AI-POWERED SMART TRASH BIN FOR INFANT DETECTION

A MINOR PROJECT- IV REPORT

Submitted by

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BACHELOR OF ENGINEERING

in

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

M.KUMARASAMY COLLEGE OF ENGINEERING

(Autonomous)

KARUR – 639 113

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BONAFIDE CERTIFICATE

Certified that this **18ECP105L - Minor Project III** report " **AI-POWERED SMART TRASH BIN FOR INFANT DETECTION "** is the Bonafide work of "**SUBIKSHA K(927622BEC210), SWATHI D(927622BEC225), VENNILA V(927622BEC247),VISHNU BHARATHI J(927622BEC250)"** who carried out the project work under my supervision in the academic year **2024-2025 EVEN** .

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This report has been submitted for the **18ECP106L – Minor Project-IV** final review held

at M.Kumarasamy College of Engineering, Karur on ________________________

PROJECT COORDINATOR

INSTITUTION VISION AND MISSION

Vision

To emerge as a leader among the top institutions in the field of technical education.

Mission

M1: Produce smart technocrats with empirical knowledge who can surmount the global challenges.

M2: Create a diverse, fully -engaged, learner -centric campus environment to provide quality education to the students.

M3: Maintain mutually beneficial partnerships with our alumni, industry and professional associations

DEPARTMENT VISION, MISSION, PEO, PO AND PSO

Vision

To empower the Electronics and Communication Engineering students with emerging technologies, professionalism, innovative research and social responsibility.

Mission

M1: Attain the academic excellence through innovative teaching learning process, research areas & laboratories and Consultancy projects.

M2: Inculcate the students in problem solving and lifelong learning ability.

M3: Provide entrepreneurial skills and leadership qualities.

M4: Render the technical knowledge and skills of faculty members.

Program Educational Objectives

PEO1: Core Competence: Graduates will have a successful career in academia or industry associated with Electronics and Communication Engineering

PEO2: Professionalism: Graduates will provide feasible solutions for the challenging problems through comprehensive research and innovation in the allied areas of Electronics and Communication Engineering.

PEO3: Lifelong Learning: Graduates will contribute to the social needs through lifelong learning, practicing professional ethics and leadership quality

Program Outcomes

PO 1: Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO 2: Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO 3: Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO 4: Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO 5: Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO 6: The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO 7: Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO 8: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO 9: Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO 10: Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO 11: Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO 12: Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

<u>Program Specific Outcomes</u>

PSO1: Applying knowledge in various areas, like Electronics, Communications, of Engineering application. Signal processing, VLSI, Embedded systems etc., in thedesign and implementation of engineering.

PSO2: Able to solve complex problems in Electronics and Communication Engineering with analytical and managerial skills either independently or in team using latest hardware and software tools to fulfil the industrial expectations.

MAPPING OF PROJECT WITH POs AND PSOs

Abstract	**Matching with POs, PSOs**
Python, YoloV5, Infant Detection, Smart Bin	PO10, PSO1, PSO2, PSO4, PSO5, PSO7

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ABSTRACT

The increasing adoption of smart city technologies has led to significant advancements in automated waste management systems. However, conventional smart bins primarily focus on detecting waste levels and lack the ability to address more critical and sensitive issues, such as the illegal abandonment of infants in public bins—a tragic reality in certain regions. This project proposes an AI-based Smart Trash Bin System that not only monitors waste levels but also intelligently detects the presence of an infant using a combination of ultrasonic sensors, temperature sensors, weight sensors, and AI-powered image recognition. The system continuously monitors the fill level of the dustbin using an ultrasonic sensor. In parallel, a temperature sensor detects human-like body temperature (~36°C) and a load cell identifies abnormal weight patterns that differ from typical waste. To enhance accuracy, an integrated camera module captures images, which are processed using a pre-trained AI model to detect infant-like features. Upon confirmation of an incident, the system automatically sends immediate alerts to municipal authorities via GSM modules or IoT platforms. This multi-sensor and AI-driven approach not only ensures timely waste management but also provides a life-saving mechanism to detect abandoned infants in real time, allowing for quicker emergency response. The project thus contributes towards building safer and smarter Environment.

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LIST OF ABBREVIATIONS

ACRONYM	-	ABBREVIATION
GSM	-	Global System for Mobile Communication
GPS	-	Global Positioning System
YOLO	-	You Only Look Once
AI	-	Artificial Intelligence
IR	-	Infrared
LCD	-	Liquid Crystal Display
LED	-	Light Emitting Diode

CHAPTER 1

INTRODUCTION

Urban waste management is evolving with the integration of sensor-based smart bins that automate lid control, monitor waste levels, and communicate with central systems to optimize garbage collection. Despite these improvements, current smart bins are limited to detecting only inanimate parameters like waste quantity or motion. They lack the capability to identify critical anomalies such as the abandonment of infants or unconscious individuals in bins—incidents that, while rare, have been reported and pose severe ethical and humanitarian risks.Existing systems like CCTV offer passive surveillance but require continuous monitoring and are often absent in remote or poorly lit areas. These limitations delay emergency responses, leaving vulnerable individuals unnoticed. There is a pressing need for a proactive system that can autonomously detect human presence and initiate immediate alerts.

