SMART INITIATIVE FOR AN ECO - FRIENDLY WASTE MANAGEMENT SYSTEM

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Abstract- For emerging smart cities, waste management will be the predominant factor to focus on and implement. The conventional waste management system operates on a daily schedule which is inefficient and costly due to time-consuming, labour, energy and resources in urban areas. The existing trash-can causes air pollution in the public as people do not recycle their trash properly. And some waste is flushed down the drain causing the sewage system to become blocked and then stagnate leading to the harmful and terrible spread of disease. With the advancement of smart technologies such as Machine Learning (ML) and the Internet of Things (IoT), the conventional waste management system can be replaced with in-system sensors to perform real-time monitoring and improve the quality of the waste management system. The waste collected is classified as biodegradable and non-biodegradable waste. The classified waste is then weighed using sensors. This sensor information will be used to calculate the waste disposal reward at that time. This reward system encourages people to keep the environment clean and safe among themselves. Once the coins are awarded, the waste is compressed inside the bin compartments. The bin level is sensed using sensors and this information is sent to monitoring team for replacement of bins. Once the bin is filled, it intimates to the monitoring team. With the help of GPS, e-vehicle from the monitoring team tracks the shortest path to the bin and replaces it immediately.

I.INTRODUCTION

The conventional waste management system operates based on a daily schedule which is the inefficient and high cost in urban areas. The existing recycle bin is ineffective in the public as people do not properly recycle their waste. With the advancement of smart technologies like Machine Learning (ML) and the Internet of Things (IoT), the conventional waste management system can be replaced with sensors that are embedded into the system to perform real-time monitoring and betterment in waste management. The aim of this research proposal is to develop an AI-based smart waste management system using LoRa technology and a deep learning model. In this work, the object detection model is trained with images of waste to generate a frozen inference graph used for object detection which is done through a camera connected to the IoT module. The ultrasonic sensor is embedded into each waste compartment to monitor the filling level of the waste and a camera is used to find the types of waste. This sensor information will be used for calculating the reward to the waste disposer at the moment. This rewarding system encourages the people on keeping the environment clean and safe among them. Once, the coins are awarded, the wastes are compressed inside the bin compartments.

From the survey it was implicit that the waste which was not properly collected and disposed end up in the waterways and landfills contaminating the environment. By implementing the smart waste bins, the human intervention in sorting the waste can be avoided to a greater extent. The fill level of the smart bins can be monitored and the time of disposal can be scheduled accordingly, thus avoiding the overflow of garbage and spreading of waste in the streets.

GPS module is integrated to monitor the location and real-time of the smart bin. LoRa advanced communication technology is used to transmit data about the location, real-time data, and filling level of the smart bin. Radio Frequency Identity (RFID) module is embedded in IoT for the purpose of waste management personnel identification. The data from various waste bins are collected by the LoRa gateway and sent to the cloud over the Internet using the Message Queue Telemetry Transport (MQTT) protocol. The benefits of the proposed system are the use of LoRa technology for data communication which enables long-distance data transmission with low Power consumption.

II. RELATED WORKS

The possibility of unread tags, ghost tags, and the need for image processing algorithms to extract the level of bins are some of the drawbacks of these systems. In [1], the graphical user interface shows an organizational view of all the bins location wise to easily identify the garbage level and the location of a trash bin. To collect the geolocation coordinates of every bin, the TBLMU is equipped with a GPS module.

In [2] study, focus on developing a highly efficient energy control framework to simultaneously determine the optimal load pattern and energy storage capacity of the BESSs for industrial users. The third stage was the establishment of an extensible optimization function to determine the optimal load pattern and energy storage capacity of the BESS. This was done by integrating the typical load pattern of the industrial users and the economic model.

David Rutqvist et.al [3] focused exclusively on the emptying detection part of the considered Smart Waste Management system since accurate emptying detection is a very important prerequisite for accurate emptying time prediction. The applied contribution is the use of the methodology for the development and investigation of several alternative solutions to the emptying detection problem. Motivation for the Accurate Emptying Detection in Smart Waste Management Systems Recalls that the goal of a Smart Waste Management system is to predict emptying time, i.e., the time when a recycling container will be full enough to be emptied.

