Smart Trash Box Technology of Computer Vision to Support Ecogreen Campus

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Abstract. Waste from daily human activities which is one of the causes of natural disasters such as floods. Research on the environment, especially on technology and environmental waste management systems, is still ongoing. Waste management includes organic waste and non-organic waste. The problem that occurs in the campus environment is the large amount of rubbish scattered around, much of this rubbish comes from used goods, and comes from human activities in daily life. Waste management on Campus is not yet well organized. In this research, technology will be developed for Smart Trash Boxes or an intelligent system for trash boxes that can classify types of organic and non-organic waste in the campus environment by applying Computer Vision techniques in image processing as an effort to support the eco-green campus. In its application, the deep learning method with the CNN algorithm is used, so that the classification results obtained in this research can differentiate between organic waste and non-organic waste to be utilized or recycled and can preserve natural resources and the environment. Finally, the use of the CNN model does not require big data for training research to obtain high accuracy. This research produces a validated accuracy value of 0.8034.

Keywords: Eco-green, Computer Vision, CNN, Deep Learning, Image Processing.

1 Introduction

Garbage is the waste product of daily human activities which is one of the causes of natural disasters such as floods [1, 2]. Research on the environment, especially on technology and environmental waste management systems, is still ongoing [3–5] one of the research done by [6] classifies four types of waste using Computer Vision techniques to recognize waste patterns with a two-stage Waste Recognition-Retrieval algorithm (W2R).

Waste management includes organic waste and non-organic waste. Organic waste is waste material that is biodegradable, meaning that it can be broken down by living organisms [7]. Organic waste includes food scraps, yard waste, and other biodegradable materials [8]. Non-organic waste refers to waste materials that are not biodegradable

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and cannot be broken down by living organisms Non-organic waste [7]. includes things like plastic, metal, glass, and other non-biodegradable materials. Non-organic waste takes hundreds or thousands of years to decompose, and if left to accumulate in landfills or the environment, it can harm the ecosystem [9]. Therefore, it is very important to recycle non-organic waste to preserve the environment and natural resources.

One of the problems that often occurs at one of the private campuses in Palembang, South Sumatra, Indonesia is the large amount of rubbish scattered around the campus, much of this rubbish comes from used goods, and human activities in daily life - day. Waste management in the campus environment is not well organized, there is still a lot of waste combined between organic waste and waste that can still be recycled (non-organic), non-organic waste comes from used goods that should be used as raw materials for technology and in efforts to utilize natural resources in the campus environment.

Based on these problems, this research will create a Smart Technology for Trash Boxes or an intelligent system for trash boxes that can classify types of organic and non-organic waste in the campus environment by applying Computer Vision techniques in image processing, to support the campus' efforts to become EcoGreen Campus. This research aims to create a Smart Trash Box that can differentiate between organic waste and non-organic waste in the campus environment by applying computer vision techniques in the Smart Trash Box to recognize patterns of organic waste and non-organic waste, then analyzing the waste classification results obtained from applying the technique computer vision using the CNN method.

In its application, the deep learning method with the CNN algorithm is used, so that the classification results obtained in this research can differentiate between organic waste and non-organic waste to be utilized or recycled by the management team to preserve natural resources and the environment.

2 Literatur Review

2.1 State of the Art

Research related to waste sorting systems has been carried out using microcontroller-based technology and artificial intelligence, including an Arduino-based intelligent waste sorting system created by [10]. The system separates waste based on biodegradable and non-biodegradable classifications. The waste sorting system in this research uses metal detector sensors and IR sensors to detect the type of waste that is put into the waste box and sends a signal to the microcontroller to open the waste lid based on the type [11] conducted research in building a waste classification system using deep learning.

