CHAPTER TWO

LITERATURE REVIEW

2.1REVIEW OF RELATED WORKS

Frances (2020) developed a smart waste bin with monitoring system. In the paper, the design and implementation of smart waste bin with monitoring system

is proposed utilizing the ongoing innovation of automation and GSM. The ultrasonic sensor in the bin persistently screens the level of the waste in the bin and communicates to the waste administration organization when the bin filled and the

Ultrasonic sensor is also used to open and close the cover of the bin whenever persons are nearby the bin. Thus the research has better level of smartness compared to existing ones in metropolitan cities in a centralized manner.

Rahman,*et al.,* (2022) implemented an Intelligent waste management system using deep learning with IoT. The developed system reflects a capable architecture of the waste management system based on deep learning and IoT. The proposed model renders an astute way to sort digestible and indigestible waste using a convolutional neural network (CNN), a popular deep learning paradigm. The scheme also introduces an architectural design of a smart trash bin that utilizes a microcontroller with multiple sensors. The proposed method employs IoT and Bluetooth connectivity for data monitoring. IoT enables control of real-time data from anywhere while Bluetooth aids short-range data monitoring through an android application. To examine the efficacy of the developed model, the accuracy of waste label classification, sensors data estimation, and system usability scale (SUS) are enumerated and interpreted. The classification accuracy of the proposed architecture based on the CNN model is 95.3125%, and the SUS score is 86%.

Sunday, *et al.,* (2021) proposed a smart waste bin for solid waste management. The aim of the paper was 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. The paper presented 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 helped to maintain cleanliness in our environment. Therefore, the system makes the waste collection more efficient.

Cheema, *et al.,* (2022) implemented a smart waste management and classification systems using cutting edge approach. They proposed a real-time smart waste management and classification mechanism using a cutting-edge approach (SWMACM-CA). It uses the Internet of Things (IoT), deep learning (DL), and cutting-edge techniques to classify and segregate waste items in a dump area. Moreover, they propose a waste grid segmentation mechanism, which maps the pile at the waste yard into grid-like segments. A camera captures the waste yard image and sends it to an edge node to create a waste grid. The grid cell image segments act as a test image for trained deep learning, which can make a particular waste item prediction. The deep-learning algorithm used for this specific project is Visual Geometry Group with 16 layers (VGG16). The model is trained on a cloud server deployed at the edge node to minimize overall latency. By adopting hybrid and decentralized computing models, we can reduce the delay factor and efficiently use computational resources. The overall accuracy of the trained algorithm is

over 90%, which is quite effective. Therefore, our proposed (SWMACM-CA) system provides more accurate results than existing state-of-the-art solutions, which is the core objective of this work.

AbdElminaam, El-Ashmawi and Elsayed (2019). Designed a fabrication smart garbage management and monitoring system using automatic unloading robot in residential area. Their research mainly concentrates on offering an easy, reliable solution to the common problem of inefficient garbage disposal faced within institutes, schools, hospitals or any other closed space. In the proposed model, three main devices are considered. The first device is a smart bin that will automatically open to put trash inside it, allow the user to know whether the bin is full or empty and send the level of trash to the program. In addition, it sends a notification of its trash level and makes alarm and shows its location when it becomes full. The Second device is a garbage collector robot which starts its process and empties the bin after receiving the radio signal from the remote controller application installed in the server. The third device is the controller device connected to the server to control the robot and display data of each bin. The results showed the superiority of our proposed model over other related models.

Mohd-Yusof, *et al.,* (2017) implemented a Smart Garbage Monitoring System for Waste Management. The project presented the development of a smart garbage monitoring system in order to measure waste level in the garbage bin in real-time and to alert the municipality, in particular cases, via SMS. The proposed system is consisted by the ultrasonic sensor to measure the waste level, the GSM module to send the SMS, and an Arduino Uno which controls the system operation. It supposes to generate and send the warning messages to the municipality via SMS when the waste bin is full or almost full, so the garbage can be collected immediately. Furthermore, it is expected to contribute to improving the efficiency of the solid waste disposal management.

Mohd-Yusof, *et al.,* (2018). Proposed a smart waste bin with real-time monitoring system**.** The paper presented IoT innovation project of a smart waste bin with real time monitoring system which integrates multiple technologies such as solar system, sensors and wireless communication technologies. The aim of this project is to provide an efficient and cost-effective waste collection management system hence providing clean, healthy and green environment. This study proposed a new framework that enables remote monitoring of solid waste bin in real-time via Wi-Fi connection, to assist the waste management activity. The system framework is based on wireless sensor network [WSN] contains three segments: renewable energy source, WSN and control station. Within this framework there are four developed subsystems: solar power system, smart waste bin, short messaging service [SMS] notification system and real-time monitoring system that are interrelated to each other to perform as an efficient, cost-effective waste management system that yield to a green and healthy living environment.

