Industrial Internship Report on

"IoT-enabled Waste Management System"

Prepared by

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Executive Summary
This report provides details of the Industrial Internship provided by upskill Campus and The IoT Academy in collaboration with Industrial Partner UniConverge Technologies Pvt Ltd (UCT). This internship was focused on a project/problem statement provided by UCT. We had to finish the project including the report in 6 weeks' time. My project was "Automatic Door Control System" The project involves using an Arduino, motor driver, DC Motor and PIR Sensor to automate door opening and closing based on human presence. It's designed for various applications including home, office, and mall automation, enhancing convenience and efficiency while reducing manual intervention. This internship gave me a very good opportunity to get exposure to Industrial problems and design/implement solution for that. It was an overall great experience to have this internship.

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1 Preface

Summary of the whole work -

Week 1:

- Overview: Focused on familiarizing with Uniconverge Technology (UCT) and understanding the services they provide. Began exploring embedded and IoT domains and contributing to IoT projects.
- Achievements: Gained initial proficiency in UCT's core functionalities, explored the project list, and analyzed the Automatic Door Control System project.
- Challenges: Encountered difficulties in the quiz section and understanding the complexity of the IoT project.
- Learning Resources: Utilized UCT documentation, attended webinars, and engaged with embedded system programming resources.
- Goals: Aimed to understand IoT devices and platforms, and enhance contribution to IoT projects.

Week 2:

- Overview: Focused on understanding IoT devices and platforms and the rise of embedded systems and IoT as emerging technologies.
- Achievements: Gained a solid understanding of IoT device fundamentals, explored Raspberry Pi and ESP32, and applied Python skills to IoT projects.
- Project Analysis: Continued work on the Automatic Door Control System, exploring how to connect Raspberry Pi and ESP32.
- Challenges: Faced challenges in the quiz section and integrating IoT concepts.
- Learning Resources: Revisited videos on IoT devices, consulted Raspberry Pi and ESP32 resources, and referred to USC_TIA documentation.
- Goals: Address integration challenges and tackle more complex IoT project tasks.

Week 3:

- Overview: Focused on understanding IoT deployment and challenges.
- Achievements: Studied real use-cases, learned about layered architecture, and experimented with Raspberry Pi and ESP32 circuits.

- Project Analysis: Continued work on the Automatic Door Control System, successfully designing the system using ESP32.
- Challenges: Faced integration challenges with IoT design and deployment.
- Learning Resources: Consulted videos on IoT deployment and referred to Raspberry Pi and ESP32 resources.
- Goals: Continue addressing integration challenges and improve IoT project contributions.

Week 4:

- Overview: Focused on embedded systems training and circuit design.
- Achievements: Explored electronic components, studied circuit diagrams, and experimented with ESP32 circuits.
- Project Analysis: Worked on the Smart Waste Management System, which uses IoT technology to optimize waste collection and promote sustainability.
- Challenges: Faced challenges integrating electronic components and designing circuits.
- Learning Resources: Consulted videos on IoT deployment and ESP32 resources.
- Goals: Prepare the internship report, complete the IoT test, and submit the final project.

About need of relevant Internship in career development -

Engaging in relevant internships is crucial for career development as they provide practical experience, enhance skills, and bridge the gap between theoretical knowledge and real-world applications. Internships offer exposure to industry practices, foster professional networking, and improve employability by demonstrating hands-on experience to potential employers.

