Review on AIML – Driven Waste Intelligence System

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Abstract

Effective waste management is a critical challenge in urban and rural environments due to improper segregation, lack of awareness, and inefficient recycling processes [1,2]. Traditional waste collection methods often mix different types of waste, reducing recycling efficiency and increasing environmental pollution [3,4]. This paper reviews AIML-Driven Waste Intelligence Systems that leverage Convolutional Neural Networks (CNN) for waste classification, rule-based logic for environmental impact analysis, and sentiment analysis for understanding user feedback [5-8]. These systems classify waste into categories such as plastic, organic, and metal, and provide treatment recommendations including recycling, composting, or reuse [9,10]. Additionally, value creation ideas to convert waste into useful products are explored [11]. Interactive dashboards visualize waste patterns and trends, aiding decision-making for households and municipal authorities [12]. The review identifies that while CNN-based models achieve 85-95% accuracy, existing systems lack environmental impact analysis, treatment recommendations, value creation ideas, sentiment analysis integration, and interactive dashboards [1-12].

Keywords- Waste Classification, Convolutional Neural Networks, Sentiment Analysis, Environmental Impact, Smart Waste Management, AIML.

1. Introduction

The rapid expansion of urban areas and changing consumer behavior have turned waste management into a critical global issue [1]. Improper disposal methods lead to soil contamination, water pollution, air quality degradation, and serious public health risks [2]. Environmental studies indicate that a substantial portion of waste deposited in landfills could have been recycled or composted if proper segregation had been performed at the source [3]. In current practice, waste is typically collected in a mixed state, which significantly reduces recycling efficiency and worsens environmental harm [4]. Most existing solutions remain limited to basic classification systems or smartphone applications that are not practical for all users, particularly municipal workers who manage large volumes of waste on a daily basis [5].

Furthermore, the majority of systems fail to provide insights into the environmental consequences of different waste categories or suggest methods for material reuse and value recovery [6]. Artificial Intelligence and Machine Learning have emerged as effective technologies to address these challenges [7]. Deep learning architectures, especially Convolutional Neural Networks (CNNs), have demonstrated outstanding performance in image recognition tasks [8]. When applied to waste management, these models can autonomously identify waste types from visual input, enabling automated sorting processes [9]. This paper presents a review of AI and ML powered waste intelligence systems that integrate multiple functionalities including CNN-based waste classification, environmental impact assessment, treatment recommendations, value creation suggestions, sentiment analysis of user feedback, and interactive data visualization [10-12].

2. Problem Identification

The following key factors highlight the need for this survey [1-5]:

1. Waste management is a critical global problem affecting environmental sustainability and public health [1,2].

2. Traditional waste segregation methods are inefficient and lead to low recycling rates [3,4].

3. AI and ML techniques have shown promising results in waste classification but lack comprehensive review [5-8].

4. Existing survey papers focus only on classification algorithms and ignore environmental impact analysis, treatment recommendations, and value creation [9-11].

5. This paper provides a structured review of 12 existing case studies, identifying research gaps for future researchers [1-12].

3. Existing System and Methodology

The following issues are identified in existing waste management systems based on the literature review [1-12]:

- Mixed waste collection lowers recycling efficiency [14]. Low public awareness about proper disposal [5,6].
- Only classification with no additional insights [7,8]. No environmental impact analysis [9].
- No treatment guidance (recycle/compost/landfill) [10].
- User feedback ignored with no sentiment analysis [11].
- No dashboards for waste data visualization [12].

4. Literature Survey

Several research studies have applied machine learning and deep learning techniques for waste classification and segregation [1-12]. This section reviews existing approaches based on Convolution Neural Networks (CNN), IoT integration, YOLO algorithm, and other AI methodologies.

A. CNN-Based Waste Classification: M.G.C.P. et al. [1] proposed a waste classification and segregation system combining machine learning and IoT approaches. Ravishankar et al. [2] developed an automated waste segregation system using Convolutional Neural Networks, achieving reliable classification results. S.V. et al. [3] presented a waste collection and segregation system using computer vision and CNN specifically designed for vessels. Nagajothi et al. [4] introduced an intelligent waste segregation technique using CNN, focusing on real-time classification accuracy.

B. Advanced Deep Learning Architectures: Pandey et al. [5] worked on identification and classification of waste using CNN in waste management systems. Srivastav et al. [6] further extended this by developing a deep learning-based CNN model for waste segregation, demonstrating improved accuracy. Kumar et al. [7] applied the YOLO (You Only Look Once) algorithm for waste detection and classification, showing promising results for real-time waste identification.

C. Custom and Sustainable Approaches: Lavanya et al. [8] developed a CNN based smart waste segregation and collection system. B.M. et al. [9] proposed a Convolutional Neural Networks based smart waste management system. K.B. et al. [10] introduced an enhanced CNN architecture specifically designed for accurate waste classification in smart city applications.

D. Edge AI and Modern Techniques: Kaushik and Kaur [11] developed a custom CNN for sustainable waste segregation, focusing on advanced classification of organic and recyclable materials. Sheikh and Kumar [12] presented next-generation waste management using AI as a catalyst for sustainability.