The deep learning algorithm used in this research is RestNet-34 with a neural network structure optimized in three aspects, namely the combination of multiple features from the input image, reuse of features from residual units, and design of a new activation function. The system designed by Kang et al was verified with waste data that had been built. The result is that this system has an accuracy of 99% with a working speed of 0.95 seconds. (Mookkaiah et al. 2022) designed and built an IoT-based smart waste management system using computer vision. The CNN neural network model used in this research is ResNet V2. The results of the research show that the proposed system has a 19.08% higher accuracy rate and a lower loss value of 34.97% compared to other CNN models. The research carried out will focus on the domain of waste image processing with a CNN artificial neural network with the LeNet model.

2.2 Computer Vision

Computer Vision is a branch of computer science that focuses on developing techniques for developing computer systems that can obtain, process, and understand information from images or videos. The goal is to make computers able to imitate human vision abilities in understanding and interpreting visual information [12]. Some tasks that can be carried out by computer vision include object detection [13]. face recognition [14], motion tracking, scene understanding [15], and image segmentation. In its development, computer vision was integrated with the CNN algorithm in classifying images (Yang et al., 2020). By using CNNs and deep learning, computers can learn data by representing images in the form of labeled pixels [16].

This approach involves using labels to perform the mathematical operation of convolution on two functions [11], which produces a third function and allows predictions about what information can be learned from the image. Research mapping related to computer vision is depicted in mapping using the VOS Viewer application shown in Fig. 1.

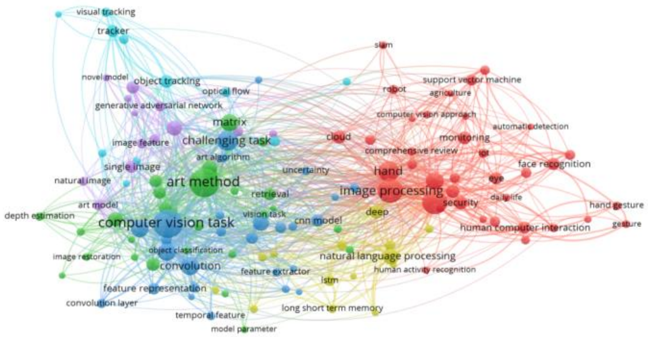


Fig. 1. Research related to Computer Vision Technique.

In Fig. 1. there are 6 clusters in the mapping of research related to computer vision. In these six clusters, the most researched from 2019 to 2023 is research related to computer vision tasks in the blue cluster and image processing in computer vision in the red cluster, while one of the least research focuses is the use of deep learning methods in image processing for computer vision research.

2.3 Garbage Management System with Image Processing

Mapping research related to garbage management systems using image processing is divided into 4 clusters, with the main cluster on the red line, namely research on waste disposal systems related to smart cities, for the focus of research that is still little carried out from 2019 to 2023, one of which is namely a smart trash box connected to a blue cluster to focus research on the sensors and monitoring systems used (Fig. 2.).

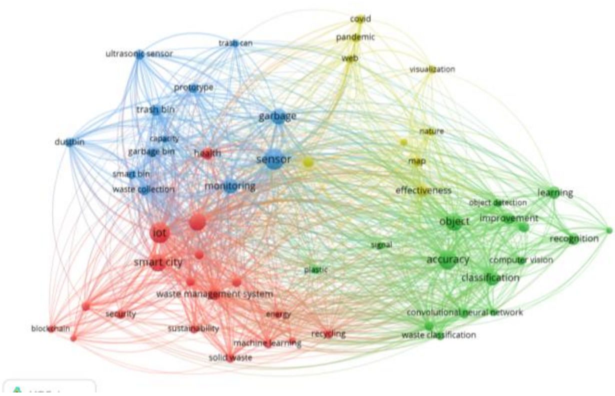


Fig. 2. Research on Garbage Management Systems until 2023.

3 Methodology

At the research methodology stage, the techniques used in solving problems that occur with partners are determined. In this research, the deep learning method (CNN) will be applied to image processing using computer vision techniques. To focus on the first problem, namely by creating a system called "Smart Trash Box". The proposed technology uses 2 trash boxes to separate organic waste from non-organic waste as shown in Fig. 3.

