Autonomous Garbage Collection System using Internet of Things

Shravan Kumar B[1] Vandana B[2] S Usha[3] Ranjith L P[4] Sithara N S[5] Akash M B[6]

[1,4,5,6]Student, Dept. of Computer Science and Engineering, RajaRajeswari College of Engineering, Bengaluru
[2]Assistant Professor, Dept. of Computer Science and Engineering, RajaRajeswari College of Engineering, Bengaluru
[3] Professor, Dept. of Computer Science and Engineering, RajaRajeswari College of Engineering, Bengaluru

***Abstract*— All around the world, the waste generation rates are rising day by day. Managing litters properly is essential for building sustainable and livable environment. But it has remained a challenge for many developing countries and its cities. Garbage collection has become very difficult to maintain or manage by the people in their day-to-day life. Effective garbage management is expensive, often comprising very less of municipal budgets. Often, the waste is disposed in unregulated dumps or is openly burned. Such practices have created serious health and environmental consequences. Poorly managed waste contribute to global climate changes, serves a breeding ground for disease vectors, and also promotes to urban violence. To overcome these problems, we are developing an Autonomous Garbage Collecting Robot. This Robot is used to collect the garbage from the bins. When the bins are filled to a certain level, that bin sends a notification to the robot. Now this robot is used to collect the garbage from that particular bin and dumps the garbage.**

***Keywords*— IoT, Path Planning, Robot, Autonomous, Smart Bin, MQTT, Broker**

I. INTRODUCTION

One of the major concerns with our society has been waste management which impacts the health and environment of our society. In the present era, one of the primary problems is detection, monitoring and management of wastes. The traditional way of manually monitoring the wastes is unwieldy and utilizes more human effort and time which can be easily be avoided with our present technologies like IoT. This system gives a real time indicator of the garbage level in the bins and ensures that the garbage is being collected regularly from the dustbin based on indication from the dustbins. Using that data we automate the collection, i.e., Robot collects the garbage from the bin and reverts back the path followed and dumps it in the dumping site.

Basically, this robot is designed for the Indoor purposes. Garbage Collection automated at the indoor premises solves a lot of garbage accumulation issues faced in the several workplaces like Lodges, Motels or an Apartment. Hence, this Autonomous Garbage Collecting Robot solves this problem by collecting the garbage from the dustbin, which it receives the notification from, based on the path planning for the locomotion, collects the garbage and returns to dumping site.

II. METHODOLOGY

In this paper, we propose a system consisting a Smart Dustbin and Autonomous Garbage Collecting Robot which collects the garbage from the Dustbin notified when the threshold level is reached.

The operation of the system can be classified into 3 modules, namely, building Client-Server Architecture for the Dustbin-Robot interaction, path planning the locomotion of the robot and finally the collection of the garbage.

A. Client-Server Architecture Using MQTT protocol

The notification to the Garbage Collecting Robot about the Dustbins status is implemented using an IoT based protocol called Message Queuing Telemetry Transport. The bin's garbage level detected by sensors is sent to the Robot through means of WiFi using MQTT protocol.

The Robot is subscribed to a Broker and dustbins publishes their garbage level to the Broker, to which Robot is subscribed to. These data are stored in the database.

B. Path Planning for the locomotion of the robot

For the Path planning of the robot, we going to consider the environment it is going to work as a framework, i.e., X-Y grid. The below figure (i) depicts X-Y grid framework.

 ISBN 978-93-81288-18-4

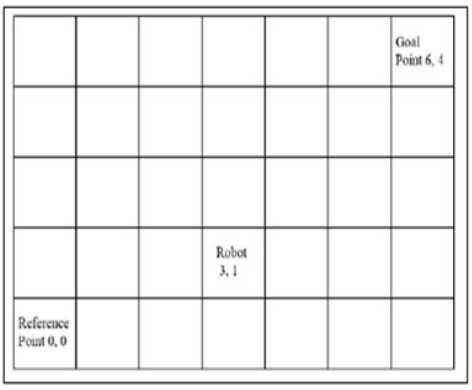


Fig (i): X-Y Grid Framework

Three main points about this framework would be as given below:

- Framework's lower left side is fixed and will be known as reference point of the framework. X and Y axis directions also will be fixed.
- Another vital point is that the starting position of the Robot is also fixed with respect to the X-Y grid framework.
- Lastly, the dustbin's position is also fixed according to the framework.