Vinodha, I*et al.,* (2020) implemented a smart garbage system with garbage separation using object detection. The smart bin was implemented using IoT as a solution to these problems. The bins are equipped with Raspberry-Pi integrated with ultrasonic sensor for garbage level detection and pi camera which separates garbage by object detection using YOLO algorithm and opens the respective bin lid automatically using servo motor. The intelligent bin is connected with mobile application via cloud for monitoring and clearance of waste which is done using optimized routing.

ALFoudery, *et al.,* (2018) worked on trash basket sensor notification using arduino with android application. The researchers introduced Trash Sensor Android Application to help waste management companies detect trash levels to collect it and help citizens from undesired odours. Using mobile and electronic technology to enable waste management companies to finish its work and make it easier for collecting trash in a simple and an easy way.

2.2REVIEW OF RELATED CONCEPTS

2.2.1 Overview of Waste and Refuse

Waste and refuse constitute a critical and pervasive issue in modern society, posing significant environmental, economic, and public health challenges. The term "waste" refers to any unwanted or discarded material, ranging from household garbage and industrial by-products to hazardous materials. As global population and consumption patterns continue to rise, the generation of waste has also increased exponentially, putting immense pressure on waste management systems worldwide. One major aspect of waste is municipal solid waste (MSW), which includes everyday items like packaging, food scraps, and discarded household goods. In many regions, inadequate waste disposal infrastructure leads to improper dumping or burning of MSW, contributing to air and water pollution. The accumulation of plastic waste, in particular, has become a global concern due to its persistence in the environment, causing harm to wildlife and ecosystems.

Industrial waste, another significant category, arises from manufacturing processes, construction activities, and other industrial operations. Improper disposal of industrial waste can result in soil contamination, groundwater pollution, and the release of harmful chemicals into the air. Efforts to promote sustainable practices in industries, such as recycling and responsible waste management, are crucial to mitigating these environmental impacts. The concept of waste extends beyond physical materials to include electronic waste (e-waste), which consists of discarded electronic devices. Rapid technological advancements contribute to the accelerated obsolescence of electronic products, leading to the accumulation of hazardous materials like lead and mercury. Proper recycling and disposal methods for e-waste are essential to prevent the release of toxic substances into the environment.

To address the multifaceted challenges posed by waste and refuse, governments, businesses, and communities are increasingly focusing on waste reduction, recycling programs, and sustainable waste management practices. Education and awareness campaigns play a vital role in encouraging responsible consumption and waste disposal habits among individuals. Innovations in waste-to-energy technologies and the development of circular economy models offer promising solutions to minimize the environmental impact of waste while promoting resource efficiency. A comprehensive and collaborative approach is essential to create a sustainable and resilient future in the face of mounting waste-related issues (Bano, *et al.*, 2020).

2.2.2 Refuse Disposal and Management

Refuse disposal and management involve the systematic handling, collection, transportation, and disposal of waste materials generated by human activities. The goal is to minimize environmental impact, prevent the spread of diseases, and efficiently utilize resources. Effective refuse disposal and management are critical for maintaining public health, safeguarding the environment, and promoting sustainable practices. The process typically involves several key stages:

i. **Generation of Waste:** Waste is generated from various sources, including households, industries, commercial establishments, and construction sites. This waste can be categorized into different types, such as municipal solid waste (MSW), industrial waste, hazardous waste, and electronic waste.
ii. **Collection:** After waste is generated, it needs to be collected from its source. Municipalities or private waste management companies often deploy collection services to gather waste from residential and commercial areas. The collection process may involve regular scheduled pickups or on-demand services.
iii. **Transportation:** Once collected, the waste is transported to designated facilities for further processing. Transportation methods vary and can include waste trucks, conveyor belts, or even pipelines for certain types of waste.
iv. **Processing and Treatment:** Different types of waste undergo various processing and treatment methods. Recycling facilities handle recyclable materials, composting sites manage organic waste, and hazardous waste treatment centers process potentially harmful materials. Effective processing helps recover valuable resources and reduces the volume of waste sent to landfills.
v. **Disposal:** Disposal is the final stage where waste that cannot be recycled or treated is safely disposed of. Common methods include landfilling, incineration, or other advanced waste-to-energy technologies. Landfills are designed to contain and isolate waste from the environment to prevent contamination.
vi. **Landfill Management:** Landfills play a significant role in waste disposal, particularly for non-recyclable and non-biodegradable materials. Proper landfill management involves engineering measures to control leachate, gas emissions, and land use, minimizing environmental impact.
vii. **Regulatory Compliance and Monitoring:** Refuse disposal and management are subject to various regulations and standards to ensure environmental protection and public health. Regulatory compliance involves adhering to guidelines for waste handling, disposal methods, and environmental monitoring.