Brief about project/problem statement -

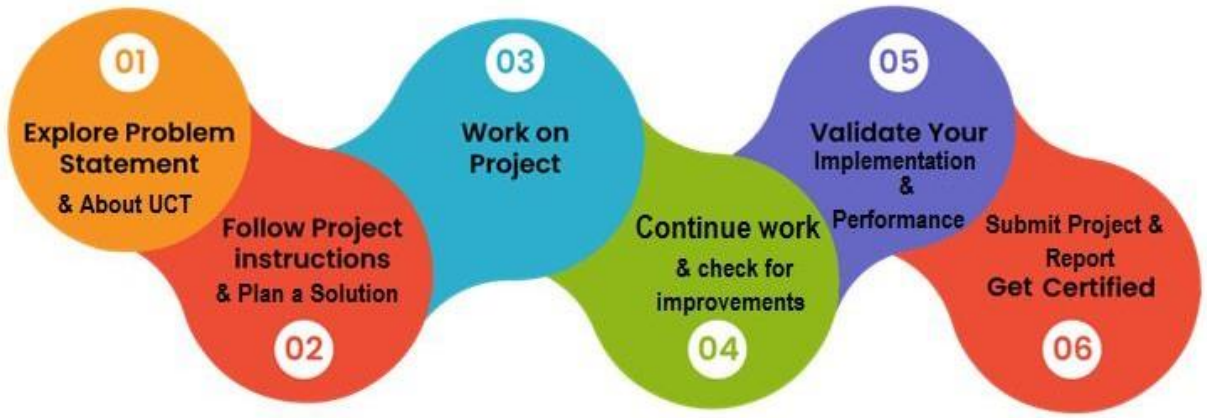
In many settings such as hospitals, offices, and public buildings, manually operated doors can be inconvenient and challenging, particularly for individuals with mobility issues. An automatic door control system is needed to enhance accessibility and convenience by automatically opening and closing doors when human presence is detected. The proposed solution aims to use a PIR sensor to detect motion within a specified range and control a DC motor via an L293D motor driver to operate the door. This system should be reliable, safe, and efficient, ensuring that doors open promptly when someone approaches and close after they pass.

The primary challenge lies in ensuring the PIR sensor accurately detects human presence while ignoring false triggers, and timing the motor's operation to fully open and close the door appropriately. Additionally, the system must manage power efficiently to ensure stable operation of the motor and control circuitry. By addressing these challenges, the system aims to provide a seamless and safe automatic door operation, improving user convenience and accessibility in various environments.

Opportunity given by USC/UCT -

The opportunity provided by USC/UCT has been instrumental in gaining hands-on experience in the embedded and IoT domain. The comprehensive training, access to resources, and collaborative environment facilitated skill enhancement and practical application of theoretical knowledge. This experience has significantly contributed to professional growth and readiness for future challenges in the field of embedded systems and IoT.

How Program was planned



Learnings and overall experience.

Practical Exposure:

The internship provided valuable practical exposure to the field of embedded systems and IoT, bridging the gap between theoretical knowledge and real-world application. Working on hands-on projects allowed me to apply and test my skills, gaining confidence in my abilities.

Mentorship and Guidance:

Received guidance from mentors and peers, which was crucial in navigating challenges and improving project outcomes. The feedback and support from experienced professionals helped accelerate my learning curve and professional development.

Professional Growth:

The internship significantly contributed to my professional growth, equipping me with the skills and knowledge needed for a career in embedded systems and IoT. It provided a clear understanding of industry practices, project management, and the importance of continuous learning and adaptability.

Future Readiness:

The experience has prepared me for future challenges in the embedded systems and IoT field, enhancing my employability and readiness to take on more complex projects. It has instilled a sense of confidence and a proactive approach to learning and problem-solving, essential traits for a successful career in technology.

2 Introduction

2.1 About UniConverge Technologies Pvt Ltd

A company established in 2013 and working in Digital Transformation domain and providing Industrial solutions with prime focus on sustainability and RoI.

For developing its products and solutions it is leveraging various **Cutting Edge Technologies e.g. Internet of Things (IoT), Cyber Security, Cloud computing (AWS, Azure), Machine Learning, Communication Technologies (4G/5G/LoRaWAN), Java Full Stack, Python, Front end** etc.