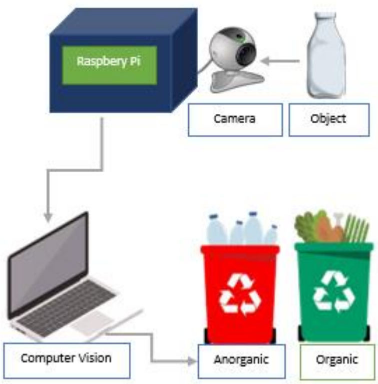


Fig. 3. Smart Trash Box System.

Implementation from computer vision technique with CNN model shown in algorithm Fig. 4.

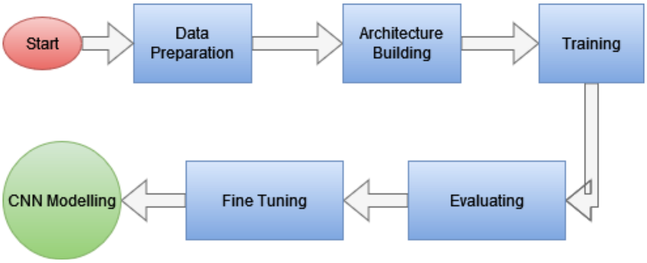


Fig. 4. CNN Algorithm.

1. Data Preparation: The first step is to prepare waste image data for the CNN model. This involves collecting a dataset of waste in the form of drink cans, plastic bottles, and paper, then dividing it into training, validation, and test sets, and pre-processing the images.

2. Architecture Building: The architecture of the CNN model that is built consists of several layers, including; a. Convolutional layers: These layers apply a series of filters to the input image, each filter looking for specific patterns or features of a type of garbage. b. ReLU Layer: The output of the convolutional layer is passed through a Rectified Linear Unit (ReLU) activation function to introduce non-linearity into the model. c. Pooling layer: This layer reduces the output of the previous layer, reducing the spatial dimensions of the image. d. Fully connected layer: This layer takes the output of the previous layer and passes it through a set of fully connected neurons, allowing the model to make predictions about the type of waste. e. Softmax Layer: This layer converts the output of the fully connected layer into a probability distribution of class types.

3. Training: In the training phase, the CNN model is trained to recognize patterns in the input image by adjusting the filter weights in the convolutional layers.

4. Evaluating: Once the model is trained, it is evaluated on the test data set to measure its performance. The evaluation matrix includes Accuracy, Precision, and Recall.

5. Fine Tuning: If the model performance is not satisfactory, the model can be refined by adjusting the parameters.

The data in this research will be taken from Sjakhjakirti University's condition and garbage photographs from open sources like Google Images and Kaggle. The Train and Test repositories, which each have an organic waste folder for organic image conditions and a non-organic waste folder for non-organic conditions, are where dataset integration, data extraction, and picture classification are completed. Table 1 below illustrates the observed image using the matplotlib. pyplot and matplotlib.images packages.

Table 1. Sample Dataset

Organic	Non-Organic
	

The dataset used is crawled data on Google Images using the keywords "organic waste" and "non-organic waste". The number of images in each data label "organic waste" and "non-organic waste" is 298. So the total images in the dataset are 596. Next, the data is separated with a composition of 70% for training data and 30% for testing data.

4 Result and Discussion

At this stage, the CNN algorithm is applied to the computer vision technique that has been designed for the Smart Trash Box. After applying the method, the system that has been created is then tested. Testing on the system aims to measure the performance of the modeling implemented in the waste image dataset. In this research, the evaluation using the accuracy value variable was generated to see the accuracy of the predictions compared to the overall test data. Precision is generated to measure the error of the CNN model produced in predicting the correct object, for example, the model predicts canned waste objects that are categorized as non-organic waste, while recall is generated to measure the error of the CNN model in predicting objects other than non-organic waste. In this research, it is hoped that the model will have higher accuracy and recall values compared to precision values.