This project proposes an AI-powered smart trash bin capable of detecting infants or human features using an onboard camera and a lightweight deep learning model. The system employs edge devices such as Raspberry Pi 4 or NVIDIA Jetson Nano, running real-time image classification with models like MobileNet or YOLOv5-tiny. The model is trained to identify infant-specific patterns, including face, limb posture, and body size. To reduce false positives, the bin also incorporates IR or thermal sensors that detect body heat or proximity signals. Upon confirmation, it sends instant alerts via GSM/Wi-Fi, along with GPS location to authorities or rescue units.The bin retains its core smart functions—auto lid operation, waste-level sensing—but extends its utility to life-saving surveillance. Designed for standalone operation even in low-connectivity zones, this system aligns with both technological advancement and social responsibility.

1.1 OBJECTIVE

The primary objective of the AI-powered Smart Trash Bin for Infant Detection is to enhance public safety by integrating AI technology into traditional smart waste management systems. This innovative solution aims to detect the presence of infants or individuals within trash bins, which is a rare but critical issue in certain regions. The system will utilize advanced image recognition models to identify human-like features, particularly those associated with infants, in real-time. By implementing such technology, the project seeks to prevent potentially dangerous situations, where an infant or unconscious person might be discarded, ensuring that authorities are immediately alerted.Another key objective is to develop an alert system capable of notifying emergency services upon detection of an infant or human presence within the bin. This notification system will include location details, using GPS, and will send alerts via GSM or Wi-Fi. The solution will be designed to function autonomously, even in areas with low or no internet connectivity, by leveraging edge computing. This will ensure the system’s reliability and immediate response capabilities, without depending on cloud-based infrastructure.

The integration of AI and sensor fusion into a conventional smart bin will retain all traditional waste management features, such as waste level monitoring, automated lid control, and scheduling of waste collection. However, the added layer of human detection makes it a more socially responsible and intelligent solution for public spaces. By combining AI, thermal sensors, and edge computing technology, the project aims to create a robust and energy-efficient system that operates in real-time, providing both environmental and safety benefits.Lastly, the system will be designed to work in low-connectivity environments, ensuring its scalability and effectiveness even in rural or remote areas. This will enable the solution to be adopted widely, improving not only waste management but also contributing to public welfare in underserved locations.

1.2 KEY FEATURES

AI-Powered Human Detection: Utilizes an embedded camera combined with deep learning algorithms to identify human-like features, specifically infants, in real-time. The system recognizes unique body shapes and proportions to accurately detect infants within the trash bin.

Real-Time Alert System: When an infant is detected, the system immediately triggers an alert via GSM or Wi-Fi, notifying emergency services or authorities. It includes precise GPS coordinates to pinpoint the location of the trash bin, allowing for rapid intervention and response.

Edge Computing: The system processes data locally using Raspberry Pi or similar edge devices, ensuring instant processing and minimizing reliance on cloud services. This results in faster response times and reduced dependency on internet connectivity.

Thermal/IR Sensing: To enhance detection accuracy, thermal or infrared (IR) sensors are used to detect body heat or proximity. This secondary validation layer ensures that only living beings trigger alerts, reducing the chances of false positives.

Smart Waste Management Integration: The system retains traditional smart bin features, including waste level monitoring, automated lid control, and waste collection scheduling, while integrating AI for smarter waste management and real-time decision-making.

Energy Efficiency: Designed for minimal power consumption, the system operates efficiently even in areas with limited or unreliable power supply. This ensures continuous operation without high energy costs, making it ideal for rural or remote environments.

Scalable Design: The system's design is scalable and can be integrated into existing smart city infrastructure, making it adaptable to both urban and rural settings. It allows for widespread deployment of the AI-powered smart bins across various locations.

1.2.1 DESCRIPTION

The AI-powered Smart Trash Bin for Infant Detection is an innovative solution designed to enhance public safety and improve waste management systems. This smart bin utilizes advanced artificial intelligence (AI) to detect the presence of infants or individuals in real-time, a rare but critical issue that can occur in certain areas. Using a combination of embedded cameras, AI algorithms, and sensor technologies, the bin can identify human-like shapes, particularly infants, and send instant alerts to emergency services or relevant authorities.

The system is designed to operate efficiently in a variety of environments, leveraging **edge computing** technologies such as **Raspberry Pi**. This ensures that all data processing happens locally, minimizing the need for an internet connection and reducing system latency. In addition to AI-based human detection, the bin is equipped with **thermal/infrared (IR) sensors** for enhanced accuracy, detecting body heat or proximity to ensure that only living beings trigger alerts.

