ideal for data logging, storage, and other applications where persistent data storage is required.



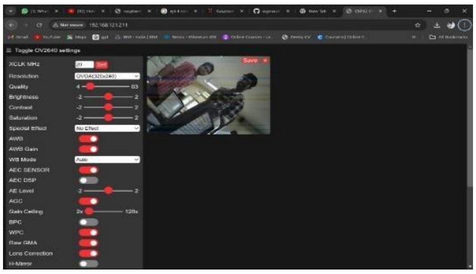
ESP32 CAM:

The integration of a camera module with a microcontroller to capture and transmit images or video data. The camera module is configured to interface with the microcontroller, allowing it to capture images based on specific triggers or commands.

CONNECTIONS:

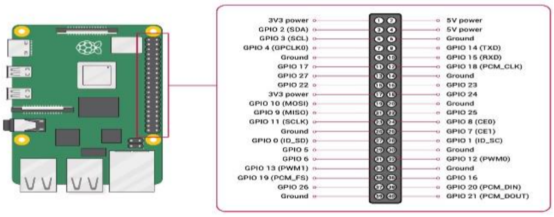


OUTPUT:



RASPBERRY PI

This report outlines the process of setting up a Raspberry Pi board, from installing the operating system (OS) to establishing remote connections using SSH and VNC Viewer. The Raspberry Pi is a versatile single-board computer popular for a wide range of projects. This guide demonstrates how to download the OS using Raspberry Pi Imager, scan the IP address of the device, and connect to it remotely for both command-line and graphical interface interactions.



INSTALLATION OF RASPBERRY PI:

To install and set up a Raspberry Pi:

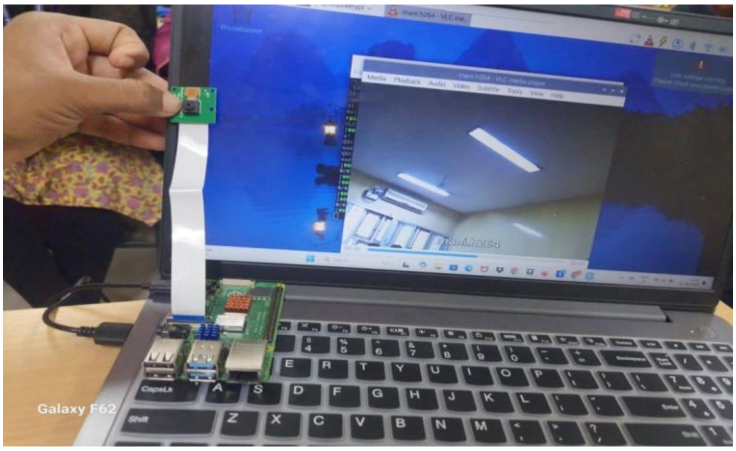
1. Download & Install Raspberry Pi Imager: Get it from the official Raspberry Pi website and install it on your computer.
2. Prepare Storage Device: Insert a USB drive or microSD card into your computer.
3. Launch Raspberry Pi Imager: Open the Imager software.
4. Select OS: Choose “Raspberry Pi (64-bit)” or another version based on your model.
5. Select Storage: Pick your USB drive or microSD card.
6. Configure Advanced Options (Optional): Set hostname, username, password, Wi-Fi, and enable SSH.
7. Write OS to Storage: Click “Write” and wait for the process to complete.
8. Power Up Raspberry Pi: Connect to power; it will boot with Raspberry Pi OS.
9. Find IP Address: Use Angry IP Scanner to find your Raspberry Pi’s IP address.
10. Connect via RealVNC Viewer: Install and use RealVNC Viewer to connect using the IP address.
11. Configure via SSH: Use a terminal to connect and configure the Raspberry P

Configure the board using raspi-config cmd

USING RASPBERRY PI CAMERA MODULE:

Raspberry Pi camera module is an accessory that connects to the Raspberry Pi, allowing it to capture photos and videos. It is controlled through software commands and is ideal for projects involving photography, video recording, or computer vision.