The [4] introduced the comfort model and the data sets for this research. The comfort model digests the feature data and produces the corresponding comfort index. In this article, we introduced interpretability to the PMV model and we use data as a bridge between the comfort model and interpretations.

Despite the architecture was not described in detail, [5] solution allows to recognize of users by a passive RFID tag on the garbage bin and to measure the amount of waste by a load cell sensor installed on the arms of the waste collecting vehicle. The RFID tag, placed on the garbage bin, is equipped with a sensor able to detect the weight of the waste. The main feature of the sensor tag was the ability to sense the waste weight by using a weight sensor located on the bottom of the garbage bin.

Among the notable solutions are the optimal placement of bins, the optimal frequency of waste collection, and the behaviour profiling of residents, to name a few. In [6]'s study, quantum GIS was used to investigate the behaviour of people towards waste disposal and the prediction of waste for a certain residential area using predictive analytics. In this paper, historical data on waste generation for residential grids are utilized to predict the behaviour of people towards waste disposal and accordingly manage the optimal waste collection.

Pedro Cruz et.al [7] investigated the contribution of each bus to the coverage of a city sensed by a fleet of urban buses. They denote the set of buses sensing the city and the set of applications served by the MWSN. Also defined the coverage contribution of bin B for a single application as: coverage is the proportion of the city that can be sensed by the considered MWSN.

III. PROPOSED SYSTEM ARCHITECHTURE

This Smart Inclusive Bin Initiative (SIBI) comprises of Arduino Mega 2560 Microcontroller, two Ultrasonic sensors, Camera, Metal detector sensor, GPS Module, LoRa Module and a coin dispenser system. In addition, A Power management unit is also integrated to deliver the required supply voltages to all the components of the SIBI. The block diagram of the designed SIBI is shown in the Fig.1. A brief description of the components used in SIBI are provided here.

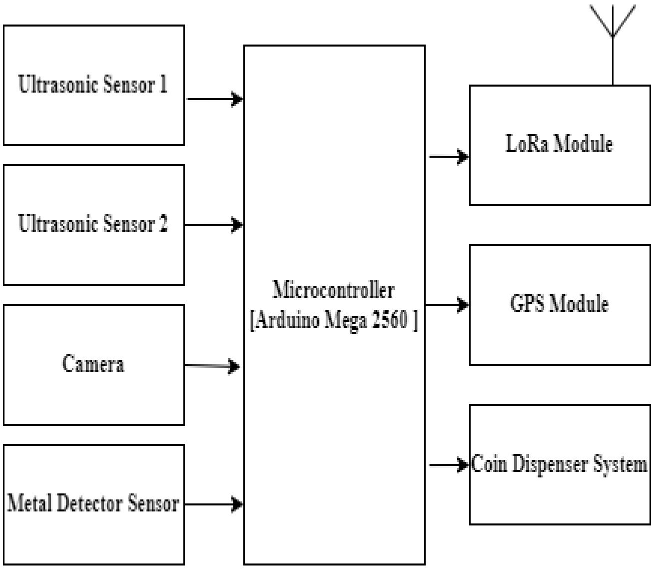

Fig. 1 Block Diagram

3.1. Microcontroller Unit

The ***Arduino Mega 2560*** is an 8-bit microcontroller which serves as host microcontroller board based on the ATmega2560. It has 54 digital input/output pins (out of which 14 can be used as Pulse Width Modulation (PWM) outputs), 16 Analog inputs, 4 UARTs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It runs at a clock frequency of 16 MHz. It also has 256 KB inbuilt flash memory. This Microcontroller interfaces with the sensors through ADC Channels, GPS Module and LoRa Transmitter Module.[8]

3.2 Ultrasonic Sensor

The Ultrasonic Sensor used in SIBI is a MB1010 LV-MaxSonar-EZ, which is Water proof light weight sensor and small in size. Two ultrasonic sensors are used here. One is for automatic open/Close of Bin lid and the other one is used to find the level of the trash in it. It measures the range of objects based on the Principle of Echo. This sensor provides ranging from 0 m to 6.45 m with high accuracy in sensing range.[9] Using this sensor, the bill level is continuously updated to the monitoring station for replacement of bins as soon as the trash level in the bin compartments reaches the threshold.