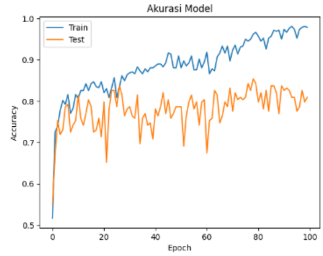
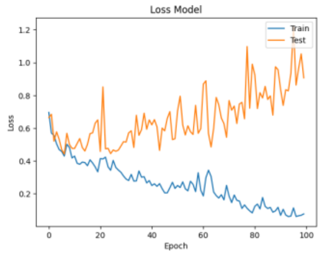
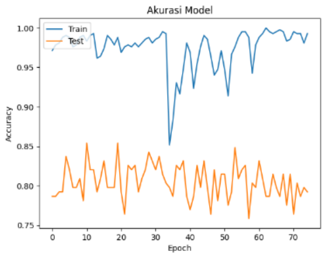
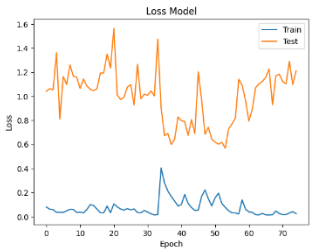
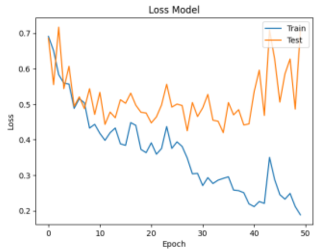
In this part, parameter tuning is carried out which aims to measure the level of accuracy of the implemented model. In addition, it is also part of training data and validation data to achieve optimal accuracy points. There is a parameter called Epoch which is then set to train the number of times the training data and validation data are trained to produce a model with optimum accuracy. In this study, the epoch values given are 25, 50, 75, and 100. The results of the hyperparameter tuning of the epoch values are shown in Table 2.

Table 2. Comparison Epoch and Validated Accuracy

Number of Epoch	Validated Accuracy
100	0.8090
75	0.7921
50	0.7472
25	0.8034

Finally, the result of this study shows Epoch 25, has model loss: 0.3413 - Accuracy: 0.8349 - val_loss: 0.4659 - val_accuracy: 0.8034 as shown in Table 3.

Table 3. Epoch Accuration and Loss Model

Accurate	Loss
	
	
	

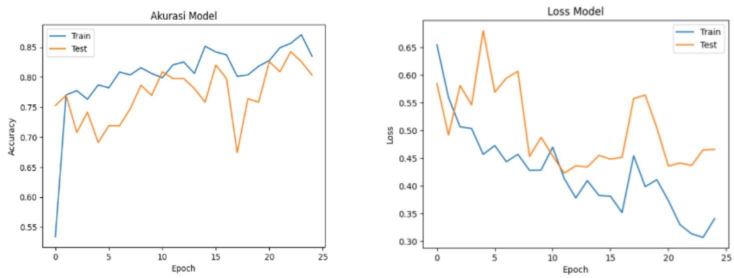


Table 3, shows hyperparameter tuning for the epoch with a value of 25 produces an accuracy value of 0.8034 which indicates that the accuracy rate is 80.34% with the training process for training data and validation data carried out 3 times. Meanwhile, the highest accuracy results are found in the epoch value of 100 with an accuracy result of 0.8090, or if converted into a percentage the accuracy value is 80.9%. While the lowest accuracy value is the Epoch value of 50 with a percentage of 74.7% accuracy value.

The epoch process requires a duration of ±1 minute, which means that if the Epoch value of 25 is running, it requires a duration of 25 minutes. In terms of effectiveness, when compared with the Epoch value of 100, in terms of the duration of the epoch and the accuracy results are not much different, it can be concluded that the recommended optimum epoch point is the Epoch value of 25.

5 Conclusion

This study carried out to evaluate the effectiveness of Epoch under organic and non-organic waste yielded varying accuracy values when Epoch values of 20, 50, 75, and 100 were used. The optimal epoch value is 25, where the accuracy value generated for the test data is 80.34% and the duration required in the epoch process is 25 minutes, assuming the time required for the epoch process. This depends on how well the time needed in the epoch process works and the accuracy value that is produced. A single epoch takes about one minute.

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