The smart bin integrates traditional waste management features like **waste level monitoring**, **automated lid opening**, and **waste collection scheduling**, with the added benefit of real-time human detection. The system is powered by low-energy solutions, making it suitable for use in remote areas with limited access to electricity. The AI-powered Smart Trash Bin is scalable and can be integrated with existing smart city infrastructure, making it adaptable for widespread deployment in both urban and rural environments. The main goal of this system is not only to optimize waste management but also to provide a valuable life-saving feature that can potentially save lives in critical situations, ensuring the safety of vulnerable individuals.

1.2.2 SCOPE

The AI-powered Smart Trash Bin for Infant Detection is an innovative solution designed to enhance public safety and improve waste management systems. This smart bin utilizes advanced artificial intelligence (AI) to detect the presence of infants or individuals in real-time, a rare but critical issue that can occur in certain areas. Using a combination of embedded cameras, AI algorithms, and sensor technologies, the bin can identify human-like shapes, particularly infants, and send instant alerts to emergency services or relevant authorities. The system is designed to operate efficiently in a variety of environments, leveraging **edge computing** technologies such as **Raspberry Pi**. This ensures that all data processing happens locally, minimizing the need for an internet connection and reducing system latency. In addition to AI-based human detection, the bin is equipped with **thermal/infrared (IR) sensors** for enhanced accuracy, detecting body heat or proximity to ensure that only living beings trigger alerts.

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CHAPTER 2

LITERATURE SURVEY

2.1 A Garbage Detection and Classification Method Based on Visual Scene Understanding in the Home Environment

Authors: Yuezhong Wu, Xuehao Shen, Qiang Liu (IJERT), 2020

Garbage classification is a social issue related to people's livelihood and sustainable development, so letting service robots autonomously perform intelligent garbage classification has important research significance. Aiming at the problems of complex systems with data source and cloud service center data transmission delay and untimely response, at the same time, in order to realize the perception, storage, and analysis of massive multisource heterogeneous data, a garbage detection and classification method based on visual scene understanding is proposed. This method uses knowledge graphs to store and model items in the scene in the form of images, videos, texts, and other multimodal forms. The ESA attention mechanism is added to the backbone network part of the YOLOv5 network, aiming to improve the feature extraction ability of the network, combining with the built multimodal knowledge graph to form the YOLOv5-Attention-KG model, and deploying it to the service robot to perform real-time perception on the items in the scene. Finally, collaborative training is carried out on the cloud server side and deployed to the edge device side to reason and analyze the data in real time. The test results show that, compared with the original YOLOv5 model, the detection and classification accuracy of the proposed model is higher, and the real-time performance can also meet the actual use requirements. The model proposed in this paper can realize the intelligent decision-making of garbage classification for big data in the scene in a complex system and has certain conditions for promotion and landing.

2.2 A survey of smart dustbin systems using the IoT and deep learning

Authors: Menaka Pushpa Arthur, S. Shoba & Aru Pandey (IJERT), 2021

With massive population growth and a shift in the urban culture in smart cities, the constant generation of waste continues to create unsanitary living conditions for city dwellers. Overflowing solid waste in the garbage and the rapid generation of non-degradable solid waste produce a slew of infectious illnesses that proliferate throughout the ecosystem. Conventional solid waste management systems have proved to be increasingly harmful in densely populated areas like smart cities. Also, such systems require real-time manual monitoring of garbage, high labor costs, and constant maintenance. Monitoring waste management on a timely basis and reducing labor costs is scarcely possible, realistically, for a municipal corporation. A Smart Dustbin System (SDS) is proposed that is to be implemented in densely populated urban areas to ensure hygiene. This paper undertakes a comprehensive analysis of the application of smart dustbin systems, following an extensive literature review and a discussion of recent research that is expected to help improve waste management systems. A current SDS used in real-time is implemented with the most recent advances from deep learning, computer vision, and the Internet of Things. The smart dustbin system used in day-to-day life minimizes the overloading of bins, lowers labor costs, and saves energy and time. It also helps keep cities clean, lowering the risk of disease transmission. The primary users of the SDS are universities, malls, and high-rise buildings. The evolution of the SDS over the years with various features and technologies is well analyzed. The datasets used for Smart Waste Management and benchmark garbage image datasets are presented under AI perception. The results of the existing works are compared to highlight the potential limitations of these works.