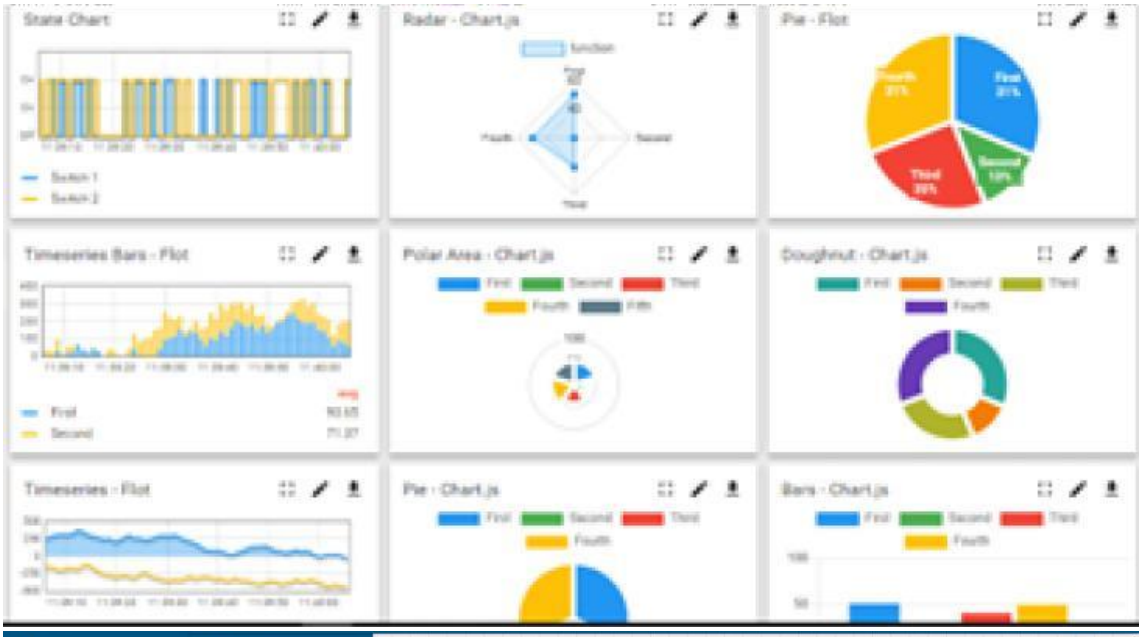
i. UCT IoT Platform (UCT Insight)

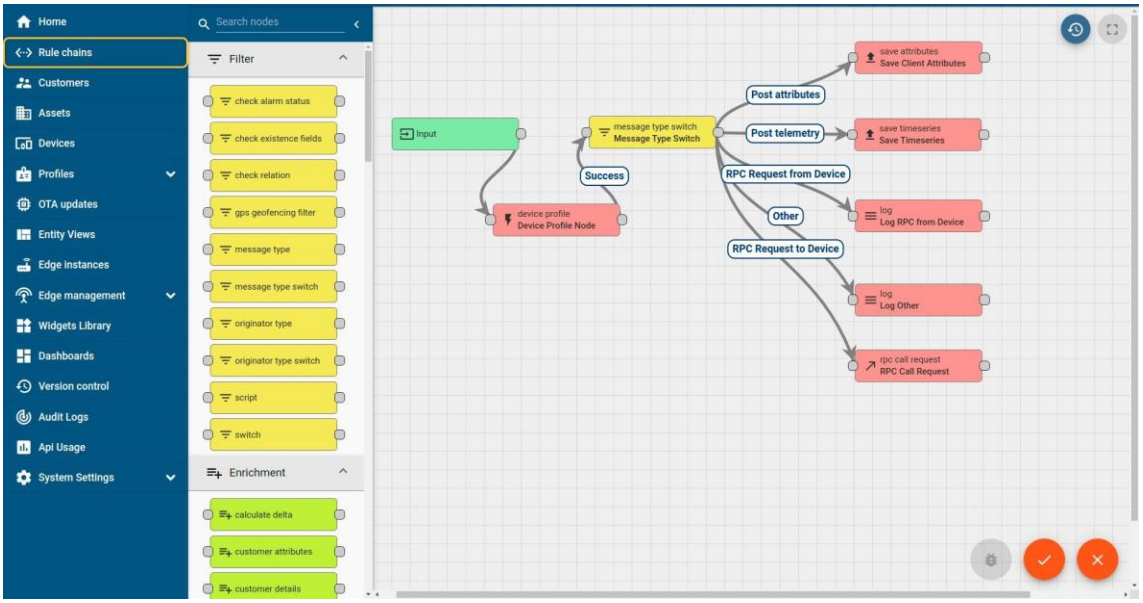
UCT Insight is an IOT platform designed for quick deployment of IOT applications on the same time providing valuable "insight" for your process/business. It has been built in Java for backend and ReactJS for Front end. It has support for MySQL and various NoSql Databases.

- It enables device connectivity via industry standard IoT protocols - MQTT, CoAP, HTTP, Modbus TCP, OPC UA
- It supports both cloud and on-premises deployments.

It has features to

- Build Your own dashboard
- Analytics and Reporting
- Alert and Notification
- Integration with third party application(Power BI, SAP, ERP)
- Rule Engine





ii. Smart Factory Platform (FACTORY WATCH)

Factory watch is a platform for smart factory needs.

