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SMART WI-FI-ENABLED TRASH BIN: REVOLUTIONIZING WASTE MANAGEMENT WITH AI-POWERED SORTING, IOT MONITORING

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ABSTRACT

This idea is proposed as a Wi-Fi enabled smart trash bin to change the way of waste management in India especially in the areas inhabited by wildlife and high tourist traffic. The system is designed to promote the correct disposal of waste by offering free Wi-Fi connection to the users after entering a one time password (OTP) while the device is equipped with IoT sensors and AI driven waste classification (YOLOv8) as well as real time connectivity. In the wildlife zones the bins are made animal proof, the units are solar powered for off grid sustainability and the units have multilingual LED displays for tourists. The waste is sorted into recyclables and non recyclables and the fill level information is sent to the authorities through the IoT for on time collection. This solution is in conformity with the Swachh Bharat Abhiyan and incorporates digital rewards (behavioral nudges), environmental protection (reduced litter in forests) as well as smart city goals (effective waste management). The revenue model is scalable and consists of advertisement displays and government partnerships to ensure it is a low cost, tech based solution to India's urbanization and ecological issues.

Keywords— WiFi-Trash Bin , YOLOv8 , Reward, IoT

I. INTRODUCTION

The quick urbanization and growing environmental issues necessi- tate novel solutions in waste management. The conventional practices of waste disposal tend to be inefficient, lack proper segregation, and have poor monitoring. The proposed Wi-Fi-Enabled Smart Trash Bin aims to transform waste disposal by incorporating Artificial Intelligence (AI), Internet of Things(IoT), and solar power to develop a sustainable and efficient solution(1). This smart waste bin powered by AI not only encourages correct disposal of waste but also rewards customers with complimentary Wi-Fi connectivity upon disposing of waste in the right manner. It uses YOLOv8 AI technology to classify waste in real-time for segregation between recyclable and nonrecyclable waste. Fitted with IoT sensors, it offers real-time monitoring of the waste level and sends notifications to municipal authorities for collection when necessary, avoiding overflows and enhancing city cleanliness. The animal Proof and solar-powered design makes it suitable for tourist destinations, wildlife areas, and urban areas. A multilingual LED screen improves user experience by providing easy disposal instructions in various languages. The project is aligned with Swachh Bharat Abhiyan and other smart city projects, leading to a cleaner greener city while providing a scalable revenue model through advertisements and government tie-ups(2). Through the integration of technology, sustainability, and user incentives, this intelligent trash can is poised to revolutionize waste management while encouraging environmental awareness and digital participation.

II. REDUCTION AND REBIRTH OF SMART DUSTBIN DUE TO SIGNIFICANT IMPROVEMENT IN AI

The development of AI has significantly impacted the design and functioning of the Wi-Fi-enabled smart trash can. The system, initially, employed AI-driven separation and IoT-enabled monitoring to optimize waste disposal with the offering of Wi-Fi connectivity as a nudge. However, since AI has developed very rapidly, Wi-Fi is no longer as crucial as a behavior stimulus.

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Reduction: Recent advances in AI-based waste sorting, like the YOLOv8 model, have increased object recognition precision to en- able near-instant waste sorting. In addition, AI-based behavioral mon- itoring and interactive digital reward mechanisms (e.g., blockchain rewards) provide more scalable and efficient incentives than Wi-Fi access. Consequently, attention is diverted from Wi-Fi rewards to a more autonomous, high-precision waste management system.

Rebirth: With AI capable of more autonomous functions, the sys- tem has been transformed from a mere incentive-driven mechanism to a unified smart waste management center. The upgraded AI model can:

Sort and segregate waste with greater accuracy, minimizing human interference. Integrate with IoT to detect waste levels in real time and schedule automatic collection [15].

Make use of smart city frameworks so that dynamic distribution of waste and recycling can be optimized. In addition, advanced AI technologies such as predictive analytics enable anticipatory waste management, reducing operating costs and urban sanitation. Instead of offering Wi-Fi, the system now focuses on AI-driven sustainability, data analytics, and automated logistics, a monumental quantum leap in intelligent waste management technology [3].