Since we know starting location and final location, we can calculate the distance and angle, the Robot should move to reach the dustbin.

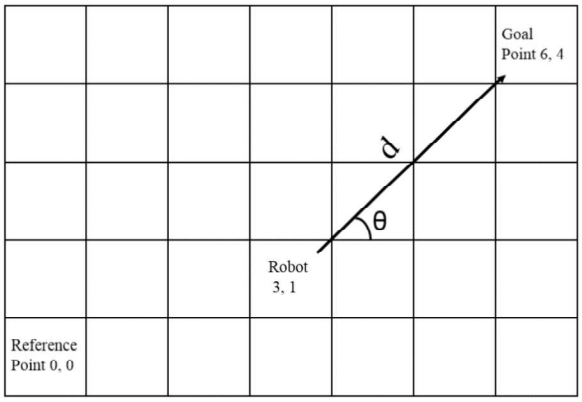
To calculate this distance, we can use Euclidean's Distance Formulae:

$$d = \sqrt{(X_{dustbin}-X_{robot})^2-(Y_{dustbin}-Y_{robot})^2}$$

Similarly, we also can calculate the angle at which it should move using Formulae:

$$\Theta = \tan^{-1}\left(\frac{(Ydustbin-Yrobo)}{(Xdustbin-Xrob)}\right)$$

Fig(ii) depicts the graphical representation of the above piece of information:



In case of obstacle, it will move away from the obstacle by certain units from its right or left side and re-calculate the distance as well as the angle it should traverse to reach the dustbin, as described in the below graphical representation:

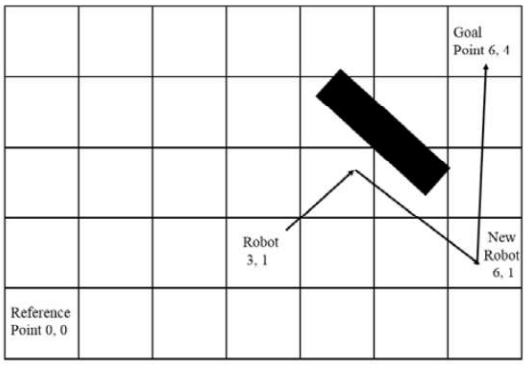


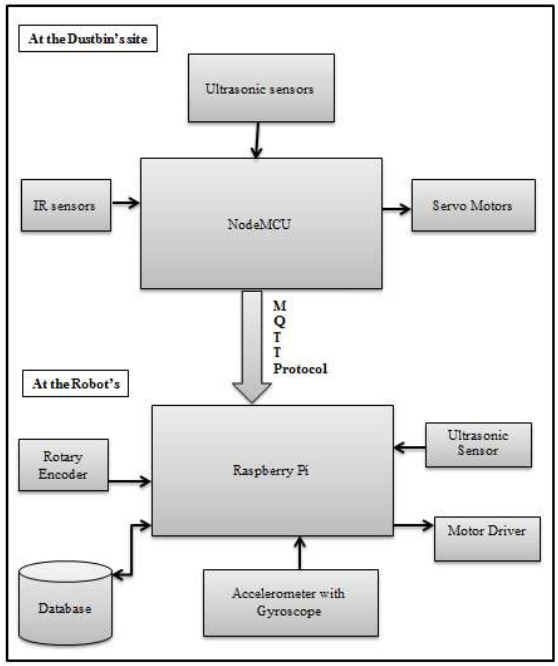
Fig (iii): Describes how the Robot would move when obstacle is detected by Ultrasonic sensors.