It provides Users/ Factory

- with a scalable solution for their Production and asset monitoring
- OEE and predictive maintenance solution scaling up to digital twin for your assets.
- to unleased the true potential of the data that their machines are generating and helps to identify the KPIs and also improve them.
- A modular architecture that allows users to choose the service that they what to start and then can scale to more complex solutions as per their demands.

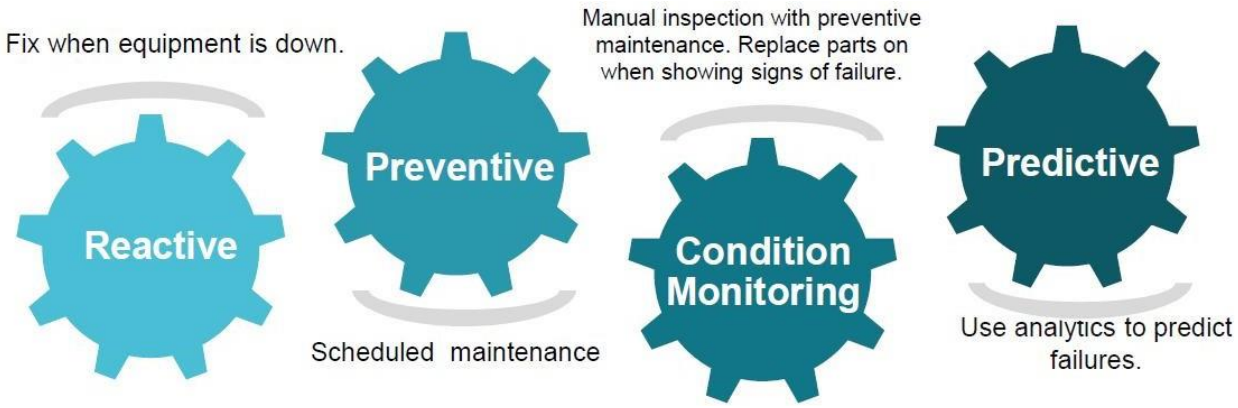
Its unique SaaS model helps users to save time, cost and money.

iii. LoRaWAN based Solution

UCT is one of the early adopters of LoRAWAN teschnology and providing solution in Agritech, Smart cities, Industrial Monitoring, Smart Street Light, Smart Water/ Gas/ Electricity metering solutions etc.

iv. Predictive Maintenance

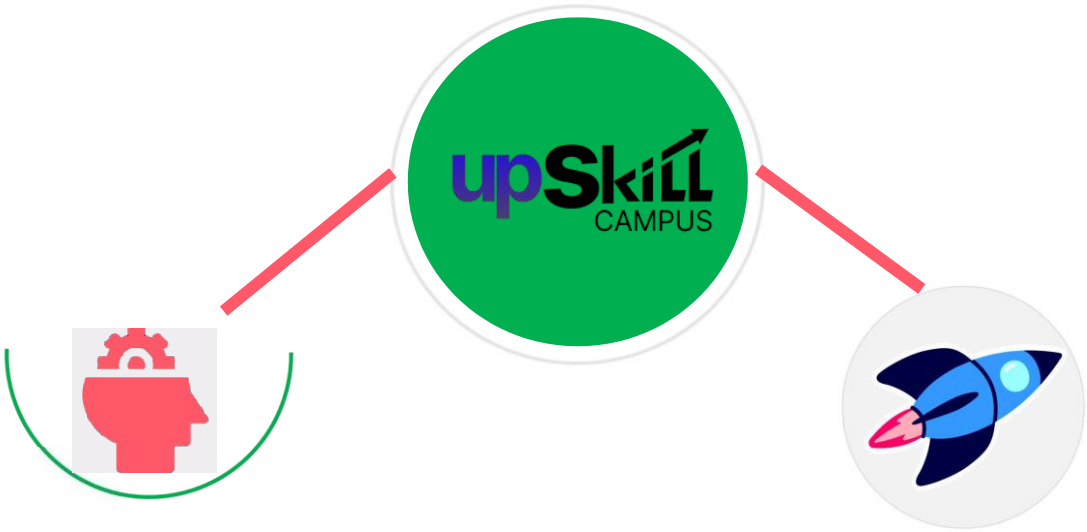
UCT is providing Industrial Machine health monitoring and Predictive maintenance solution leveraging Embedded system, Industrial IoT and Machine Learning Technologies by finding Remaining useful life time of various Machines used in production process.