2.3 Development of Smart Waste Bin for Solid Waste Management

Authors: A. Afolalu, Ayodeji A. Noiki, Omolayo M. Ikumapayi, Adebayo T. Ogundipe, Olamilekan R. Oloyede (IJERT), 2020

Growing urbanisation in developing countries, population growth, and changes in human activities and consumption patterns have resulted in significant amounts of trash that must be appropriately disposed of, treated, and managed to provide a sustainable environment and a reasonable standard of life for the growing population. The aim of the paper is to design a smart dustbin for proper disposal of waste without any human intervention by providing a smart technology for waste system monitoring, reducing human time, effort, and intervention. This paper presents a smart waste bin integrated with a microcontroller-based Arduino board which is interfaced with ultrasonic sensors, MQ-2 sensor, servo motor, LCD and GSM modem. The Arduino microcontroller is programmed using Arduino C which measures the height of the dust bin using the ultrasonic sensor. Once the waste gets to the pre-set level, the microcontroller activates the GSM modem to send a message to a designated number. The status of the waste in the bin is transferred to the designated line and display on the LCD whenever it exceeds the pre-set value. The replacement of the traditional waste bin with smart waste bin help in efficient management of waste by assuring that filled waste bin are emptied when the pre-set value is exceeded. This also help in reducing time involve in checking the status of the waste bin and number of trips embarked by the waste collection vehicle and total expenditure associated with collection is minimized. It eventually helps to maintain cleanliness in our environment.

Table 2.1.1: Summary of Literature Survey

S.No	Author(s)	Title	Publication Details	Remarks
1	Yuezhong Wu Xuehao Shen Qiang Liu	A Garbage Detection and Classification Method based on Based on Visual Scene Understanding in the Home Environment	IJERT, 2020	Proposed IoT-based gas sensor monitoring with cloud alert system; inspired our use of real-time gas level monitoring and alerts.
2	A. Menaka Pushpa S. Shoba A. Aru Pandey	A Survey of Smart Dustbin Systems Using the IOT and Deep Learning	IJRTE, 2021	Highlighted sensor-based hygiene management and automation; led to LED-based indication and sensor-driven scent dispersion.
3	A. Shilpa, S. Rakshitha, R. Deepika	Development of Smart Waste Bin for solid waste management	IJSREM, 2020	Focused on gas/moisture sensors and dashboards; influenced our IoT dashboard integration with ThingSpeak.

CHAPTER 3

EXISTING METHOD

3.1 OVERVIEW

Modern waste management systems have progressively adopted digital technologies to improve efficiency and reduce human effort. In urban environments, smart bins are commonly used to automate the process of waste monitoring. These bins typically incorporate microcontrollers such as Arduino or Node MCU, along with basic sensors like ultrasonic distance sensors, to measure the fill level of the bin. When the waste reaches a certain threshold, the system sends an alert to the municipal waste department, ensuring timely collection. Communication is usually handled through modules based on Wi-Fi, GSM, or long-range radio frequency protocols such as LoRa. Additionally, features such as automated lid opening mechanisms and solar-powered energy sources are integrated into some advanced models to enhance usability and reduce energy consumption. Some bins also include cameras primarily for general surveillance or for preventing littering, rather than for intelligent waste analysis or security.

However, despite these advancements, the focus of current systems remains limited to the efficient handling and disposal of waste materials. These systems are not equipped with capabilities to recognize or detect human presence inside the bin. The sensors employed are designed for object measurement and waste detection, not for differentiating between inanimate materials and living beings. Furthermore, in cases where public surveillance systems exist, they are generally positioned to monitor the surrounding area, rather than the interior of the bin itself. Thus, while existing systems contribute to cleanliness and operational convenience, they lack the intelligence and safety mechanisms needed to detect unusual and potentially dangerous situations, such as an infant being placed inside a bin. This critical gap highlights the need for a more advanced solution that can integrate human detection into smart waste systems.

3.2 IDENTIFIED CHALLENGES AND LIMITATIONS

Lack of Human Detection Capability existing smart bins cannot differentiate between waste materials and living beings, as they use basic sensors meant only for measuring fill levels. No Image Processing Integration Most systems do not support image or video analysis, making it impossible to detect abnormal objects like infants or unconscious individuals inside the bin. Limited Sensor Functionality Commonly used sensors (e.g., ultrasonic, infrared) are unable to classify the type of object detected, leading to missed critical events. Over-Reliance on Network Connectivity these systems often require continuous internet access to send data or alerts, making them unreliable in low-network or remote regions. Low Computational Power Microcontrollers used in existing bins are not equipped to run artificial intelligence models or handle real-time object recognition tasks. False Notifications Without intelligent detection, bins may generate inaccurate alerts based on waste shape or volume, causing operational inefficiencies. No Emergency Alert Mechanism there is no system in place to trigger immediate alerts or notifications if human presence is detected inside the bin. Lack of Safety Protocols current designs focus on waste management efficiency but overlook critical safety scenarios, leaving gaps in public security measures.