III. LITERATURE REVIEW:

- Waste generation is rising due to urbanization, increased pros- perity, and higher consumption. The design and implementation of garbage collection and disposal monitoring and control systems are the most critical sector of work in the arena of sustainable development. For instance, waste truck and city infrastructure management, planning and optimization of waste truck routes, sensor data collection and analysis from smart garbage bins (SGBs), etc. are all encompassed by smart waste management (SWM).The present research intends to present a complete overview of the state of the art in terms of systems, applications, and methodologies on solid waste collection and treatment in SWM systems. We conducted an extensive review of the literature in an attempt to accomplish this objective. Of the 3,732 studies identified in the initial searches across 5 databases, 173 primary studies were selected for extraction and analysis in this study.To 1) determine the principal techniques and services employed in SWM systems at the city and SGB levels,2)enumerate sensors and actuatuos and compare how they are utilized ina different SWM systems types, 3) enumerate direct and indirect stakeholders of the SWM systems, 4) deter- mine the types of information that are exchanged between the SWM systems and stakeholdes, and 5)determine the principle areas promise and research gaps in SWM systems. We provided suggestions on the application of city-level and SGB-level SWM systems based on analysis of available methodologies, tools, and services.
- As daily living activities such as eating and cooking create a lot of waste in the home, so much waste is created in homes. For the sake of both environmental protection and human health, the waste should be handled in the right manner. While current IoT-based smart waste systems achieve good garbage classification accuracy, they are suboptimal in that they can only output restricted trash types, which are inadequate for real-life domestic trash segregation processes. To address the issue, this work introduces SGBS, a new intelligent trash can system with multi-sensors. For determination of waste status and type of waste being disposed of, we utilized temperature, humidity, and gas sensors. To carry out garbage categorization activities, we henceforth put forth a new estimation process of garbage content through machine learning algorithm training using combined daily sensor data measurement as well as detailed wasteful domestic trash content labels. We tested the expected SGBS on one test of five kitchen trash contents for a month in five single-family houses. For the classification problem, we ensured that leave-one-house cross-validation results reported 91 percent accuracy in five paper/softbox contents, 89 percent in five kitchen trash contents, and 85 percent in the eight garbage cans.
- In reality, loading operations must be enumerated to present statistical information regarding cargo loading capacity. Due to the impact of environmental factors, object detection algorithms are not enough for such tasks. In addition, existing temporal action localization methods can miss item spatial information and detect the incorrect action time boundary for multiple objects in the cargo loading task. This research proposes a cargo loading recognition system to bridge this technical gap. The TAR algorithm, the core of the system, is grounded in the object identification model and relies on

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object size regularity and location regularity to identify the cargo loading process in real time. With the utilization of time regularity and nap mechanisms, we guarantee the robustness and real- time operation of the algorithm. To finish the explanation of the proposed method, the garbage truck recycling task is used as an example. The accuracy of the proposed method is more than 99 percent according to experiments, and its real-time performance on the Neural Network Computing Unit (NPU) is greater than 20 frames per second. The self-sustaining camera is used due to the resource and scenario limitations of intelligent application. The algorithm developed can record the process of movement and carry out data statistics using relatively minimal computer resources in the event of mechanical movement, as in the situation explained herein [4].