2.2 About upskill Campus (USC)

upskill Campus along with The IoT Academy and in association with Uniconverge technologies has facilitated the smooth execution of the complete internship process.

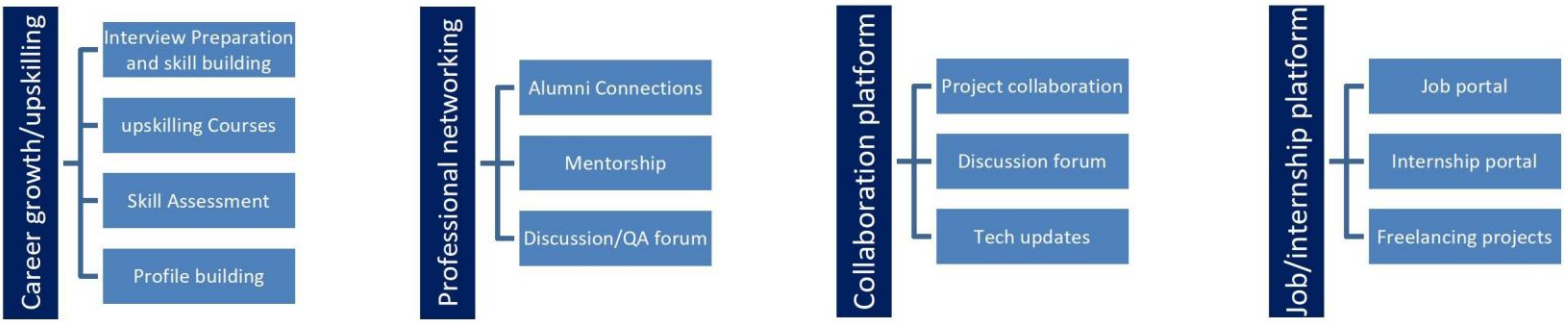
USC is a career development platform that delivers **personalized executive coaching** in a more affordable, scalable and measurable way.



Seeing need of upskilling in self paced manner along-with additional support services e.g. Internship, projects, interaction with Industry experts, Career growth Services

upSkill Campus aiming to upskill 1 million learners in next 5 year

https://www.upskillcampus.com/



2.3 Objectives of this Internship program

The objective for this internship program was to

- ☛ Get practical experience of working in the industry.
- ☛ To solve real world problems.
- ☛ To have improved job prospects.
- ☛ To have Improved understanding of our field and its applications.
- ☛ To have Personal growth like better communication and problem solving.

2.4 Reference

[1] Internet of things (IoT)- Introduction, Utilities, Applications by Tarika verma

[2] https://www.everand.com/author/447162721/Sever-Spanulescu

[3] https://www.youtube.com/

3 Problem Statement

Tittle: IoT-enabled Waste Management System Using ESP32

Objective:

To design and implement an IoT-enabled waste management system using an ESP32 board that detects the fill level of a waste bin using an ultrasonic sensor and sends notifications when the bin is full. The system aims to improve waste collection efficiency and reduce operational costs.

Background:

Efficient waste management is crucial for maintaining clean and hygienic urban environments. Manual monitoring of waste bins is labor-intensive and inefficient. An IoT-enabled waste management system can automate this process, providing real-time data on bin status and optimizing waste collection routes.

Scope:

Detection Range**:** The system should detect the fill level of the waste bin using an ultrasonic sensor.
Data Transmission**:** The system should send data to a central server for monitoring.
Notification**:** The system should send notifications when the bin is full.
Power Supply: The system should be powered appropriately to ensure reliable operation.

Components:

1. ESP32 Board: Microcontroller with built-in Wi-Fi for processing sensor inputs and transmitting data.
2. IR Sensor: To detect the fill level of the waste bin and the presence of waste near the bin.
3. Servo Motor**:** To control the opening and closing of the bin lid.
4. Power Supply**:** To provide necessary power to the ESP32, IR sensor, and servo motor.
5. Connecting Wires**:** For electrical connections between components.