The complete locomotion is controlled using a Motor Drivers.

C. Garbage Disposal from the bin

The garbage is dumped into the robot as it reaches which intuited to the bin using an Infrared sensors and the robot the collects the garbage and backtracks the path followed and moves back to the dumping site.

IV. BLOCK DIAGRAM



Fig(v) : Block Diagram of the System

The above diagram describes the various block involved in the system proposed.

V. FLOW CHART

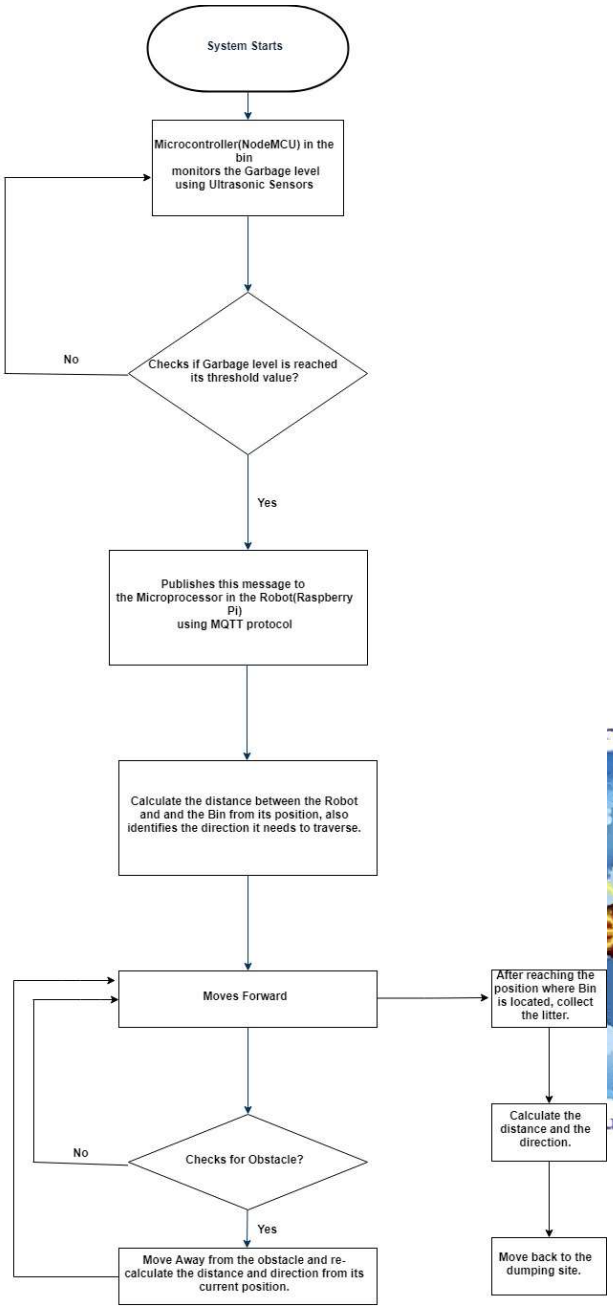


Fig (vi): Flow chart of the proposed system

The above diagram briefs about how the system work flows starting from the Smart Bin Module sending data to the Robot till the very end collecting the garbage and dumping it in the dumping site.

Flow chart explains the system's sequence of execution. When the system starts, the bin keeps on checking if the garbage bin is filled. Once the bin reaches the threshold value, it notifies the Robot, using MQTT protocol.

As the robot is notified with which Bin is filled, the robot then calculates the distance of the bin from the initial position of the robot. And the also evaluates the Angle by which it should turn by. Once it is calculated, the robot moves by that angle and also travels towards the bin, as per calculated distance.

On the way it also cross checks for obstacles, if obstacles are found, then it moves away from the obstacle and re calculates the path from that position and moves again towards the destination.

Once it reaches the Garbage Bin, the Bin identifies that Robot has approached the Bin and hence all the garbage is being disposed and Robot collects the Garbage. Finally robot traverses back to the dumping site, where it started from and dumps the garbage.