- Products are now able to be tracked using theInternet of Things(IoT) and radio frequency identification(RFID). This paper presents an intelligent refrigerator system for next- generation Internet of Things applications with a low cost. The suggested intelligent refrigerator automatically bills and resupplies metallic beverage cans.Metal cans can be replenished by a product shortage notification message that is initiated by initiating a product shortage alert message and sending it to local shop. Designing a low-profile, low-cost tahe antenna for metallic objects is very challenging,especially when item-level tagging must be produced in large quantities.Thus, utilizing the metallic structure as the primary radiatorna new ultrahign frequenct(UHC) RFID tag antenna is presented for metallic cans. With the characteristics mode analysis, we determined that under the imposition of the proper inductive load, some characteristic modes relevant to the metallic structure are used to radiate. Also, an RFID chip is combined with a cheap, printed (using conductive ink) miniature loop coupled to a meandering dipole as an inductive load. When contained within metal cans, the desired tag's 3-dB bandwidth encompasses the whole UHF band, between 860 and 960 MHz. For the verification of the system's robustness developed, the read range of the RFID tag is more than 2.5 meters in both directions.97.5 percent of the tags were read and successfully billed when tagged metal cans were placed in a refrigerator for automatic billing as part of a case study to prove the concept. This research highlights the strong aspect of the Internet of Things by opening up the path toward the metallic bodies tagging for tracking in domains from consumer electronics to infotainment solutions.
- In reality, loading actions need to be counted in order to obtain statistics of cargo loading capacity. Under the influence of external conditions, object detection algorithms may not be capable of meeting the requirements of such tasks. Besides, the current temporal action localization menthods may disregard object spatial information and the action time boundary of multiple objects in the cargo loading task. This work proposes a framework for cargo loading identification to bridge this tech- nical gap. The cor eof the framework is the Target Area Rise- Descend(TAR)algorith,which is rooted in the object detection model and the achieves real-time cargo loading process identifi- cation through the use the regularity of the object placement and object. By employing time regularity and nap mechanisms, we ensure the robustness and real-time operation of the algorithm. For purposes of completing describing the proposed solution, the example of the recycling task of garbage trucks is presented. Experiments on a Neural Network Computing Unit (NPU) show that the accuracy of the proposed approach is over 99 percent and its real-time performance is more than 20 frames per second. Self-power cameras are applied considering the intelligent application scenario restrictions and resources. The proposed method can record the motion process and generate statistics of data for mechanical motion that is simialr to the scene in this paper with an incredibly minimal amount of processing power [5].
- China has recently included the categorization of domestic rubbish in its legislative regulations. It is extremely inefficient to identify and separate household garbage manually. To achieve this, we introduce a multimodel cascaded convolutional neural network (MCCNN) in this paper for domestic garbage image identification and categorization. To get the detections, MC- CNN combined three subnetworks: Faster-RCNN, YOLOv4, and DSSD. In addition, we employed a cascaded classification model with the detection component to estimate the correct- ness of the detection outcomes for reducing the false-positive predictions. We established a large-scale waste image dataset (LSWID) consisting of 30,000 multilabeled images of domestic trash classified into 52 categories to train and evaluate MC- CNN. The LSWID is the largest known set of photographs of residential garbage. Moreover, a smart waste bin was designed and put into practice in a Shanghai neighborhood, enhancing the recycling efficiency of trash.

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As indicated by experimental data, detection accuracy was enhanced by an average of 10PER- CENT, showcasing state-of-the-art performance.

