

Smart Sorter: Neural Network-Enhanced Recycling Bin

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Problem Statement and Motivation

The world is facing an escalating crisis of municipal solid waste (MSW) management, with a staggering 2.01 billion tonnes generated annually and a projected increase to 3.40 billion tonnes by 2050. Despite efforts, 33% of this waste remains inadequately managed, posing significant environmental, public health, and economic risks. The urgency for sustainable waste management solutions has never been clearer. In light of this pressing challenge, there's a critical need for innovative approaches that not only minimize landfill waste but also maximize recyclable recovery. Smart bin recycling stands out as a promising solution, leveraging technology to streamline waste sorting and ensure efficient resource utilization. By emphasizing collaboration and action, we can pave the way for a cleaner, healthier, and more sustainable future, addressing the multifaceted implications of inadequate waste management head-on.

Tasks

Our tasks lie at the intersection of advanced deep learning techniques and waste management solutions. By employing deep learning models for waste categorization, we harness the power of artificial intelligence to automate and enhance the sorting process, improving efficiency and accuracy. Leveraging the stable diffusion model (SDM) for dataset augmentation, we expand the available data resources, enabling more robust model training and validation. Utilizing datasets such as CMU-Africa images and TrashNet, comprising thousands of categorized waste images, we establish a solid foundation for our model development. Through our innovative approach, we not only instantiate the TrashNet model with Modified Residual Blocks and tailored layer configurations but also provide a comprehensive structure inspection to ensure its efficacy. Our tasks represent a significant step forward in sustainable waste management practices, offering scalable and adaptable solutions that can revolutionize how we address the global waste crisis.

Methodology

Our methodology encompasses a multifaceted approach to address the challenges of waste classification and real-time categorization. Leveraging advanced techniques, we efficiently expand the dataset using Stable Diffusion XL with

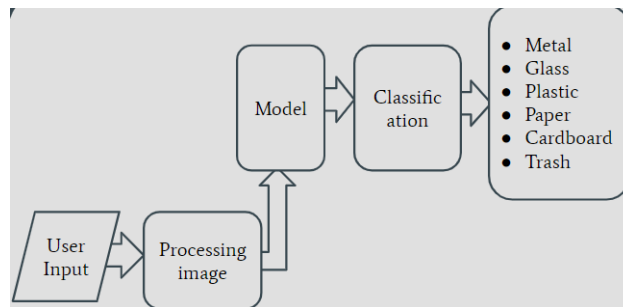


Figure 1: Architecture Flow Chart

Dream Booth and LoRA, overcoming constraints posed by limited resources. In developing our CNN model, we introduce a ResNet variant tailored for waste classification, integrating novel elements such as an Attention Module

and Multi-Feature Fusion. The Attention Module dynamically emphasizes crucial features within the data, enhancing the model's ability to discern relevant patterns. Additionally, our Multi-Feature Fusion approach combines diverse information sources, enriching the feature representation and bolstering model performance. Real-time categorization capabilities are achieved through the application of the CNN model to process live camera feed inputs, enabling rapid waste type identification. By innovatively combining these methods, we not only address the challenges of small dataset limitations and computational resource constraints but also significantly enhance the accuracy and generalization capabilities of our waste classification system.

Results

The ResNet50 baseline model, evaluated on the TrashNet dataset, exhibited outstanding performance metrics with 97% accuracy and a minimal loss of 1.04%, showcasing its robustness in waste classification tasks. Leveraging techniques such as data augmentation and regularization during training, the model demonstrated strong generalization capabilities while completing the training process in 30 epochs using a Tesla P100 GPU on Google Colab. With a total of 22,548,485 trainable parameters and no non-trainable parameters, the model's architecture is intricate yet efficient, incorporating essential components like convolutional layers, batch normalization, ReLU activation, and specialized modules such as the Attention Module and Multi-Feature Fusion. Memory usage analysis revealed manageable computational requirements, with the estimated total size of the model at approximately 240.02 MB, ensuring practical deployment feasibility. These findings highlight the model's efficacy in advancing sustainable waste management practices, emphasizing its potential for real-world implementation and future research endeavors.

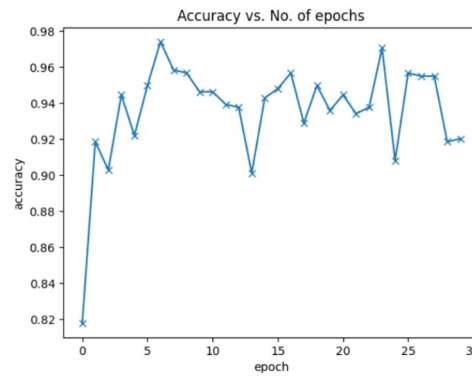


Figure 2: Accuracy vs number of epoches

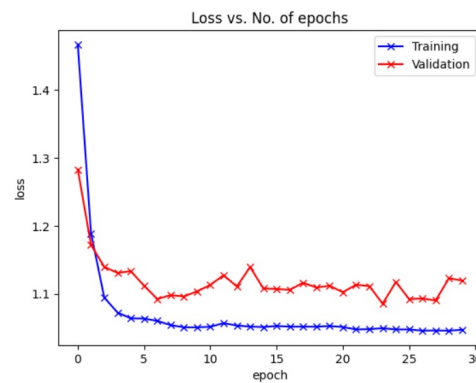


Figure 3: Loss vs number of epoches

Conclusion

Our project represents a significant step forward in addressing the pressing need for effective waste management solutions. Through the development of a Variant ResNet50 model, we have significantly enhanced waste material classification, paving the way for optimized recycling practices. By leveraging advanced deep learning techniques and innovative model architectures, our approach holds promise for revolutionizing garbage classification processes. With its robust performance and potential for real-world implementation, our model offers hope for a cleaner, more sustainable future by facilitating more efficient waste sorting and recycling practices on a global scale.