1. Working Principle:

The system uses an IR sensor to detect the fill level of the waste bin. When the bin is nearly full, the ESP32 processes this data and sends a notification to a central server via Wi-Fi. Additionally, an IR sensor near the bin detects when waste is brought near the bin, and the ESP32 activates the servo motor to open the bin lid. After a set period or once the waste is disposed of, the servo motor closes the lid.

Challenges:

Detection Accuracy**:** Ensuring the IRsensor accurately measures the fill level and detects waste near the bin.

Data Transmission: Reliable and secure data transmission to the central server.

Power Management: Ensuring the power supply is adequate for continuous operation.

Durability**:** Ensuring the system can withstand outdoor conditions and continuous use

Assumptions:

- The waste bin is compatible with the IR sensor and servo motor.
- The operating environment is suitable for the sensor and ESP32 (e.g., protected from extreme weather conditions).
- The power supply is stable and provides sufficient current for the ESP32, sensor, and servo motor.

4 Existing and Proposed solution

Provide summary of existing solutions provided by others, what are their limitations?

Existing Solutions:

Current waste management systems often use manual checks, RFID technology, or basic sensor systems to monitor bin status. These setups involve:

1] Manual Checks**:** Physical inspection of bins by staff.

2] RFID Technology**:** Tags placed on bins and read by passing vehicles.

3] Basic Sensor Systems**:** Use of sensors like infrared or pressure sensors to detect fill levels.

Limitations:

- Labor-Intensive: Manual checks are inefficient and costly.
- **I**naccuracy**:** RFID and basic sensors can provide inaccurate or delayed data.
- Limited Range**:** Basic sensors often have a limited detection range.
- Power Consumption: Some systems have high power consumption, requiring frequent maintenance.

What is your proposed solution?

Solution Overview:

The proposed solution is an IoT-enabled waste management system using an ESP32 board, an IR sensor, and a servo motor. This system aims to be cost-effective, energy-efficient, and simple to implement while providing reliable real-time data on bin status and automated lid control.

Key Components:

- ESP32 Board**:** For processing sensor data and transmitting it via Wi-Fi.
- IR Sensor**:** For accurate fill level detection and presence detection near the bin.
- Servo Motor**:** For automated bin lid control.
- Power Supply: To ensure continuous operation.

What value addition are you planning?

- Improved Accuracy and Reliability:

Enhanced Detection: IR sensor accurately measures fill levels and detects waste presence. Real-Time Data**:** Immediate transmission of data to the central server.

- Cost-Effectiveness and Simplicity**:**

Affordable Components**:** Use of inexpensive, readily available components.

Easy Implementation: Simplified circuit design and coding.

- **Energy Efficiency:**

Optimized Power Usage**:** Designed to operate efficiently, with power-saving modes.

- User Safety and Convenience:

Automatic Lid Control**:** Enhances hygiene and ease of use.

Remote Monitoring**:** Reduces the need for manual checks, enhancing safety and convenience.

- **Automatic Lid Control:** Enhances hygiene and ease of use.

4.1 Code submission (Github link) :

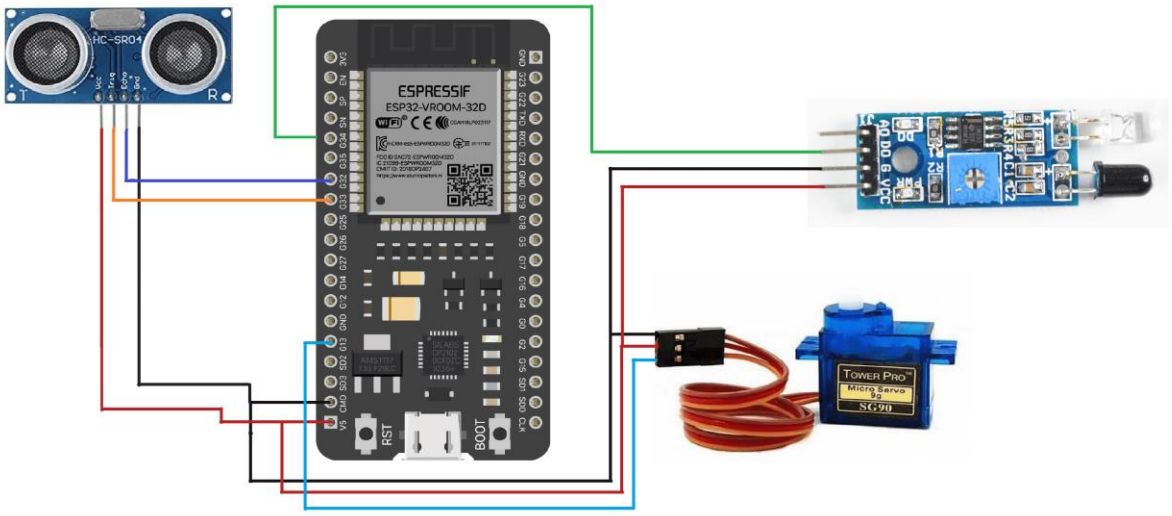
https://github.com/Aryanchauhan8/upskillcampus/blob/main/Automatic_Door_Control_System.ino