- Most studies on English as a foreign language (EFL) are only on humans. These studies talk about how edge computing can make learning for everyone possible. To educate humans and everything else, the XoT (Xducation of Things) concept was proposed. The words AI-Agent and smartthings (digital and physical smart objects) are used everywhere. Solution to an Intelligent Question At the center of this system is the Forwarding Mechanism (SQA-Forwarding) which is attempting to help everything learn. To verify this, a smartXoT environment was established through the XoT framework and its impact on EFL students was gauged.26 EFL students were divided into an experimental group (EG) and a control group (CG) to be employed for a quasi-experimental study comparing differences in learning attainment between smartthings and EFL students learning in a smartXoT environment with and without SQA- Forwarding. On the positive side, the results indicated that smartthings in the EG built knowledge bases bigger compared to those in the CG. On the negative side, the SQA-Forwarding interaction between EFL learners and smartthings significantly improved students' writing skills through editing in order to improve the quality of students' work. Thus, the XoT framework offers a novel and fascinating way of educating individuals and everything [6].
- INternet of things (IoT) is being employed to improve the quality of life in all aspects of everyday life. The subject of waste management is important, especially for developing countries. The purpose of this research is to propse a state-of the art,Internet of Things-based solid waste management system for cities and developing countriesis. Residing in a densely popu- lated urban area has become increasingly difficult because of the absence of planning and availability of resources. In the context of Internet of things,this research study provides a framework for blockchain-based vehicular and hoc networks(VANETs). The step-by-step procedures for the blockchain-based VANET- based decentralized solid waste management solution are pro- posed. Ultra-high frequency (UHF) technology and IoT sensors are employed in order to find trash cans and locate waste vehicles in real-time. Moreover, geofencing technologies are also applied in order to monitor and quickly pick up the waste from the dumping spots. Lastly, the proposed solution applies blockchain technology to enhance security, reliability, and trust between machine-to-machine (M2M) communications between Internet of Things devices. A pilot project is also applied in Karachi, Pakistan, for collecting the experimental results. A pilot project is also applied in Karachi, Pakistan, for collecting the experimental results. For illustrating the daily performance of waste collection and waste vehicle performance, a real-time dashboard is also procured. The results indicate that SSWMS was implemented to a successful extent in order to achieve trash weighing, smart waste bin identification, real-time monitoring, and tracking waste collection from dump sites uti- lizing geofencing. Due to the inherent properties of blockchain and the Internet of Things, blockchain-based VANETs can be utilized in the future for fleet management systems (FMS), smart transportation, and route management.
- Because of its permanence and low ability to recycle, plastic pollution has become a concern in the world. To tackle this eminent challenge, this research proposes a new strategy that employs a Detection-Based Reward System (DBRS) with a new business model in ensuring environmental cleanliness, encour- aging effective plastic waste management, and reducing plastic waste in the environment. The main function of this system is plastic bottle identification, which utilizes the strengths of the YOLOv5 algorithm due to its high accuracy, fast speed, and open-sourced nature. Just enrolling the users on the system triggers an automatic detection process that utilizes the plastic bottles deposited by them to calculate reward points.In a central- ized database, reward points are securely stored. In addition to being functional, this combined system possesses an excellent business plan that will enable it to achieve the Sustainable Development Goals (SDGs), which will ensure a healthier world, by enabling the widespread application of trash disposal protocols. With a highly exceptional mean Average Precision (mAP) of 0.973, the DBRS shows cutting-edge performance in detecting plastic bottles, which is specifically notable and shows its efficiency in preventing plastic pollution [7].
- Waste is a global problem. The piling up of waste reduces the beauty of a place and is an abode of disease. The arrival of the internet of things makes human labor easier. We can implement IoT to create

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smart trash cans. Even though smart garbage cans are used everywhere in the present times, they are still to be tested to establish their efficiency. The aim of this research is to assess the model of the monitoring system and the effectiveness of smart trash cans. The HCSR-04 ultrasonic sensor is used as medium to gauge the density of waste to be tested, and a NodeMcU ESP8266 microcontroller based on an Arduiono Uno is employed to create a model of solid waste density monitoring. The test results of the system indicate that it can display waste height data,provide information regarding the trash,and correctly inform users whether the trash if full or empty. The results prove that the model created can correctly recognize the solid waste density test. Therefore, research proves that smart trash can mitigate the negative impacts of waste accumulation.

