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SMART DUSTBIN BASED ON AI AUDIO CLASSIFIER

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Abstract: The increasing global concern for environmental sustainability has prompted the development of innovative technologies aimed at optimizing waste management processes. In this context, the AI Audio Classifier based Smart Dust-Bin emerges as a groundbreaking solution, leveraging artificial intelligence to enhance recycling practices.

Keywords – Artificial Intelligence, Audio Classification, Waste Management, Edge AI, Semantic Audio Analysis, Signal Processing Algorithms, Audio Pattern Recognition, Smart Dust-Bin, IoT (Internet of Things), Sound Recognition Edge Computing, Sensor Technology.

I. INTRODUCTION

The AI Audio Classifier based Smart Dust-Bin, an innovative waste management solution, integrates artificial intelligence with edge computing to enhance recycling processes. By capturing and analyzing audio signals of deposited items through integrated microphones, the system accurately classifies materials such as glass, plastic, and metal based on their distinct sound signatures. This real-time, decentralized approach ensures efficient sorting directly within the bin, minimizing contamination and promoting proper recycling practices. With benefits including increased accuracy, sustainability, reduced costs, and user-friendly interfaces, this technology represents a significant step toward creating a more environmentally conscious and effective waste management system.

II. LITERATURE SURVEY

[1] The research paper discusses a waste management system using big data and various sensors. The developed trash box and android application are shown. The accuracy of the system is evaluated, with a 95.3125% accuracy achieved. The limitations and potential improvements are also mentioned.

[2] This paper presents a smart recycling bin that uses waste image classification to automatically separate urban waste for increased recycling. The authors trained classification models on two embedded systems, Jetson Nano and K210, achieving high accuracy. The bin program collects user feedback, and the overall power consumption was reduced. The prototype demonstrates a promising solution for improving waste recycling.

[3] The paper discusses the potential of artificial intelligence (AI) in revolutionizing waste management practices. It reviews various studies on AI applications in waste management, including waste prediction, sorting robots, smart waste classification, and optimization of waste treatment processes. The use of AI can improve efficiency and sustainability in waste management systems.

Table no 1 literature survey

Paper.no	**Title**	**Technology /Methodology**	**Hardware Devices**	**Results**
[1]	"Intelligent waste management system using deep learning with IoT"	CNN model is 95.3125%, and the SUS score is 86%	Used of Camera Module, Servo Motor and raspberry pie	Accuracy [%] Glass 52 94.231 Metal 42 95.238 Paper 63 93.651 Plastic 45 95.556 Trash 13 92.308
[2]	"A smart recycling bin using waste image classification at the edge"	AI models, specifically CNN (Convolutional Neural Network) image classification models, implemented on devices like Jetson Nano and K210	Microcontroller such as Atmega 328P, Raspberry Pi 4 Sensors: moisture sensors, gas sensors, bacteria sensors	Accuracy [%] EfficientNetB0 99.44 MobileNetV3Large 99.50 Mobile Net V3 Small 98.94
[3]	"Artificial intelligence for waste management in smart cities"	(AI) technology, Internet of Things technology, Machine learning algorithms for waste pyrolysis, carbon emission prediction	Sensors: moisture sensors, gas sensors, bacteria sensors. Robotic Arm	Use of AI in waste logistics can reduce transportation distance by up to 36.8%, cost savings by up to 13.35%. Identifying and sorting waste with accuracy ranging from 72.8 to 99.95%
[4]	"Smart dustbin based on ai audio classifier"	IoT, AI algorithms for sound processing	Arduino Nano 33 BLE Sense, Hall sensor A3144, Li-ion 1s 250mAh battery, TMC2208 stepper driver Edge impulse studio	The proposed work aims to use sound signals for categorization of various types of wastes using ai technology to improve the accuracy to sort the waste material in the dustbin