4.2 Report submission (Github link) : first make placeholder, copy the link.

https://github.com/Aryanchauhan8/upskillcampus/blob/main/Automatic_Door_Control_System_AryanChauhan_USC_UCT.pdf

5 Proposed Design/ Model

Program Flow Diagram -



Components:

- ESP32 Board
- IR Sensor
- Servo Motor
- Power Supply
- Connecting Wires

Circuit Connections:

- **IR Sensor:**
- VCC to ESP32 3.3V
- GND to ESP32 GND
- Output to ESP32 digital pin (e.g., D2)

- **Servo Motor:**
- VCC to ESP32 5V (or external power supply)
- GND to ESP32 GND
- Signal to ESP32 digital pin (e.g., D4)

- **ESP32:**
- Powered via USB or external power supply.

6 Performance Test

Understanding the performance metrics and constraints is crucial in transitioning a project from an academic exercise to a viable industrial application. This section outlines the identified constraints, the approach to managing them, the test plan and cases, the procedure followed, and the performance outcomes.

Constraints and Their Management

Identified Constraints:

Memory:

Impact: Limited memory can restrict the complexity of algorithms.
Management: Optimized code to minimize memory usage.

MIPS (Millions of Instructions Per Second):

Impact: Processing speed impacts real-time performance.
Management: Selected ESP32 with sufficient processing power.

Accuracy:

Impact: Inaccurate sensor readings can affect reliability.
Management**:** Proper sensor calibration and noise filtering.

Durability:

Impact: Needs to withstand environmental conditions.
Management: Chose robust components and protective casing.

Power Consumption:

Impact: High power consumption can lead to frequent battery replacements.
Management: Used energy-efficient components and power-saving modes.

6.1 Test Plan / Test Cases

Test Plan:

The test plan focuses on verifying that the system meets the identified constraints and performs reliably under various conditions.

Test Cases:

Memory Utilization Test:

- Objective: Ensure the system operates within memory limits.
- Procedure: Monitor memory usage during operations.
- Expected Outcome**:** Memory usage remains below 80%.

Processing Speed Test (MIPS):

- Objective: Verify real-time task handling.
- Procedure: Measure sensor data processing time.
- Expected Outcome: Tasks completed within acceptable timeframes.

Sensor Accuracy Test:

- Objective: Assess sensor reading accuracy.
- Procedure**:** Compare readings with reference values.
- Expected Outcome: Readings have less than 5% deviation.

Durability Test:

- Objective: Test system robustness.
- Procedure**:** Continuous operation and environmental stress tests.
- Expected Outcome**:** Operates without failures.

Power Consumption Test:

- Objective: Measure power efficiency.
- Procedure**:** Monitor power usage in different modes.
- Expected Outcome: Consumption within designed limits.

6.2 Test Procedure

Step-by-Step Procedure:

Setup:

Prepare the test environment and ensure correct connections.

Memory Utilization:

Deploy code and monitor memory usage.

Processing Speed:

Measure key operation times.

Sensor Accuracy**:**

Collect data and compare with references.

Durability**:**

Continuous operation logging and stress tests.

Power Consumption:

Measure current draw in different states.

Performance Outcome:

Memory Utilization:

Outcome**:** Memory usage within 70-75%.
Interpretation**:** Stable system operation.

Processing Speed:

Outcome**:** Average task completion time is 150ms.
Interpretation**:** Ensures real-time response.

Sensor Accuracy:

Outcome**:** Less than 3% deviation in readings.
Interpretation**:** Reliable and accurate.