5. Results and Discussion

Based on the review of existing literature [1-12], the following research gaps are identified:

- Lack of Environmental Impact Analysis - Most existing systems [1-8] focus only on classification and do not analyze the

environmental impact of different waste types.

- No Treatment Recommendations - Current approaches [1-10] do not suggest appropriate treatment methods such as recycling, composting, or landfilling after classification.
- Absence of Value Creation Ideas - None of the reviewed papers [1-12] provide suggestions for converting waste into useful products.
- No Sentiment Analysis Integration - User feedback and sentiment analysis are not incorporated in any existing waste management system [1-12].
- Missing Data Visualization Dashboards - Interactive dashboards for waste pattern analysis and trend visualization are not provided [1-12].
- Limited Real-World Deployment - Most models [2,3,4,5] are tested in controlled environments, not real-world municipal conditions.

CNN-based models have shown good accuracy (85-95%) for waste classification [1-8]. However, existing systems have several limitations [9-12]. They focus only on classification and do not provide environmental impact analysis, treatment recommendations, or value creation ideas [1-12]. Sentiment analysis and interactive dashboards are also missing [11,12]. Real-world deployment remains a challenge [2-5].

6.Conclusion

This survey paper has reviewed 12 existing research studies on AI and ML based waste management systems [1-12]. CNN-based models have shown good accuracy (85-95%) for waste classification [1-8]. However, existing systems have several limitations [9-12]. They focus only on classification and do not provide environmental impact analysis, treatment recommendations, or value creation ideas [1-12]. Sentiment analysis and interactive dashboards are also missing [11,12]. Real-world deployment remains a challenge [2-5]. Future systems should integrate classification with environmental impact analysis, treatment recommendations, and value creation ideas [9-12].

References

[1] M. G. C. P, S. Yadav, A. Shanmugam, H. V and N. Suresh, "Waste Classification and Segregation using Machine Learning and IOT Approach," 2021 2nd International Conference on Intelligent Engineering and Management (ICIEM), London, United Kingdom, 2021.

[2] A. Ravishankar, A. Murthy, M. Sharma, R. K. Chitra and R. Anitha, "Automated Waste Segregation using Convolution Neural Network," 2021 International Conference on Smart Generation Computing, Communication and Networking (SMART GENCON), Pune, India, 2021.

[3] S. V, Akshaya, A. S, S.S.Ponnaganti, V. G. Pillai and P. P K, "Waste Collection & Segregation using Computer Vision and Convolutional Neural Network for Vessels, " 2021 International Conference on Computing, Communication, and Intelligent Systems (ICCCIS), Greater Noida, India, 2021.

[4] D. Nagajyothi, S. A. Ali, V. Jyothi and P. Chinthapalli, "Intelligent Waste Segregation Technique Using CNN, " 2023 2nd International Conference for Innovation in Technology (INOCON), Bangalore, India, 2023.

[5] A. Pandey, H. Jain, H. Raj and P. P. Gupta, "Identification and Classification of Waste using CNN in Waste Management, " 2023 IEEE 8th International Conference for Convergence in Technology (I2CT), Lonavala, India, 2023.

[6] S. Srivastav, K. Guleria and S. Sharma, "Waste Segregation using Deep Learning-based Convolutional Neural Network Model, " 2023 4th IEEE Global Conference for Advancement in Technology (GCAT), Bangalore, India, 2023.

[7] A. S. Kumar, A. Mathai, R. Dinesh, H. Mohan and D. S, "Waste Detection and Classification Using Yolo Algorithm and Sensors, " 2023 16th International Conference on Sensing Technology (ICST), HYDERABAD, India, 2023.

[8] V. Lavanya, G. Abikash Shivam, S. Shanmugasundaram and R. Deepalakshmi, "CNN Based Smart Waste Segregation and Collection System, " 2024 4th International Conference on Data Engineering and Communication Systems (ICDECS), Bangalore, India, 2024.

[9] B. M, N. S, H. E and L. K M, "Convolutional Neural Network Based Smart Waste Management System, " 2024 International Conference on Power, Energy, Control and Transmission Systems (ICPECTS), Chennai, India, 2024.

[10] K. B, S. R and P. M, "Enhanced CNN Architecture for Accurate Waste Classification in Smart Cities, " 2024 International Conference on IoT Based Control Networks and Intelligent Systems (ICICNIS), Bengaluru, India, 2024.

[11] P. Kaushik and S. Kaur, "Custom CNN for Sustainable Waste Segregation: Advanced Classification of Organic and Recyclable Material, " 2024 International Conference on Emerging Technologies and Innovation for Sustainability India,2024. (EmergIN), Greater Noida.

[12] N. Sheikh and P. Kumar, "Next-Gen Waste Management: Al as a Catalyst for Sustainability, " 2025 International Conference on Machine Learning and Autonomous Systems (ICMLAS), Prawer, Thailand, 2025