3.3 Metal detector Sensor

Non-contact metal detecting sensor is used to segregate the metallic wastes thrown in the Bin. Here the Inductive Proximity sensors are used as it can able to detect the metals in the waste.[10] These segregated metals are stored in separate Compartment.

3.4 Camera

OV7670 Camera Module a cost-effective image sensor which is used to capture the Images of trash to classify the wastes. A Machine Learning model uses these captured images to classify the wastes accordingly. This module is small in size and easily interface with the 8/16/32 host microcontroller via UART ports. [11]

3.5 LoRa Module

To enable wireless data transmission with minimal power and long distance LoRa (Long Range Radio) Module ***RN2903*** is used here. It communicates with the host microcontroller via UART and also it can be programmed using UART Port. It can be implemented faster as the infrastructure requirements is very less when compared with other wireless technologies. The main advantage of LoRa is one LoRa Gateway can take up thousands of nodes for data transmission and Operates with the frequency band of 915 MHz. The Block diagram of RN2903 LoRa Transceiver is shown in Fig. 2. [12]

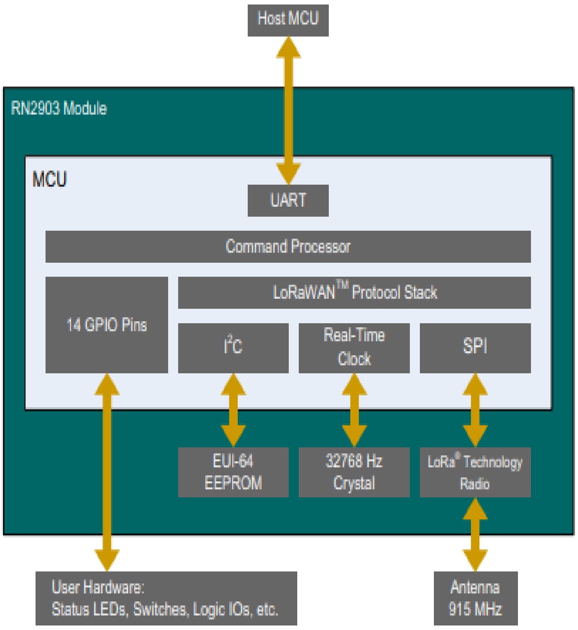

Fig. 2 RN2903 Block Diagram [12]

3.6 GPS Module

To manage solid waste over a large area, several trash cans must be placed. The geographical location for each trash bin is required for the garbage truck to collect garbage. It takes time to manually record the geolocation data of a large number of trash cans. Furthermore, geolocation data aids in the identification of moved trash bins, stolen trash bins, and determining the shortest and most effective garbage collection route. We use ***NEO-6M,*** a cost-effective, high-performance GPS Module to find the geolocation of the trash cans placed. It has inbuilt battery for backup and highly sensitive in Indoor Applications. It updates the position at the rate of 5 Hz. Configurable from 4800 baud to 11520 baud rates.[13] With this sensor, garbage truck can find the optimized route to the bin for replacement.

3.7 Coin Dispenser System

Coin Dispenser System is one the main feature of SIBI. It is to encourage the people to drop the waste in the bin. Coins are given as reward to people for the waste. The amount of waste (in Kg) is calculated, based on the amount the rewards will the distributed as a token of appreciation.

IV. METHODOLOGY

Smart Inclusive Bin Initiative includes four broad categories namely IoT sensor Node, LoRa gateway, Firebase cloud and Machine Learning. To capture the image of wastages and to identify the types of wastages, camera is placed on the top of the dustbin. The IoT model is provided with camera, ultrasonic sensor, Coin Dispenser System and GPS module along with Access point. Access point act as a bridge between LoRa gateway and IoT sensor node. The proposed work having seven stages is indicated in the Fig.3