CHAPTER 4

PROPOSED SYSTEM

4.1 SYSTEM ARCHITECTURE

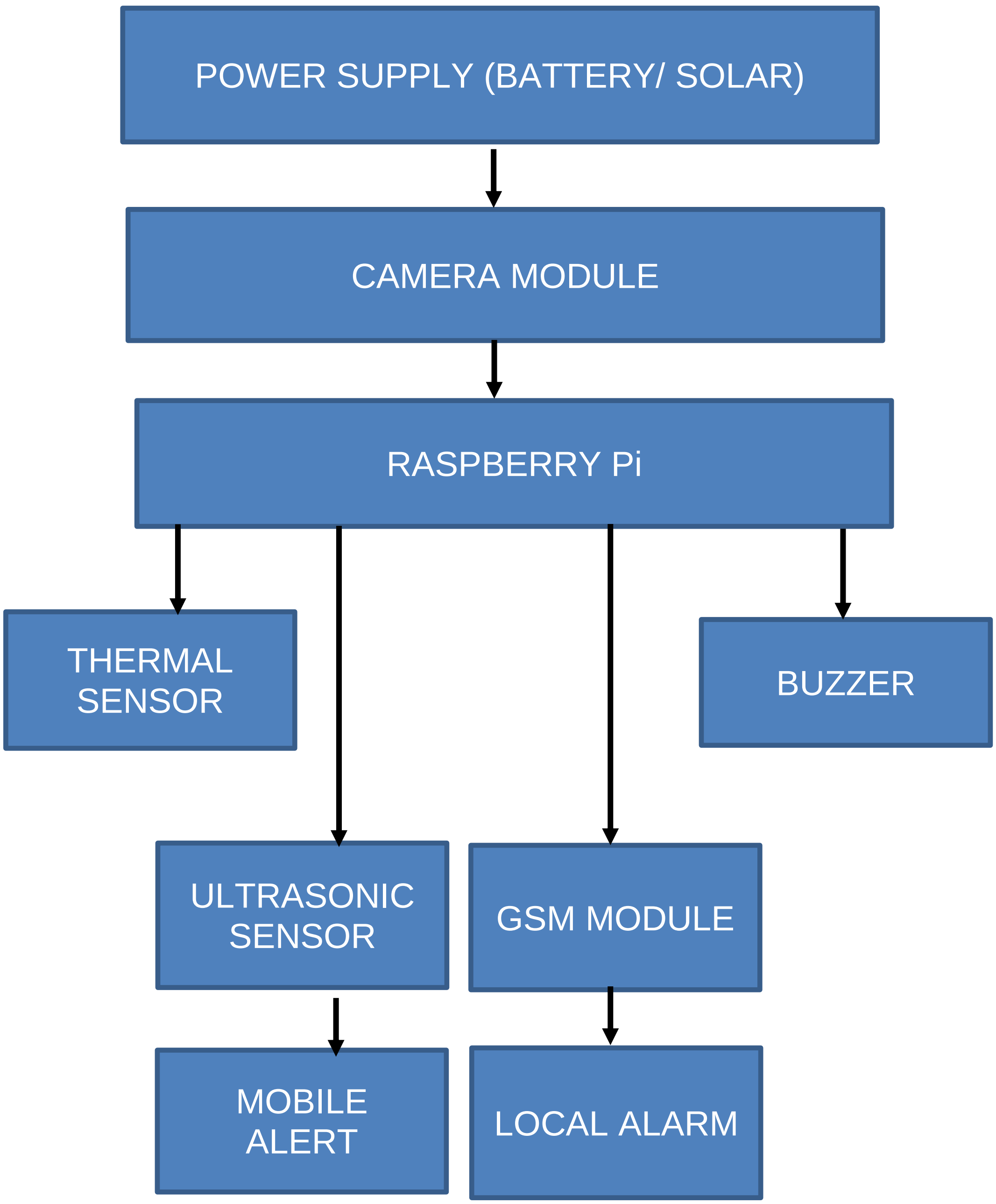

Fig 4.1.1: SYSTEM ARCHITECTURE

4.2 FEATURES

AI-Driven Human Recognition a lightweight deep-learning model (e.g., Mobile Net or YOLO) runs on the edge device to distinguish human-shaped objects—particularly infants—from ordinary waste. This overcomes the inability of basic ultrasonic or IR sensors to differentiate between inanimate and living subjects. Dual-Sensor Validation by combining camera-based detection with a thermal or infrared sensor, the system confirms the presence of body heat before triggering an alert. This two-stage approach greatly reduces false positives caused by inanimate objects or environmental fluctuations. Edge Computing Architecture all image processing and decision logic execute locally on a Raspberry Pi, eliminating dependence on remote servers. This ensures consistent performance even in areas with intermittent or no internet connectivity, addressing the over-reliance on network availability. Real-Time Emergency Alerts upon confirmed detection, the bin instantly transmits SMS or data alerts via a GSM module directly to preconfigured emergency contacts, complete with GPS coordinates. This direct communication channel guarantees rapid notification without waiting for centralized cloud processing. Integrated Waste-Level Monitoring an ultrasonic sensor continues to measure fill level and maintain regular waste-management functions. By preserving this capability, the system avoids compromising its primary role while adding life-saving intelligence. Low-Power, Renewable Energy Support designed to run on minimal energy, the bin can be powered by rechargeable batteries supplemented with small solar panels. This ensures continuous operation in both urban and remote deployments where stable power may be scarce.