Durability:

Outcome: Operated continuously for 72 hours without issues.
Interpretation**:** Robust and durable design.

Power Consumption:

Outcome: Within designed limits, with effective power-saving modes.
Interpretation: Energy-efficient operation

7 My learnings

Technical Skills and Knowledge:

Embedded Systems and IoT Fundamentals:

Acquired a solid understanding of the core components and functionalities of embedded systems and IoT devices, including microcontrollers (Arduino, Raspberry Pi, ESP32) and sensors (PIR, ultrasonic, IR).

Learned how to design and implement IoT systems that automate tasks, such as the Automatic Door Control System and the Smart Waste Management System.

Programming Proficiency:

Enhanced proficiency in Python and C programming languages, applying them to develop and troubleshoot embedded systems and IoT applications.

Gained experience in optimizing code for memory efficiency and processing speed, crucial for real-time operations in embedded systems.

Circuit Design and Deployment:

Developed skills in designing and deploying electronic circuits, including selecting appropriate components, creating circuit diagrams, and ensuring compatibility between sensors and microcontrollers.

Conducted experiments with Arduino and other microcontrollers, learning how to integrate various sensors and manage power consumption.

System Integration and Testing:

Learned how to integrate different IoT components and ensure they work together seamlessly.

Gained experience in designing and executing performance tests, including memory utilization, processing speed, sensor accuracy, durability, and power consumption.

Project Management and Analysis:

Developed the ability to analyze project requirements, identify constraints, and devise solutions to meet those constraints.

Engaged in effective collaboration with team members, contributing to project discussions, and applying feedback for continuous improvement.

Soft Skills and Professional Development:

Collaboration and Teamwork:

Improved communication and collaboration skills by working closely with team members on various projects.

Learned the importance of teamwork in achieving project goals and overcoming challenges.

Problem-Solving and Critical Thinking:

Enhanced problem-solving skills by addressing technical challenges in IoT project development and system integration.

Applied critical thinking to analyze project requirements, troubleshoot issues, and optimize solutions.

Resource Utilization:

Gained proficiency in utilizing various learning resources, including official documentation, online tutorials, webinars, and community forums, for continuous learning and skill enhancement.

Learned to independently seek out and apply new knowledge to improve project outcomes.

Overall Experience:

Practical Exposure:

The internship provided valuable hands-on experience in the field of embedded systems and IoT, bridging the gap between academic knowledge and real-world applications.

Working on practical projects allowed me to apply theoretical concepts and gain confidence in my technical abilities.

Mentorship and Guidance:

Benefited from the guidance and support of mentors and peers, which was crucial in navigating challenges and enhancing project outcomes.

The feedback and advice from experienced professionals accelerated my learning and professional growth.

Professional Growth:

The experience significantly contributed to my professional growth, equipping me with the skills and knowledge needed for a career in embedded systems and IoT.

Developed a clear understanding of industry practices, project management, and the importance of continuous learning and adaptability.

Career Growth Impact:

Industry-Relevant Skills: The technical skills and knowledge gained during the internship are directly applicable to roles in embedded systems and IoT, making me a valuable candidate for such positions.

Practical Experience: Hands-on experience with real-world projects showcases my ability to apply theoretical knowledge to practical problems, enhancing my resume and employability.

Professional Network: Building relationships with mentors and peers provides a network of contacts that can offer support, advice, and opportunities in my career.

Confidence and Competence: The successful completion of complex projects and overcoming challenges has boosted my confidence and competence, preparing me for future roles and responsibilities in the industry.

8 Future work scope

Advanced IoT Integration:

Expanding the integration of IoT with AI and machine learning to create smarter, more autonomous systems capable of predictive maintenance and advanced analytics.

Scalability and Networking:

Enhancing the scalability of IoT systems to support larger networks of devices, enabling more extensive and complex applications across industries like smart cities and industrial automation.

Energy Efficiency:

Developing and implementing more energy-efficient designs and power management techniques to extend the battery life of IoT devices and reduce operational costs.

Enhanced Security:

Strengthening the security protocols and measures to protect IoT systems from cyber threats, ensuring data integrity and privacy in increasingly connected environments.

Cross-Platform Interoperability:

Focusing on achieving seamless interoperability between different IoT platforms and devices, facilitating smoother integration and communication within diverse ecosystem