VI. RESULTS

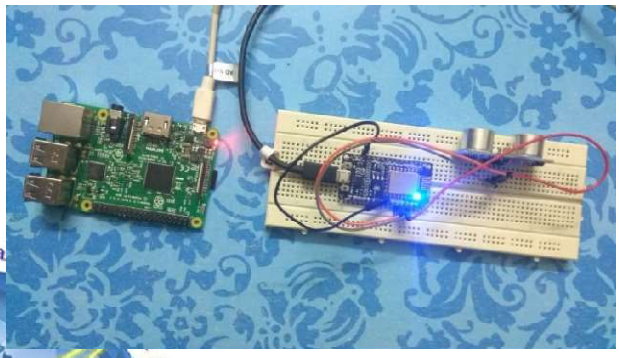


Fig (vi): Smart Dustbin Module's NodeMCU module interacting with Raspberry Pi using MQTT protocol

Above Fig (vi) depicts the Smart Dustbin module, which checks if the threshold level is reached and notifies the Raspberry Pi using MQTT protocol.

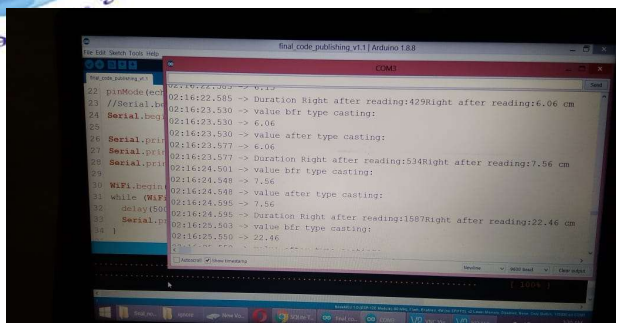


Fig (vii): Console displaying Smart Dustbin Module's interacting with Raspberry Pi using MQTT protocol

Above Fig (vii) shows active interaction between Smart Dustbin and the Robot, using MQTT protocol.

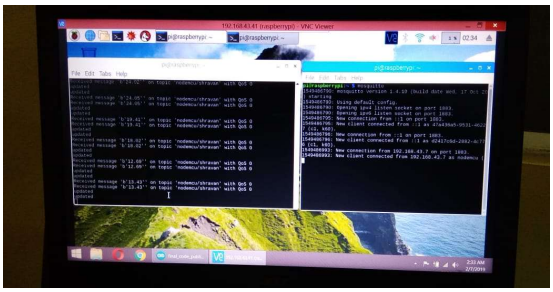


Fig (viii): Monitor Console showing that Data from NodeMCU module is sent to the Raspberry Pi, i.e, Robot is notified.

Above Fig (viii) shows on the Monitor console, confirming that the notification from the Smart Bin is received at the Robot's site.

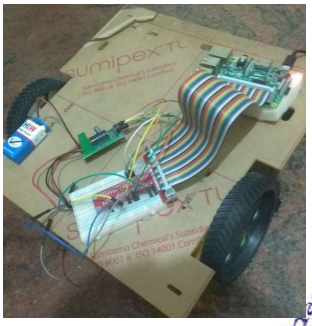


Fig (ix): Monitor Console showing that Data from NodeMCU module is sent to the Raspberry Pi, i.e, Robot is notified.

The above figure shows the Autonomous Garbage Collecting Robot which is in its initial phase. The Robot is made up of Acrylic material of dimensions sizing 30 cm x 30 cm, with required body cutting done using Laser Cutting Machine.

VII. CONCLUSION

The implementation of Autonomous Garbage Collecting Robot in the Indoors will have great impact in monitoring and maintaining the Garbage Accumulation problems. Since GPS Module doesn't work in the indoors, the described mathematical Cartesian Method would give and autonomous Path planning procedure for the Autonomous Robot to follow, for its mobility to expected destination from the source in the indoor.

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