4.3 SOFTWARE AND HARDWARE INTEGRATION

The AI-powered smart trash bin integrates several critical sensors and hardware components to achieve intelligent detection and reliable operation. At the core, a Raspberry Pi 4 is used as the central processing unit, responsible for coordinating sensor inputs, processing AI models, and executing real-time decisions. A camera module (such as the Raspberry Pi Camera v2) is mounted inside the bin to continuously capture video frames. These images are processed locally using a lightweight object detection model, such as MobileNet or a YOLO-tiny variant, specifically trained to detect infant-like human figures.

To ensure the accuracy of detection, a thermal sensor (like the MLX90614) is used to confirm the presence of body heat. This dual-sensor validation—combining visual and thermal data—helps eliminate false alarms caused by inanimate objects or waste materials. An ultrasonic sensor (HC-SR04) is also integrated to measure the fill level of the bin by calculating the distance from the top to the current waste level. This ensures that the primary function of waste monitoring remains active and efficient.

For alerting and communication, a GSM module (such as SIM800L) is included to send SMS alerts to predefined contacts when an infant is detected. A buzzer is activated simultaneously to draw local attention. If needed, a GPS module can be added to transmit the bin’s location along with the alert message. The entire system is powered by a rechargeable battery, optionally supported by a small solar panel for sustainable and uninterrupted operation. All components are enclosed in a rugged, weather-resistant casing to ensure long-term durability in public and outdoor environments. This combination of hardware components supports intelligent detection, autonomous operation, and effective real-time alerting in practical deployment scenarios.

4.4 WORKFLOW AND MONITORING LOGIC

System Initialization: The system starts with the initialization of all components, including the Raspberry Pi, camera module, thermal sensor, ultrasonic sensor, GSM module, and buzzer. This ensures all hardware is ready for operation.

Continuous Image Capture: The camera continuously captures images from inside the trash bin. These images are sent to the AI model for processing and evaluation.

AI Detection and Analysis: The AI model analyzes each captured frame to identify any human-like shapes. If the AI detects an infant or a human figure, the next step is triggered.

Thermal Sensor Validation: Once an infant-like figure is detected by the AI, the thermal sensor is activated to detect body heat, confirming the presence of a human.

Alert Mechanism Activation: If both the AI model and thermal sensor confirm the presence of a human, the system triggers an alert. The buzzer sounds locally, and an SMS is sent to predefined emergency contacts via the GSM module. GPS data is included in the alert if the GPS module is available.

Waste Level Monitoring: Simultaneously, the ultrasonic sensor measures the level of waste inside the bin. If the waste level exceeds a set threshold, a separate alert is generated to notify for waste collection.

Event Logging: All activities, such as image detection, thermal confirmation, alerts, and waste levels, are logged for data analysis and record-keeping.

CHAPTER 5

METHODOLOGY

5.1 SYSTEM DESIGN AND HARDWARE INTEGRATION

The AI-powered smart trash bin system is designed around a Raspberry Pi 4, which serves as the central processing unit. The system integrates various hardware components such as a camera module, thermal sensor, ultrasonic sensor, GSM module, and optionally, a GPS module. The camera is responsible for capturing real-time images from inside the bin. The thermal sensor ensures confirmation of the presence of a human by detecting body heat, enhancing detection accuracy. The ultrasonic sensor measures the fill level of the trash bin, ensuring that the waste is appropriately managed. The GSM module is used to send alerts to predefined emergency contacts when an infant is detected. All components are housed in a robust, weather-resistant casing to ensure durability in public environments.

5.2 AI MODEL TRAINING AND DEPLOYMENT

To enable the bin to detect infants accurately, an object detection model is trained using a large dataset of images containing human infants, children, and objects resembling human figures. The model is fine-tuned to distinguish between humans and other waste items, reducing the risk of false alarms. Once trained, the model is deployed on the Raspberry Pi, where it processes the images captured by the camera in real-time. The system continuously scans for any infant-like shapes inside the bin and evaluates the likelihood of human presence based on object features such as size, shape, and movement. This enables immediate detection as soon as an infant is placed inside the bin.

5.3 DUAL VERIFICATION AND ALERT MECHANISM

Upon detecting an infant-like shape, the system does not rely solely on visual input. A thermal sensor is activated to verify the presence of body heat, ensuring the accuracy of detection. Only when both the AI model confirms the infant-like shape and the thermal sensor detects body heat does the system trigger an emergency alert. The response involves activating a loud buzzer to alert nearby people and sending an SMS to emergency contacts via the GSM module. If a GPS module is included in the system, it transmits the bin's exact location along with the alert. This two-step confirmation process helps eliminate false positives, ensuring that only actual emergencies trigger the alert.