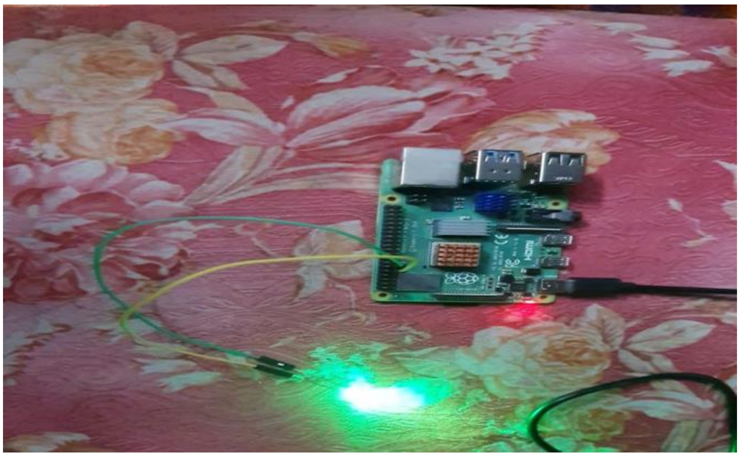
OUTPUT:



LED BLINKING USING RASPBERRY PI:

The Raspberry Pi LED program involves connecting an LED to a GPIO pin on the Raspberry Pi and using a Python script to control its state, enabling you to turn the LED on and off or create blinking effects. This setup is useful for learning about GPIO manipulation, signal control, and basic electronic interfacing.

OUTPUT:



PROJECT DEVELOPMENT

IMAGE-TEXT TO SPEECH CONVERSION USING RASPBERRY PI

PROBLEM STATEMENT:

Develop a system using a Raspberry Pi to convert text from images into spoken words, enhancing accessibility for individuals with visual impairments. The system involves capturing images with a camera module or USB webcam, extracting text using Optical Character Recognition (OCR) technology, and converting the text into speech with Text-to-Speech (TTS) technology. The main challenge is to ensure accurate text extraction and efficient speech synthesis to provide a seamless user experience. The goal is to create a practical tool that makes printed information accessible through auditory means.

LITERATURE REVIEW:

Integrating OCR and TTS technologies is crucial for converting text from images into spoken words, thus enhancing accessibility for visually impaired individuals. OCR tools like Tesseract and Google Cloud Vision API offer advanced text extraction capabilities through machine learning techniques, while TTS systems such as Festival and eSpeak convert text into natural-sounding speech. Existing solutions, such as Seeing AI and OrCam MyEye, demonstrate real-time text-to-speech conversion applications. Challenges include improving text extraction accuracy in various conditions and optimizing real-time processing for a seamless user experience. Research continues to address these issues, aiming for more effective and user-friendly systems.

HARDWARE COMPONENTS:

The system utilizes a Raspberry Pi 4, a Camera Module or USB Webcam for image capture, a Speaker (either USB or analog) for audio output, a MicroSD Card for storage, a 5V USB-C Power Supply, a Case with Heat Sinks for cooling, and optional Keyboard and Mouse for setup. An Internet Connection (Wi-Fi or Ethernet) is also required for software installation and updates.

SOFTWARE COMPONENTS:

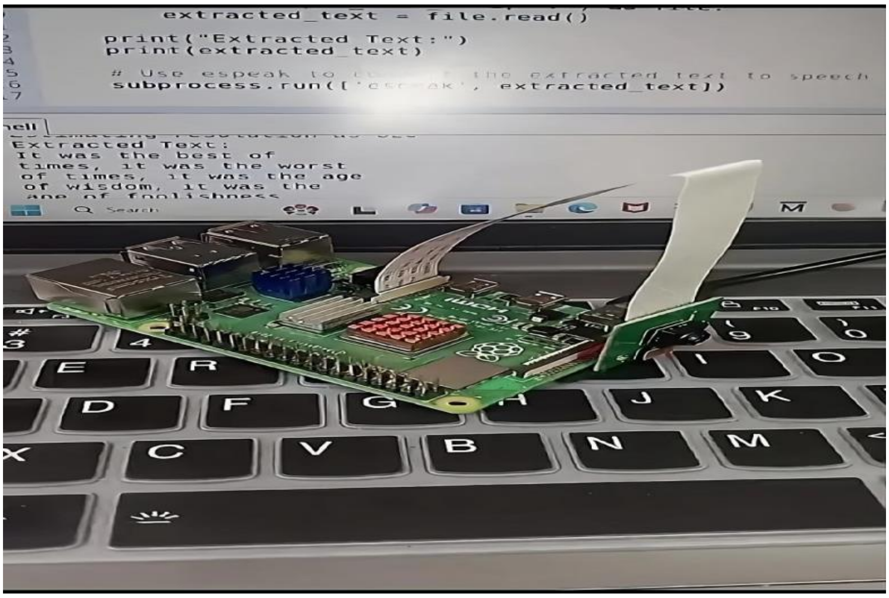
The software stack includes Raspberry Pi OS as the operating system, OpenCV for image processing tasks, Tesseract OCR for text extraction, pytesseract (a Python wrapper for Tesseract) for easier integration, gTTS (Google Text-to-Speech) for converting text into speech, pygame for handling audio playback, and Python 3 as the programming language.

IMPLEMENTATION STEPS:

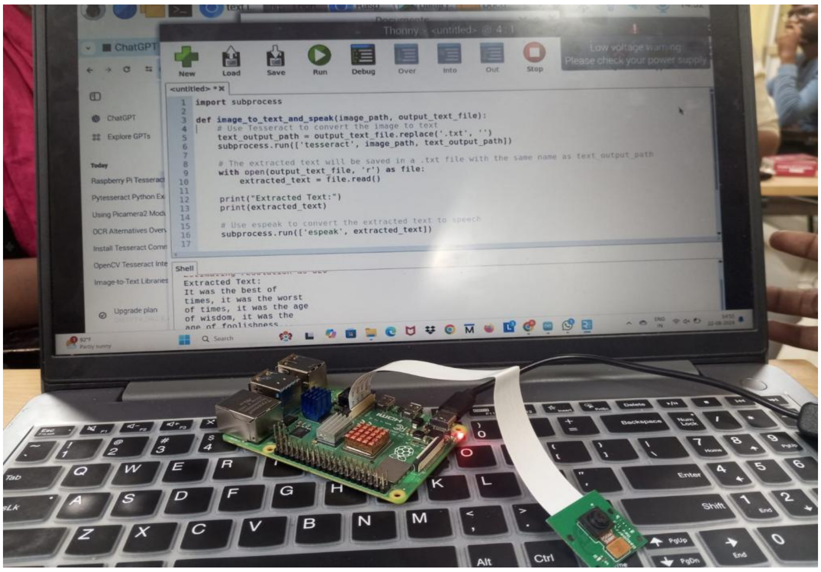
To implement the image-to-speech conversion system using a Raspberry Pi 4, follow these steps:

1. **Setup the Raspberry Pi:**
    - Install Raspberry Pi OS on a microSD card and boot the Raspberry Pi 4.
    - Connect the Raspberry Pi to a network via Wi-Fi or Ethernet.
    - Update the system to ensure all packages are current.
2. **Install Required Software:**
    - Install OpenCV for capturing and processing images.
    - Install Tesseract OCR for recognizing and extracting text from images.
    - Install gTTS (Google Text-to-Speech) to convert the extracted text into speech.
    - Install pygame to handle audio playback on the Raspberry Pi.
3. **Capture Image:**
    - Connect a camera module or USB webcam to the Raspberry Pi.
    - Use the camera to capture images containing text.
4. **Text Extraction:**
    - Use Tesseract OCR to extract text from the captured images.
    - Ensure accuracy by testing with various image qualities.
5. **Convert Text to Speech:**
    - Convert the extracted text into speech using the gTTS library.
    - Generate an audio file that contains the spoken text.
6. **Audio Playback:**
    - Play the generated audio file through a connected speaker.
    - Test the system to ensure clear and accurate text-to-speech conversion.
7. **Testing and Refinement:**
    - Test the system with different images to ensure reliability.
    - Refine image capture, text extraction, and speech synthesis as needed to improve performance.