III. SYSTEM ARCHITECTURE

3.1 BLOCK DIAGRAM

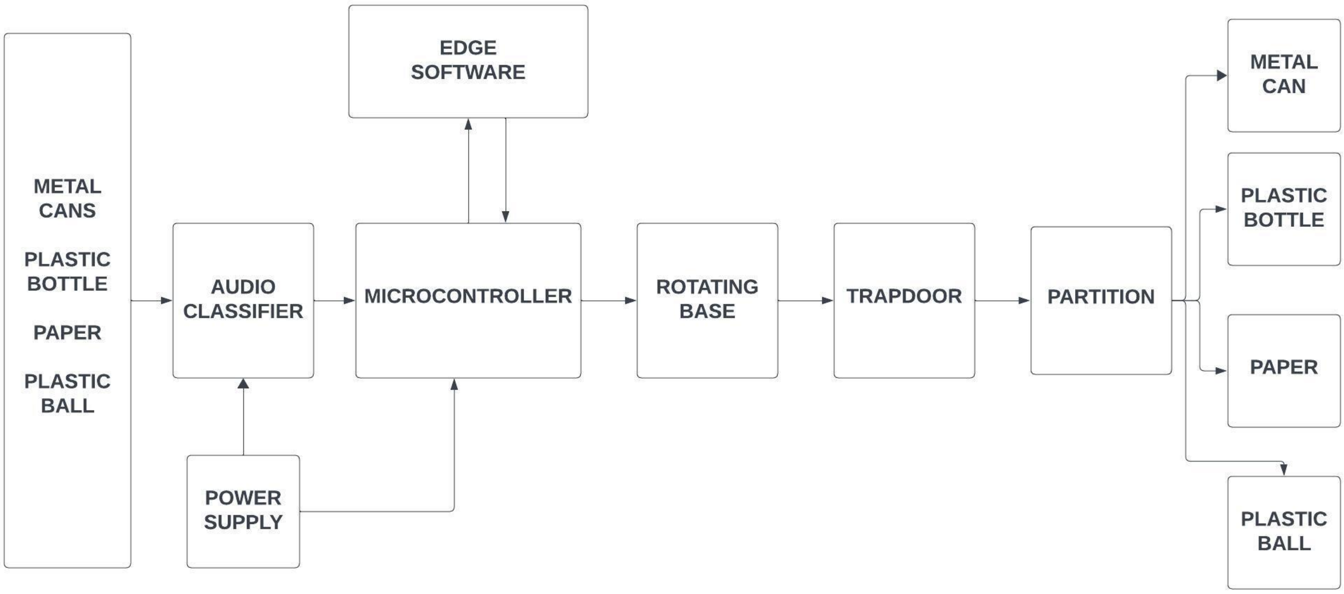

fig 3.1: proposed block diagram of smart dustbin based on ai audio classifier

3.1.1 BLOCK DIAGRAM EXPLAINATION

1. Trash Items (Metal Can, Plastic Bottle, Paper, Plastic Ball): - Represents the various recyclable materials that users dispose of into the recycling bin.

2. **Audio Classifier:** - This component employs AI and audio recognition technology to analyze the sounds produced by different materials when placed in the bin. It classifies these sounds into categories corresponding to the type of trash (e.g., metal can, plastic bottle, paper, plastic ball).

3. Microcontroller: - Serves as the central processing unit that coordinates the actions of the system based on the outputs from the audio classifier. It communicates with other components to initiate appropriate responses.

4. Power Supply: - Provides the necessary electrical power to all components, ensuring continuous and reliable operation of the system.

5. Edge Software: - A software module running on the edge (locally on the device) that interfaces with the audio classifier and microcontroller. It processes the classification results and triggers subsequent actions.

6. Rotating Base: - A mechanical component that facilitates the rotation of the recycling bin. When triggered by the system, it rotates the bin to allow the categorized items to move towards specific partitions for further sorting

7. Trapdoor: - Located at the bottom of the recycling bin, the trapdoor opens based on the classification results. It allows the sorted items to move to the next stage of the sorting process.

8. Partition: - Divides the interior of the recycling bin into sections corresponding to different types of recyclable materials. Each partition directs items to the appropriate collection area.

9. Trash Parts (Separated Bins for Metal, Plastic, Paper): - Represents the separate compartments or bins where each type of recyclable material is collected after being sorted. Users can easily retrieve sorted items from these dedicated bins. The process begins with users disposing of items into the recycling bin. The audio classifier identifies the material based on the sound it produces. The microcontroller processes this information, and the edge software triggers the rotation of the base. The trapdoor opens, allowing the sorted items to move to the designated partition, directing them to the appropriate trash part for further collection

IV.FUTURE SCOPE

The future scope for smart dustbins incorporating AI audio classifiers is extensive, presenting opportunities for significant advancements in waste management technology. Ongoing research and development in machine learning algorithms promise enhanced accuracy in recognizing and categorizing diverse types of waste, improving the efficiency of smart dustbins. Integration within larger IoT ecosystems within smart cities is a foreseeable progression, fostering seamless communication between smart devices and waste management systems for optimized urban efficiency. Future iterations may provide real-time monitoring and analytics on waste disposal patterns, offering valuable insights for city planning and resource allocation. Advancements in sensor adaptability to varying environmental conditions, coupled with efforts to engage and educate users through gamification or reward systems, can further encourage responsible waste disposal practices. The exploration of energy-efficient solutions, including alternative power sources like solar, contributes to the sustainability of these systems. Prioritizing security and privacy measures ensures the protection of user data in an increasingly interconnected environment. Additionally, the global adoption of standardized technology and data formats will facilitate interoperability across different regions. The future might also witness the inclusion of additional sensory inputs beyond audio, such as visual or chemical sensors, for more precise waste categorization. Cost-effective manufacturing processes are integral to making these smart dustbins affordable and accessible, enabling their deployment in a broader range of urban settings. In summary, the future of AI audio classifier-based smart dustbins is dynamic, promising impactful contributions to sustainable and efficient waste management practices in urban environments. Ongoing innovation and collaboration will play pivotal roles in shaping this future landscape.

V.CONCLUSION

The Smart Dust-Bin based on AI Audio Classifier based using edge computing is a pioneering project at the intersection of artificial intelligence and waste management. Its emphasis on real-time processing, privacy, and offline functionality showcases the potential of edge computing in transforming how we handle recyclables. The project's scalability through distributed processing offers a promising solution for waste classification across diverse settings. However, challenges such as limited processing power, storage constraints, and security considerations underscore the need for a balanced approach in deployment. Despite these challenges, this project represents a significant step toward leveraging advanced technologies for sustainable waste management. As technology evolves, addressing these limitations will be crucial for the widespread success of similar initiatives, contributing to a more efficient and environmentally conscious future.

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[2]Nermeen Abou Baker, Paul Szabo-Müller and Uwe Handmann1 2021"Transfer learning-based method for automated e-waste recycling in smart cities" Applies transfer learning as a special technique of Artificial Intelligence by fine-tuning the output layers of Alex Net as a pre-trained model and perform the implementation on a small-size dataset that contains 12 classes from 6 smartphone brands.

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