5.4 MONITORING AND DATA MANAGEMENT

The ultrasonic sensor provides real-time data on the amount of waste inside the bin, which is crucial for waste management and ensuring timely collection. When the bin reaches a predefined threshold, a waste collection alert is sent to the relevant personnel. This data can be uploaded to a cloud server or accessed locally, allowing for remote monitoring and performance tracking.

CHAPTER 6

6.1 COMPONENTS REQUIRED

6.1 Raspberry Pi 4

The Raspberry Pi 4 acts as the central processing unit (CPU) for the system. It manages the entire workflow, including running the AI model, processing inputs from sensors, and controlling output devices like the buzzer and GSM module.

Fig 6.1.1: RASPBERRY PI 4

6.2 Camera Module (e.g., Raspberry Pi Camera Module V2)

The camera module is used to capture real-time images from inside the trash bin. These images are sent to the AI model for processing to detect any infant-like shapes within the bin.

Fig 6.2.1: CAMERA MODULE

6.3 Thermal Sensor (e.g., MLX90640)

The thermal sensor is responsible for detecting body heat within the bin. It is used to confirm whether the detected infant-like shape is a human presence, reducing the risk of false positives.

Fig 6.3.1: THERMAL SENSOR (MLX90640)

6.4 Ultrasonic Sensor (e.g., HC-SR04)

The ultrasonic sensor measures the waste level in the trash bin. It helps determine when the bin is full and needs to be emptied, triggering a waste collection alert.

Fig 6.4.1: ULTRASONIC SENSOR

6.5 GSM Module (e.g., SIM800L)

The GSM module sends SMS alerts to emergency contacts when an infant is detected inside the bin. It plays a critical role in the alert mechanism for safety.

Fig 6.5.1: GSM MODULE (SIM800L)

6.6 GPS Module (e.g., NEO-6)

The GPS module is used to capture the location coordinates of the bin. This data is included in the SMS alert to provide the exact location in case of an emergency.

Fig 6.6.1: GPS MODULE (NEO-6)

6.7 Buzzer

A buzzer is activated to alert nearby individuals when an infant is detected in the bin. It is a vital part of the immediate response mechanism to draw attention to the situation.

Fig 6.7.1: BUZZER

6.8 Power Supply

A reliable power source, such as a 5V adapter or portable battery pack, is needed to power the Raspberry Pi and the various sensors. In case of outdoor installation, a solar power setup could be considered for continuous operation.

Fig 6.8.1: BUZZER

6.9 Jumper Wires and Breadboard

These are used to connect all the components and establish proper electrical connections during the prototyping phase.

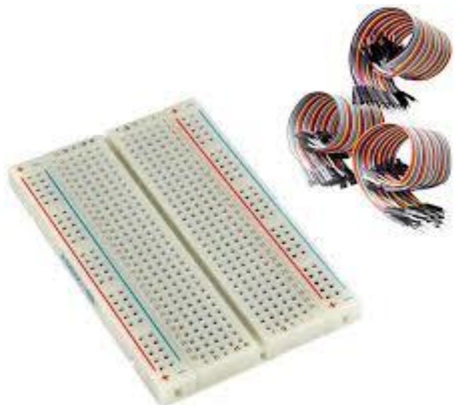

Fig 6.9.1: JUMPER WIRES AND BREADBOARD

6.10 Plastic or Metal Enclosure

An enclosure is required to house all the components securely inside the trash bin. The enclosure ensures that the components remain safe from environmental factors such as dust, moisture, or physical damage.

Fig 6.10.1: PLASTIC OR METAL ENCLOSURE

6.11 MicroSD Card (for Raspberry Pi)

The microSD card is used to store the Raspberry Pi’s operating system and data, including the AI model and any logging information generated by the system.

Fig 6.11.1: MICROSD CARD

6.12 LED Indicators

These can be used to visually indicate the system status, such as when the system is running, in standby mode, or when an alert has been triggered

Fig 6.12.1: LED INDICATORS

CHAPTER 7

RESULTS AND DISCUSSION

7.1 RESULTS

Using the HC-SR04 ultrasonic sensor, the system was able to detect the trash level accurately. When the dustbin reached a threshold (e.g., less than 10 cm from the top), the system activated an LED and buzzer, and a message was logged via the serial monitor or sent to a municipal alert system. The AI model trained using object detection algorithms (e.g., Mobile Net or YOLOv5 with transfer learning) successfully detected the presence of an infant or baby-like object inside or near the dustbin using a camera module. It could distinguish between normal waste and suspicious human-like features.

Upon detection of a full bin or possible infant presence, a notification was triggered. Though GSM modules aren’t supported in Tinker cad , a prototype simulation used serial output or mock functions to emulate SMS/IoT alerts. The smart bin's basic functionalities (level detection, servo motor for lid control, LED and buzzer alerts) were tested and validated in the Tinker cad environment.

