Smart Garbage In-house Segregation Plant, GARB-I

Group 10: Akshay Kumar Jaju, Mark Youssef and Vedant Girish Dalvi

Service Computing Department, IAAS, University of Stuttgart
st180311@stud.uni-stuttgart.de
st176803@stud.uni-stuttgart.de
st179677@stud.uni-stuttgart.de

Abstract. Today, huge amounts of waste/garbage are generated every day, which has further piled the pressure on landfills and caused ecological concerns worldwide. Recycling seems to be the best long-term solution to this problem. Waste segregation is the most important step for effective recycling. While segregation is actively practiced in residential establishments in many countries, it is not the case for commercial buildings like hotels. In this project, we plan to implement a "Smart Garbage In-house Segregation Plant - GARB-I" which can give impetus to garbage recycling in hotels and help them in fulfilling the mandatory recycling requirements. This project plans to execute the garbage segregation by a CNN model using a camera with a Raspberry Pi and many sensors like IR, humidity, temperature, light, and actuators like motors and relays. The data from these sensors will be processed by the Raspberry Pi 3 B+ board and uploaded to the Cloud for AI planning.

Keywords: Waste/Garbage Segregation · CNN · IR Sensor · Hotels.

1 System Introduction

1.1 Background information

On average, hotels generate around 1 kg of waste per guest per night[1]. Any product that cannot be reused and becomes waste should be sorted into its component fractions so that, as much as possible, it can be recovered for recycling. It is estimated that at least 70 percent of waste generated at hotels can be recycled, provided that there is a functional and effective separation and collection system in-site[1]. In order to achieve these results, it is essential to consider waste separation in the hotels and establish an appropriate sorting system.

1.2 Problem Statement

Keeping in mind that comfort in rooms is a main objective in hotels, there are different environmental practices which are being implemented without reducing well-being of guests while generating environmental benefits. In most cases,

hotel rooms only include a couple of waste bins, located in the bathroom and bedroom, where waste fractions are mixed. While bins located in the bathroom are intended for toilet waste, the one in the bedroom is used to collect all types of litter generated by guests (i.e., plastics, magazines, bio-waste, etc.). This is the bin that holds the largest potential to be adapted to a more sophisticated waste sorting and collection system. Currently, individual small-sized bins adapted for separation of different fractions (i.e., paper, plastic, glass and food waste) are presented as a solution [1]. An alternative could be the placement of several bins for different fractions in the room, although it would require more space and therefore it is less recommended. The hotel is then responsible for waste sorting and management and will make sure that all waste fractions are properly separated in their respective container. Later, an authorised waste manager takes care of the waste generated at the hotel and collects it periodically from the respective facilities. However, this solution leads to increased costs and labour. We propose a smart garbage sorting plant which will be situated in the hotel which can segregate the waste automatically and prevent all this hassle.

1.3 Project Goals

We are trying to solve the following problems with this project:

1. Efficient waste segregation in Hotels.
2. Cost-effective and sustainability of the waste-Management.
3. Monitoring of the waste segregation and getting the data over cloud.
4. Planning and scheduling of waste management in the Hotel.

2 System Analysis

2.1 Functional Requirements

2.1.1 Mandatory Requirements

2.1.1.1 User Story: Hotel Guest waste disposal
As a **Guest**,
I want to **dispose my waste in one can**,
So that **I don't have to sort it manually**

2.1.1.2 User Story: Manager notified when sorted bins are getting full
As a **Facility Manager**,
I want to **be notified when the sorted bins in the plant are getting full**,
So that **I can contact the waste recycling contractor to come and collect the separated materials**.

2.1.1.3 User Story: Room Service Trash Collection
As a **Room Service Personnel**,
I want to **collect trash from one can and put it in one can**,
So that **I can save time and cover more rooms**.

2.1.1.4 User Story: Hotel Worker managing individual sorting
As a **hotel worker**,
I want to **arrange the items one by one**,
So that **the machine can sort them into the allocated bins**.

2.1.1.5 User Story: Hotel Worker Comfortable Environment
As a **hotel worker**,
I want to **the room to be automatically ventilated when needed**,
So that **I am not exposed to foul smell from bio-degradable waste**.

2.1.2 Desirable Requirements

2.1.2.1 User Story: Hotel Worker managing bulk sorting
As a **hotel worker**,
I want to **just put all trash collected into the sorting machine**,
So that **the machine can sort them into the allocated bins**.

2.2 Non-Functional Requirements

2.2.1 Mandatory Requirements

2.2.1.1 User Story: Hotel Certification
As a **Facility Manager**,
I want to **increase waste separation and recycling rates**,
So that **the hotel can get certified with (e.g. ISO 14001, EMAS, etc.)**.

2.2.1.2 User Story: Hotel Infrastructure
As a **Hotel Manager**,
I want to **employ cost-effective and sustainable waste management**,
So that **the hotel doesn't have to hire more workers and invest in infrastructure only once that could be used for years**.

3 System Architecture Design

Fig. 1 shows the System Architecture for the Smart Garbage In-house Segregation Plant, GARB-I.

The system architecture includes various elements. Generally, the system structure can be divided into four (4) layers, which are user layer, reasoning layer, ubiquitous layer and physical layer.

Sensors and actuators are part of the physical layer. The sensors collect information from the environment, which can be converted into data for analysis.

