Sinkron : Jurnal dan Penelitian Teknik Informatika
Volume 7, Number 4, October 2023
DOI : https://doi.org/10.33395/sinkron.v8i4.13107
e-ISSN : 2541-2019
p-ISSN : 2541-044X

Comparison of Activation Functions on Convolutional Neural Networks (CNN) to Identify Mung Bean Quality

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Abstract: Mung bean production levels by farmers in Indonesia are not stable. When there is a surplus, the stock of mung beans in the warehouse will accumulate, the storage factor affects the quality of mung beans. Indicators of quality mung beans can be seen from the color and size through direct observation. However, the aspect of view and assessment and the level of health of each observer is a human error in the classification of mung bean quality so that the results are less than optimal. One alternative way to identify object quality is to use deep learning algorithms. One of the popular deep learning algorithms is convolution neural network (CNN). This study aims to build a model to classify the feasibility of mung beans. The process of building the model also goes through the image preprocessing stage. In the process of building the model, there are ten setup parameters and four setup data used to produce the best model. As a result, the best CNN algorithm model performance is obtained from data setup I, with accuracy, precision, recall and F1 score above 75%. In addition, this study also analyzes Rel U and Adam activation functions on CNN algorithm on model performance in identifying mung bean quality. CNN algorithm with Adam activation function has 92% accuracy, 92.53% precision, 91.9% recall, and 92.19% F1 score. In addition, the performance of CNN algorithm with Adam activation function is superior compared to CNN algorithm with Adam activation function and previous study.

Keywords: Mung beans; CNN; image preprocessing; Rel U; Adam; Accuracy; Precision; Recall; F1 score

INTRODUCTION

Mung beans (Vigna radiate L.) is a type of nut plants that are widely grown by farmers and it is a very high level of market demand and needs in Indonesia (Siagian et al., 2020). Besides being consumed, it contains a lot of nutrients, vitamins and protein, another benefit of mung beans is for medicinal purposes (Carolin et al., 2021). The demand for mung beans continues to increase from year to year and on the other hand its production is unstable (Siagian et al., 2020) This has implications for the different quality of mung bean stock in the warehouse. It is not uncommon for quality deterioration or rotting to occur due to various factors. Thus, serious attention needs to be paid to identifying the quality of mung beans.

Mung bean quality can be determined by indicators of bean size and color (Rathore et al., 2022). The size of the beans can determine their hard nut content. Mung beans with small seeds contain higher hard seeds than those with large seeds. According to a study by (Rathore et al., 2022) The larger the seed size, the lower the level of hard seed content. Therefore, farmers usually prefer mung beans with large seeds and dull green seeds because they taste better (fluffier) and have a higher selling price value than those with small seeds. In addition, consumer tastes or market demand for certain qualities, such as seed color and size, also determine the selling price. Good quality criteria for mung bean seeds are large size (65-70 g/1,000 seeds), no hard seeds, high protein content (>30%), round seed shape, and dull green seed color. Seed color is one of the important factors affecting the quality of mung bean seeds. Mung beans that are dull green in color have better quality.

According to the economic law (Schwab, 2013), when the stock of mung beans is low and the supply is late, the price of mung beans becomes high in the market. These conditions result in high selling prices in the market. As a consequence, it is not uncommon for poor quality and unfit mung beans to be sold in the market. Of course, this condition is detrimental to the consumer market.

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The Logistics Agency (Bulog) is mandated to control and ensure the availability of logistics commodities in Indonesia (Bantacut & Fadhil, 2018b, 2018a), one of them is mung bean. Currently, the classification of mung bean quality is manually identified through visual observation. The fatigue factor and differences in perception of each observer cause the identification and classification process to be not optimal.

Machine learning is a technology or algorithm that has been widely implemented in various fields to help solve various problems in various fields. In its application, machine learning algorithms are trained to recognize patterns, classify data and make predictions based on the data entered. Deep learning is a method of applying machine learning that uses artificial reasoning networks to mimic the way the human brain works. Using algorithms as its 'neurons', deep learning is able to determine and analyze the characteristics of a data set. Furthermore, deep learning models can recognize complex patterns in images, text, sound, and other data to generate accurate insights and predictions.

LITERATURE REVIEW

There are several previous studies that have applied machine learning and deep learning algorithms to identify the quality of mung beans and other agricultural objects. A study by (Safitri, 2021) created a system to classify the quality of mung beans using the KNN method. The feature extraction methods used are GLCM and HSV. The process of building the model used 120 green beans as training data and to evaluate used 30 images as testing data. The evaluation metric uses accuracy. The performance of the resulting model to identify the quality of green beans is 96%.