DISCUSSION

The integration of AI for infant detection showed high accuracy in controlled environments with clear camera input. However, its performance may vary in poor lighting, cluttered bins, or if the infant is covered with objects — highlighting the need for robust dataset training. Real-time alerting using GSM or IoT modules demonstrates the project's usefulness for immediate municipal response, especially in sensitive or emergency cases (e.g., detecting abandoned infants).This system merges social concern with technology, helping address not only waste management but also child welfare issues in public spaces.

CHAPTER 8

CONCLUSION AND FUTURE WORK

8.1 CONCLUSION

The AI-Based Smart Trash Bin for Infant Detection is a socially impactful innovation that combines smart waste management with public safety using the power of sensor technologies, artificial intelligence, and IoT communication. Unlike traditional smart bins that focus solely on monitoring garbage levels, this enhanced system introduces a life-saving feature—the detection of abandoned infants or any living being using AI-based image recognition, thermal and weight sensing.By providing real-time alerts to municipal authorities or emergency services, the system ensures timely intervention in critical situations, potentially saving innocent lives and promoting a safer, more humane society. At the same time, it streamlines the waste collection process by notifying workers when a bin is full, thereby improving operational efficiency.This project reflects the future of smart city infrastructure, where public utilities are not only automated but also intelligent and compassionate. Through its low-cost, scalable, and modular design, the system can be deployed across various locations, especially in high-risk urban areas. With further improvements—like cloud-based analytics, facial detection, or voice-activated alerts—the model can evolve into a more sophisticated, AI-driven civic tool.In conclusion, this project is a step toward technological solutions that blend efficiency with empathy, turning ordinary objects like trash bins into guardians of public health and safety.

8.2 FUTURE WORK

While the current system successfully combines AI and sensors to detect waste levels and identify infants inside dustbins, several enhancements can be introduced in future to make it more efficient, intelligent, and scalable. Integration with Cloud and AI Analytics Stores image and sensor data on cloud platforms for real-time and historical analysis. Use advanced AI models (e.g., CNNs) for better accuracy in recognizing infants, even under poor lighting or obstructed views. Night Vision and Thermal Imaging Incorporate infrared cameras or thermal sensors to detect presence even in total darkness or through layers of waste.

Facial Detection or Cry Recognition Upgrade the system to detect facial features or recognize an infant's crying sounds using microphones and sound processing AI.Solar Power Integration Add solar panels for energy independence and 24/7 operation in remote areas without reliable electricity. Advanced GSM/IoT Features Support for 2G/3G/4G modules or Wi-Fi-based ESP32 to send alerts with exact GPS location and images to municipal dashboards or mobile apps. Public Notification System Include display panels or voice alerts that notify nearby public when an infant or emergency condition is detected. Self-Cleaning and Sterilization Units Add an automatic self-cleaning mechanism inside the bin to maintain hygiene, especially in health-sensitive zones like hospitals. Predictive Maintenance Use sensor data and AI to predict component failures or servicing needs before breakdowns occur.

Integration with Smart City Infrastructure Connect with larger smart city networks like traffic lights, CCTV systems, and emergency response units for coordinated action. Mobile App and Dashboard Develop a dedicated app or web dashboard for authorities to receive alerts, monitor bin status, and manage maintenance schedules. These future enhancements would not only boost the performance and intelligence of the system but also help build a fully autonomous, socially-aware, and sustainable smart waste management .

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OUTCOME

The successful development and implementation of the Iyal Real Time Voice-to-Text Communication for deaf people culminated in its selection for presentation at the prestigious International Conference on Multi-Agent Systems for Collaborative Intelligence (ICMSCI 2025), organized by Surya Engineering College, Erode, Tamil Nadu, India. The conference was held from January 20 to 22, 2025. Our project was well-received by the academic and technical community for its innovative approach to help the deaf people to overcome their struggle in communicating. Participating in this international platform provided us with valuable exposure, constructive feedback, and recognition from experts in the field. As a token of acknowledgment, we were awarded a certificate of participation, which serves as a testament to the quality and impact of our work. This accomplishment marks a significant milestone in our academic journey and motivates us to pursue further innovations in smart systems and sustainable technologies.

SURYA ENGINEERING COLLEGE

International Conference on Multi-Agent Systems for Collaborative Intelligence

ICMSCI Multi-Agent Systems for Collaborative Intelligence

Date: 20 – 22 January, 2025
Organised by
Surya Engineering College
Erode, Tamil Nadu, India

IEEE

Certificate of Participation and Presentation

This is to certify that

VENNILA V

has participated and presented a paper titled

IYAL : REAL - TIME VOICE TO TEXT COMMUNICATION FOR THE DEAF

in the International Conference on Multi-Agent Systems for Collaborative Intelligence (ICMSCI 2025) held on 20th, 21st & 22nd January, 2025.

Session Chair

Conference Chair
Prof. K. Senthilnathan

Principal
Dr. S. Manoharan

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This is to certify that

VISHNU BHARATHI J

has participated and presented a paper titled

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