Public Education and Awareness: Public engagement is crucial for the success of refuse disposal and management programs. Educating communities about proper waste segregation, recycling practices, and the importance of reducing waste generation contributes to more sustainable waste management practices (Salang, *et al.,* 2021).

2.2.3 Smart Waste Bin

Smart waste bins represent a technological advancement in waste management, utilizing innovative features to enhance efficiency, sustainability, and overall waste collection processes. These intelligent bins are equipped with various sensors, connectivity options, and data analytics capabilities to revolutionize traditional waste management systems. The primary component of a smart waste bin is its sensor technology. These sensors can detect the fill level of the bin in real-time, allowing for precise monitoring of waste accumulation. When a bin reaches a predetermined capacity, the system triggers an alert, enabling timely and optimized waste collection schedules. This real-time monitoring not only enhances operational efficiency but also reduces unnecessary collection trips, saving both time and resources.

Connectivity is a key aspect of smart waste bins, as they are often equipped with IoT (Internet of Things) technology. This connectivity allows the bins to transmit data wirelessly to a centralized management system. Municipalities, waste management companies, or facility managers can remotely monitor multiple bins across a city or facility, gaining insights into waste patterns, optimizing collection routes, and making data-driven decisions to improve overall waste management effectiveness. Smart waste bins also contribute to environmental sustainability. By optimizing collection routes based on real-time data, fewer vehicles are needed for waste collection, resulting in reduced fuel consumption and lower carbon emissions. Additionally, the efficient use of resources helps minimize the environmental impact associated with traditional waste management practices.

These bins can incorporate additional features such as compacting mechanisms or solar-powered components. Compacting mechanisms enable bins to accommodate more waste, reducing the frequency of collections and further optimizing operational costs. Solar-powered capabilities provide an environmentally friendly energy source for the sensors and connectivity components, making smart waste bins more sustainable and less dependent on traditional power sources. The implementation of smart waste bins represents a significant step towards creating smart cities and fostering sustainable urban development. As technology continues to advance, the integration of artificial intelligence, machine learning, and data analytics into waste management systems will likely enhance the capabilities of smart waste bins, leading to even more efficient and sustainable waste collection and disposal processes (Bano, *et al.,* 2020).

2.2.4 Alarm Notification of Smart Waste Bin

Alarm notification in the context of smart waste bins refers to the capability of these intelligent waste management systems to generate alerts or notifications based on predefined conditions or events. These notifications are typically sent to relevant stakeholders, such as waste management personnel, municipal authorities, or facility managers, to prompt timely and appropriate actions. The goal is to improve the overall efficiency, responsiveness, and effectiveness of waste collection and management processes.

Here are key aspects of alarm notification in smart waste bins:

i. **Fill Level Alerts:** One common trigger for alarm notifications is the fill level of the smart waste bin. Sensors within the bin continuously monitor the waste levels, and when the content reaches a predefined threshold, an alert is generated. This information helps optimize waste collection schedules by ensuring that bins are emptied before reaching full capacity, reducing the risk of overflow or inefficient use of resources.

ii. **Maintenance Alerts:** Smart waste bins may also include sensors to monitor their own health and functionality. For instance, if a sensor malfunctions or if there is a mechanical issue with the bin, an alarm notification can be sent to alert maintenance personnel. This proactive approach allows for timely repairs, minimizing downtime and ensuring the continued functionality of the waste management system.

iii. **Environmental Sensors:** Some advanced smart waste bins incorporate environmental sensors to detect factors like temperature, humidity, or the presence of hazardous materials. If unusual conditions are detected, an alarm notification can be triggered. This is particularly important in scenarios where environmental factors may impact waste handling or pose risks to public health.

iv. **Connectivity:** The alarm notifications are often sent through wireless connectivity, utilizing technologies like Internet of Things (IoT). This connectivity allows for real-time communication between the smart waste bins and a centralized management system. Notifications can be received via email, text message, or through dedicated software platforms, providing flexibility in how stakeholders are informed.

v. **Data-Driven Decision Making:** Alarm notifications contribute to data-driven decision-making in waste management. By receiving timely alerts, authorities and organizations can analyze patterns, optimize collection routes, and make informed decisions to enhance overall efficiency and resource utilization.

Alarm notifications in smart waste bins play a crucial role in ensuring that waste management processes are responsive, proactive, and well-coordinated. This capability is fundamental to the development of smart cities and sustainable urban environments by minimizing the environmental impact of waste and optimizing the use of resources Salang, *et al.*, 2021).