- This research shows how machine learning can be applied to de- sign a smart garbage disposal system based on IoT technologies. The inefficiencies of the present waste management techniques are overcome by this research. Data from IoT network sensors is collected for experimentation, and an algorithm is applied to classify the waste capacity. The system delivers the necessary information, including the capacity of the garbage can, tem- perature, humidity, and light intensity around. In addition, it categorizes the capacity of trash based on information collected from sensors that are part of the Internet of Things system. The garbage can can be controlled and monitored in real time by users due to the ability of mobile apps. A total of 150 data samples were collected during the testing process.The trial results of the SVM,K-NN, and DT algorithms proved that SVM is the most superior algorithm garbage classification in an Internet of Things based smart waste management system.The SVM algorithm reflected excellent accuracy,precision,and recall measyres of 92.3percent,90.2percent,and 87.8percent, respec- tively. This work is a contribution to an efficient and effective waste management system in maintaining campus surroundings clean [8].
- The study's goals were to create intelligent, creative waste bins that could be used as educational tools for waste segregation and to assess students' learning outcomes after playing a game with them. Four hundred pupils in grades four, five, and six made up the sample population. Four garbage bins are arranged in a collection of clever, creative waste bins, one for biodegradable waste (green bin), one for poisonous waste (red bin), one for regular waste (blue bin), and one for recycling waste (yellow bin). The Arduino board's program code was integrated by the bin. RFID tags were given for twelve waste products in four categories.The garbage can's lid will automatically open and close when customers place their trash in the proper type of bin. On the other hand, the lid will not open if the trash is placed in the incorrect trash can. The results showed that the sample group's garbage segregation learning result increased by

  3.52 scores, or 17.6. To put it briefly, clever, creative trash cans that can support rubbish segregation education [9].
- Proper garbage handling is a critical issue for efficient waste management in today's big communities. In order to improve waste collection operations, this study describes the design and prototype of an intelligent waste bin system based on ultra- sonic sensors that incorporates artificial intelligence (AI) and simulated weight sensors. ESP32 microcontrollers and ESP32- CAM modules are used in the system to track waste types and fill levels. Potentiometers simulate the weight of the trash, while ultrasonic sensors measure the distance to the rubbish surface. The monitoring system's accuracy is increased by using AI software to read the ESP32-CAM's photos and identify the type of waste.Data is saved and displayed using Oracle APEX dashboards once sensor and AI readings are wirelessly transferred to a shared server. Using level and weight sensors, garbage bin software may change into "full" status; an MIT App Inventor smartphone app makes it easier for users to switch trash bin statuses. It facilitates decision-making for municipal solid waste management organizations, lowering operating expenses and promoting environmental sustainability. Through real-time data gathering, processing, and decision-making, the suggested system has a great deal of potential to improve the efficiency of urban trash management. The project supports Sustainable Cities and Communities, which is the eleventh Sustainable Development Goal of the UN [10].

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IV. METHODOLOGY

*Hardware Parts And other Components With Working Flowchart.—

The outer casing consists of waterproof and weather-resistant materials such as metal and plastic designed for both indoor and outdoor applications.

Smart Lid – Ultrasonic sensor-equipped touchless lid enables hands-free operation for opening and closing.

Waste Compartment – Separated sections exist for both recyclable materials and nonrecyclable waste items. The Weighing Platform records waste weight data to enable monitoring while providing rewards. The Motorized Sorting Mechanism utilizes either conveyor systems or robotic arms to perform waste segregation tasks. Battery and Power System – Solar-powered battery backup for grid-less sustainability. AI Camera (YOLOv8) – Detects waste types like plastic, organic, and hazardous materials.

*Special Features for Different Environments The design features ensure resistance to animal interference while being environmentally sensitive. The system interface is multi-language and offers user support [11].

The microcontroller systems (Arduino/Raspberry Pi) manage dust- bin automation processes.

The AI-Based Image Processing Unit executes YOLOv8 opera- tions to sort waste materials.

The IoT Cloud Platform serves as a repository and waste data processing location with the capability to provide immediate alerts. The Mobile/Web App system allows officials to track the amount of wastes while planning the collection routes.

V. COMPARISON OF PRIOR ART WITH OUR INVENTION.

- Restricted Accessibility for Visitors Public Places Most available smart bins had been built with urban areas in mind and were not user- friendly for foreign users [8].
- Our intelligent bin comes equipped with multilingual LED screens, thus making it userfriendly for tourists and multicultural user groups in public areas [12].
- Inefficient Waste Monitoring Collection Earlier systems used gas or ultrasonic sensors for level detection, but did not have realtime IoT notifications for efficient waste collection.
- Our system incorporates IoT-based real-time monitoring, which immediately informs authorities when bins are full, minimizing overflow and enhancing sanitation.
- Limited Waste Segregation Precision Some of the prior art uti- lized simple AI algorithms or manual sorting support, which resulted in inefficiencies in segregating recyclables and non-recyclables.