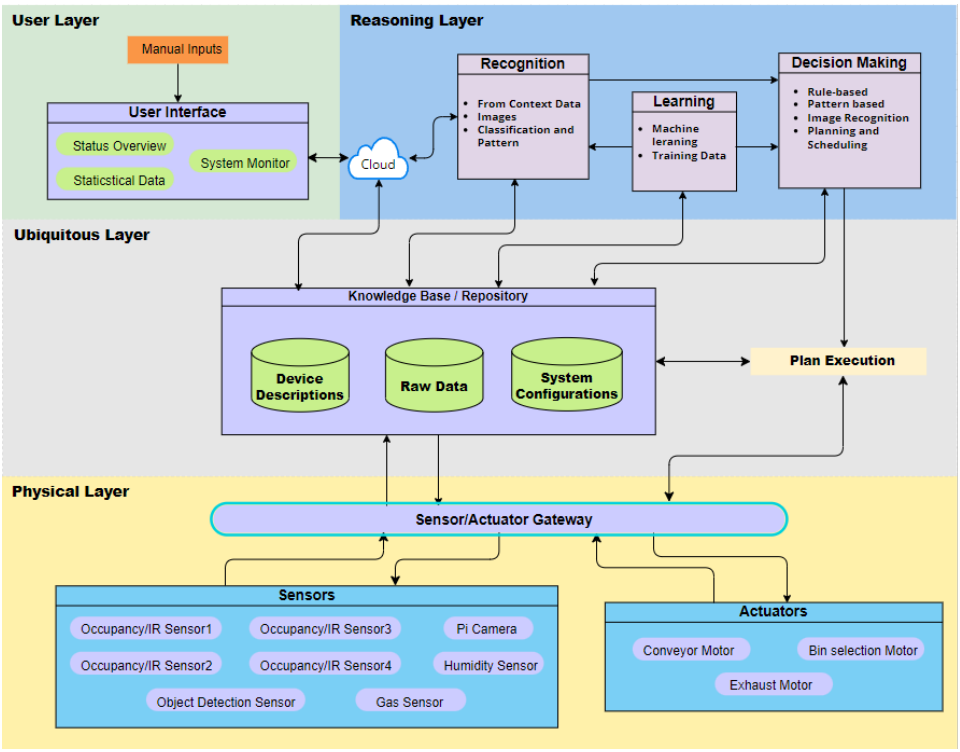

Fig. 1. Smart Garbage In-house Segregation Plant, GARB-I

The sensors in the system includes:

a. Pi Camera: The Pi camera is used to recognise the type of garbage using CNN and segregate it accordingly to plastic, paper/carton, glass and rest of the garbage, dropped into the assigned bin.

b. IR/Occupancy Sensors: There are 5 IR sensors used, out of which four IR sensors are required to measure the percentage of load/the occupied area in the each garbage sorted bin and one IR sensor is used to detect the item, that is vented out from any hotel room/area, on the conveyor belt.

c. Humidity Sensor: Humidity sensor is used to measure the moisture content in the segregation area and to control the humidity such that the garbage does not make foul smell that would annoy any customer and does not cause uncomfortable place for the hotel workers to work.

d. Gas Detector: Gas detector is used for any fire emergency situations and alert the hotel staff and manager about it.

The actuators in the system include:

a. Conveyor Motor: Conveyor motor operates the conveyor belt, on to which the garbage from the common venting duct is collected, type of garbage is recognised and then sent to the segregation bins.

b. Bin Selection Motor: Bin selection motor is triggered based on the recognised type of garbage on the conveyor belt and accordingly based on the plan of execution of bin selection the motor rotates and the type of garbage bin selected is facing to the conveyor belt.

c. Exhaust Motor: Whenever humidity in the in-house segregation plant GARB-I increases beyond the threshold humidity set-point,the exhaust motor turns on and vents out the air from the plant and intakes fresh air from the outside environment.

In the ubiquitous layer, the data management and computing of the data from the sensor to the intelligent system takes place. Also, the analog data from sensors (pi camera, IR sensors, humidity sensor) and actuator is converted to the digital data, which could be easily computed by the intelligent computing system in the reasoning layer. The reasoning layer is responsible for the AI planning, smart waste recognition using CNN, cloud IoT management and giving feedback to the UI. The CNN is employed to identify the type of waste/garbage such as plastic, paper & carton, glass and the rest-waste and be able to recognise it efficiently. At the same time, it should be able to learn and store to the data to make this process more effective and failure proof. It also should be to make decisions accordingly and fetch it to the plan execution, that would actuate the responsible task to be done.

In the user layer, the user is able to overview the current status of the Garbage segregating process and take the further steps, as well as can look the past statistical data and do the planning and scheduling based on the peak segregation time period (During Check-out and Check-in hours, Hose-keeping hours).

References

1. Tanya Gupta, Rakshit Joshi, Devarshi Mukhopadhyay, Kartik Sachdeva, Nikita Jain, Deepali Virmani, Laura Garcia-Hernandez (2021) A deep learning approach based hardware solution to categorise garbage in environment, Springer
2. Aziz F, Arof H, Mokhtar N, Mubin M, Talip MSA (2015) Rotationinvariant bin detection and solid waste level classification. ElsevierMeas 65:19–28
3. Bhatia A (2019) Fighting India's garbage crisis: what are the chal-lenges India faces in managing its waste. New Delhi TelevisionLimited. Retrieved from https://swachhindia.ndtv.com/
4. Chahine K, Ghazal B (2021) Automatic sorting of solid wastesusing sensor fusion. Int J Eng Technol 9(6):4408–4414