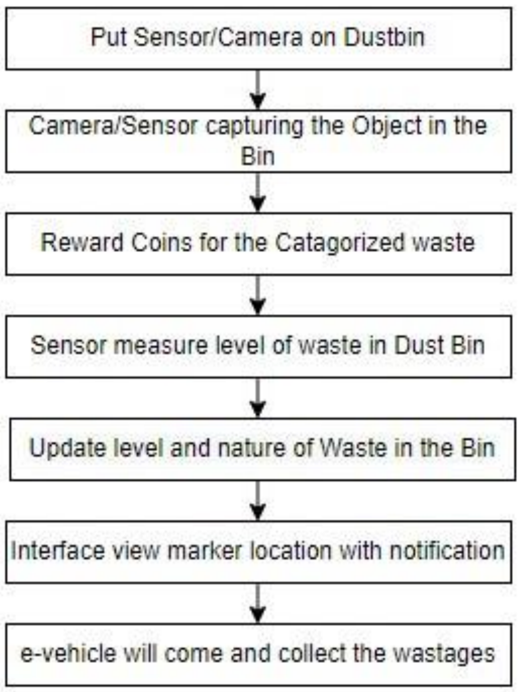

Fig. 3 Proposed System Working Model

The waste has two types, one is Bio-degradable and another one is non-Biodegradable. Bio-degradable wastes are Food items, paper, wood pieces etc., non-biodegradable wastes are metals, plastics and e-waste etc. Rewards are given to the people by its weight and amount which is defined to it. There are three level indicators for smart waste bin level; the waste level is measured by using ultrasonic sensor.

LED Indication	Bin Level Status
Green	Less than 50% Filled
Yellow	50% - 80 % Full
Red	100% Full

Once the bin reaches its full capacity, the information is conveyed to the server immediately with the help of LoRa Technology. The LoRa technology can be used for long distance communication (d<15km) with minimal power consumption and high data rate when compared to other technologies like Bluetooth, RFID and Zigbee [14]. Global positioning system (GPS) is placed on the IoT module to monitor the location and real time surveillance. With the help of GPS System, the waste collecting vehicle finds the optimum route to the bin to replace the Smart Bins. The detailed Architecture of the Proposed system is shown in Fig.4

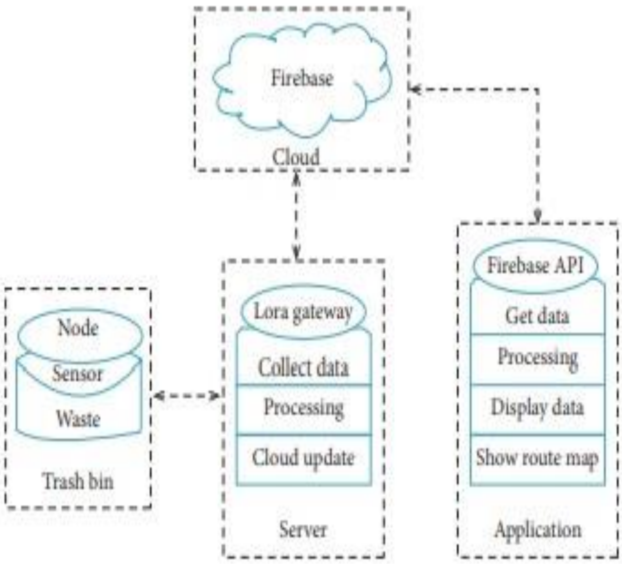

Fig.4 Detailed Architecture

V. CONCLUSION

SIBI will be helpful for public healthcare department and smart city development to monitor and controlling of wastages in the public environment. This will improve the public safety and ensure non-spreading of infectious. This smart bin reduces management cost and increases the operational efficiency in waste management. Coins rewarding system motivates people to dispose the waste in the bins instead of throwing anywhere else and improves street sanitization. The Bio-degradable wastes collected are converted into Organic manure which will be very much useful for terrace gardening in cities. In future, a specific identity can be given for all registered people, people can collect manure for their waste at doorstep using their user ID. This encourages people in urban areas to do terrace farming and stay healthier with organic foods. The non-bio-degradable wastes are recycled for reuse. And medical wastes are incinerated by proper methods, which prevents people from various diseases.

It can be concluded that the performance of solid waste management pathways should be evaluated based on their economic feasibility in the long run; SIBI would also facilitate the managers for successful management of ever-increasing magnitude of solid wastes with greater flexibility. The concepts like investment in the solid waste sector could also be regarded as a positive step towards sustainable waste management worldwide.

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