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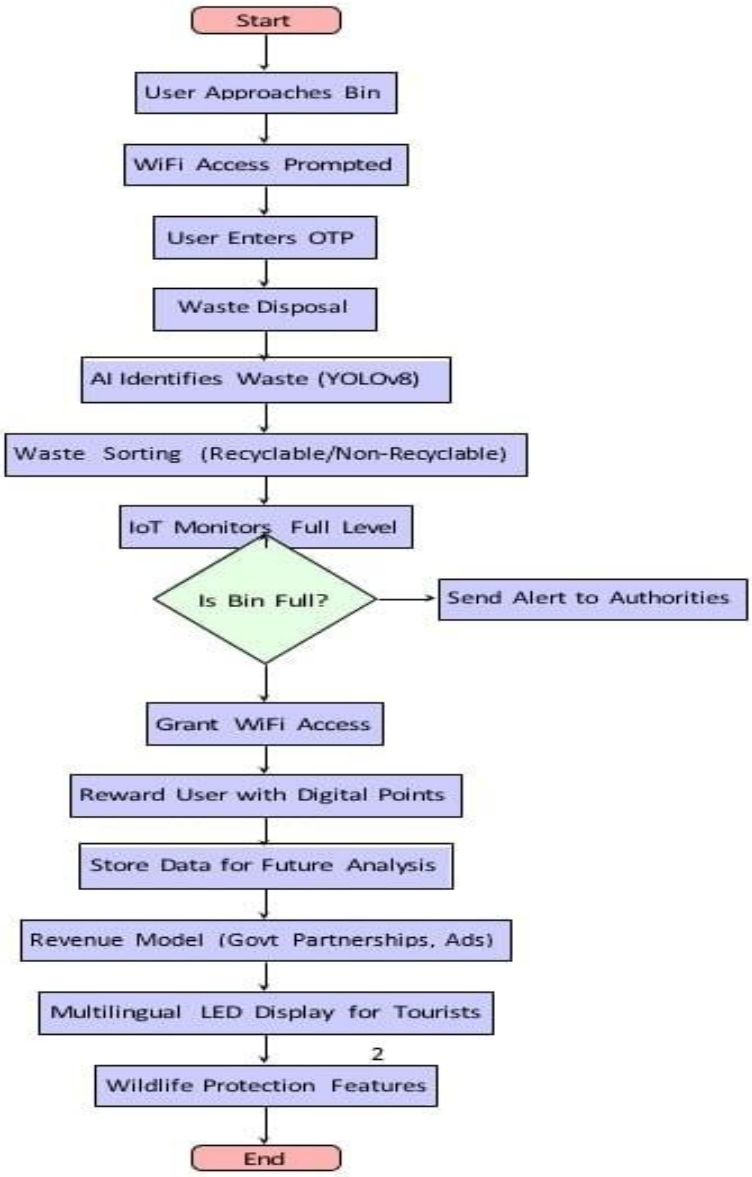

Fig. 1. Steps for Wifi-Trash Bin Construction

Our invention incorporates YOLOv8 AI-based waste sorting, which provides highly precise and automated waste separation for improved recycling results.

a. Unsustainable Business Model Certain brilliant bin solutions used a single-round of funding or institutional incentives and there- fore long-term adoption was difficult.

b. Our innovation uses a scalable business model based on adver- tisements and partnerships with government bodies, hence providing financial viability.

c. Dependence on Grid Power supply and Battery Backup. Many of the past inventions relied on battery backups or wired power sources, limiting their application in remote or outdoor locations.

d. Our system is powered by the sun, and therefore it is energy- efficient, economical, and suitable for off-grid locations like wildlife reserves and tourist attractions [15].