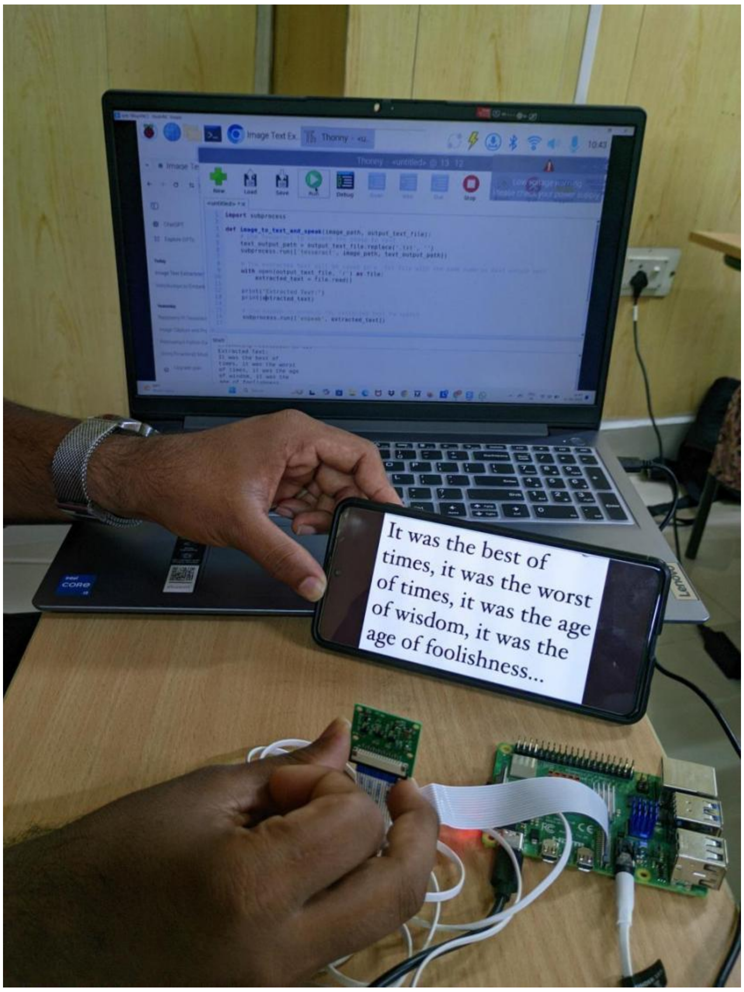
OUTPUT:



extracted_text = file.read()
print("Extracted Text:")
print(extracted_text)
subprocess.run([
extracted_text])
Extracted Text:
It was the best of
times, it was the worst
of times, it was the age
of wisdom, it was the



New
Load
Save
Run
Debug
Over
Into
Out
Stop
import subprocess
def image_to_text_and_speak(image_path, output_text_file):
text_output_path = output_text_file.replace('.txt', '')
subprocess.run(['tesseract', image_path, text_output_path])
with open(output_text_file, 'r') as file:
extracted_text = file.read()
print("Extracted Text:")
print(extracted_text)
subprocess.run(['espeak', extracted_text])
Shell
Extracted Text:
It was the best of
times, it was the worst
of times, it was the age
of wisdom, it was the


It was the best of
times, it was the worst
of times, it was the age
of wisdom, it was the
age of foolishness...

CONCLUSION AND FUTURE WORKS:

This project successfully creates a Raspberry Pi-based system to convert text from images into spoken words, enhancing accessibility for visually impaired individuals. By integrating OCR and TTS technologies, the system effectively transforms printed text into audible speech, providing an essential tool for improving access to information.

Looking ahead, future enhancements could focus on increasing the accuracy of text extraction under various conditions and optimizing the system for real-time performance to ensure a smoother user experience. Additional improvements might include expanding support to multiple languages, integrating with other assistive technologies, and developing a more intuitive user interface. Continued research into advanced OCR and TTS systems will also be valuable for achieving more natural and precise speech synthesis, further advancing accessibility solutions.