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public places, and promotes a cleaner, technologically based waste disposal system.

Name of the prior art	Key features of prior art	Key features of our invention
AI-POWERED SMART DUSTBIN WITH CRYPTO CURRENCY REWARDS FOR SUSTAINABLE CAMPUS AND BEYOND. (APP NO= 202341071239)	QR code rewards, automatic waste sorting and cryptocurrency incentives.	Free WI-FI via OTP as a reward.Animal-proof design, solarpowered, multilingual LED displays for tourists.
AI-DRIVEN SMART WASTE SEGREGATION SYSTEM FOR DUSTBIN WITH BATTERY BACKUP. (APP NO= 202541001309)	This system focuses on autonomous sorting.This system ensures reliability with battery backup.	-YOLOv8 AI classification, realtime IOT alerts for waste collection, alignment with (Swachh Bharat Abhiyan).
SYSTEM,DESIGN, AND METHOD OF IOT-BASED SMART DUSTBIN. (APP NO= 202541005150)	Gas/ultrasonic sensors for filllevel alerts, cloud connectivity.	Wi-Fi as a behavioral nudge, scalable revenue model (ads, govt.partnerships), wildlifezone optimization.
SMART DUSTBIN WITH FOOD WASTE MONITORING SYSTEM. (APP NO= 202411102292)	-Food waste weighing, coupon incentives.	-Digital rewards (not coupons), focus on tourist areas and ecological protection. Free WI-FI via OTP as a reward. YOLOv8 AI classification.
A SMART DUSTBIN SYSTEM. (APP NO= 202411101914)	-Touchless lid, ultrasonic fill-level sensors, Arduino control.	-Solar-powered off-grid operation, integration with smart city goals, reduced litter in forests.Free WI-FI via OTP as a reward. Animal-proof design

VII. CONCLUSION

The intelligent dustbin based on Wi-Fi is an innovative and environment-friendly solution for the waste management system that addresses many environmental and technological issues. With AI-fueled trash segregation (YOLOv8), IoT-checked surveillance, and a reward scheme through providing complimentary Wi-Fi, the innovation provides a smart, efficient, and scalable urban as well as environment-sensitive location model. The Wi-Fi-based smart dustbin is a novel and eco-friendly solution for the waste management system to solve most environmental as well as technological challenges. With AI-powered trash sorting (YOLOv8), IoT-monitored surveillance, and reward mechanism through offering free Wi-Fi, the innovation ensures a smart, optimized, and scalable city as well as environment- friendly location model.Unlike conventional smart bins based on mere automation or manual sorting, this invention enhances the precision in waste sorting by stimulating proper disposal behavior among consumers [17].

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Moreover, the multilingual LED display contributes to tourist accessibility, and the model of revenue generated through advertisement- and government-partnership ensures financial sustain- ability for the project. Aligning with initiatives like Swachh Bharat Abhiyan and smart city initiatives, this smart dustbin, in addition to increasing urban cleanliness, also helps bring digitalization in waste management. This project takes one step further in integrating technology with sustainability, paving the path for a wiser and cleaner future.

VI. RESULTS

The Wi-Fi smart trash can is an advanced garbage disposal facility for urban and eco-friendly places, including tourist and wildlife sites. It possesses AI (YOLOv8) for waste segregation, IoT sensors for real-time monitoring, and solar energy for grid-free operations. Individuals are motivated to litter in a proper manner by being provided free Wi-Fi connectivity through OTP.The bin is pet-proofed, features multi-language LED screen interfaces for simplifying usage, and segregation of waste into recyclable and non-recyclables using automation. Alerts are triggered for the authorities when the bin is full to enable timely pickup. The scheme can be well supported for intelligent city initiatives as well as for Swachh Bharat Abhiyan for maintaining cleanliness as well as being sustainable. Having a revenue scheme through advertisements coupled with government support also makes the model financially viable. The technology increases the efficiency of waste separation, minimizes littering in

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