Study by (Suhartono, 2012) determines the quality of mung beans by identifying the bean's color and size. They created an artificial neural network (ANN) system combined with image processing to identify the quality of mung beans. The results of image processing in the form of numerical data have a more objective value. ANN will be trained with numerical data input from image processing in order to be able to provide decisions about the quality of mung beans. The methods used to design this system are questions and answers, literature, and experiments. From these methods, an image processing system will be made combined with an artificial neural network. Image processing is used to process images of green beans so as to produce data that will be used as input for artificial neural networks and the network will determine the quality of the beans whether good or bad. The neural network used is a backpropagation network with supervised learning. The ANN model used consists of three layers, an input layer with 12 input nodes, a hidden layer with 800 nodes, and an output layer with 4 output nodes. The results achieved by the network were able to recognize 29% of new data that had not been trained.

Studies which have used the CNN algorithm in identifying the quality of mung beans have been provided by (Sari, 2020). The study utilizes digital image processing technology for the classification process. The Convolution Neural Networks (CNN) algorithm was chosen because of its advantage of being able to perform a self-learning process in object recognition, object extraction or classification. Testing with a sample of 200 mung bean seed images resulted in an accuracy rate on the training data of 100% and on the testing data of 90% so it can be concluded that the CNN method can identify the feasibility of mung bean seeds well.

Due to the advantages of the CNN algorithm, it is also widely implemented to identify the quality of other objects. CNN algorithm utilizes the physical image of cabbage vegetable to identify the quality of the vegetable (Dhamayanti et al., 2021). CNN algorithm is able to perform classification using 270 data where 210 is used as train data and 60 data is used as test data. With a learning rate of 0.004, 30 epochs and three different performance algorithms namely; Stochastic Gradient Descent (SGD), Adaptive Moment (Adam), and Root Mean Square Propagation (RMSProp) with the highest results being in the Adam algorithm whose accuracy rate is 80% for test data and 73% for train data based on the color composition contained in the image. Other objects that have been able to identify their quality by the CNN algorithm are Lactuca sativa (Rahman, 2023). The research identifies lettuce leaf images to determine the condition of the plant using the CNN algorithm. The best accuracy results are obtained in the dataset division of 80% training, 10% validation, and 10% testing with the addition of dropout after maxpooling the second and third layers of 0.2 and dropout in the fully connected layer 0.3, Adam optimizer with a learning rate of 0.0001. In the training process, the accuracy reached 90% at the 50th epoch then evaluated using confusion matrix by entering testing data with the best accuracy obtained reaching 84%.

METHOD

This section presents the research flowchart and the explanation. Fig. 1 presents the research flowchart of this study. This study argues that the availability of datasets is the most important thing in building models using machine learning algorithms or deep learning. Therefore, the first activity carried out is collecting datasets. The next process is image processing. The preprocessing is quite useful to improve the quality of images and thus boost them for further analysis. The output of image preprocessing is image dataset. The dataset will be split into training data and testing data. The training data was used to develop a mung bean quality identification model using CNN algorithm. While the testing data is used to evaluate the model with several performance metrics.

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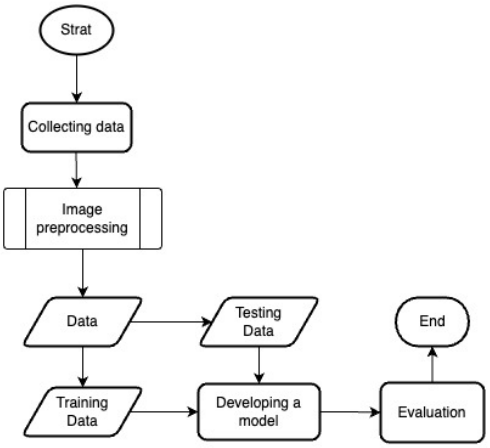

Fig. 1 Research flowchart

Collecting Data

This study used primary data obtained by photographing mung bean seeds directly. The camera used was iPhone XS Max. Mung beans were obtained from traders in three traditional market locations in Medan City. The image data collection process included images of good quality mung beans and poor-quality mung beans. There were 315 images of mung beans that were successfully taken, with details of 200 images of mung beans with decent quality for distribution and consumption, while 115 with unfit quality. Examples of mung bean images from each condition can be seen in Table 1.

Table 1. Example of dataset

Image	Condition	Description
	Viable beans	The image of this mung bean is good quality because it is seen from the shape and also the green color..
	Unviable beans	The image of poor quality mung bean seeds is characterized by the presence of damaged parts and also the darker color.

Image Preprocessing

Image preprocessing process, cropping and resizing will be done on the mung bean seed image data. This cropping process is done to get more objects from the mung bean seed itself compared to the background of the image. In addition, the cropping process is also very effective if done because the object to be studied is only the image of mung bean seeds.

Model CNN

Convolutional Neural Network (CNN) is one of the algorithms of deep learning and is the development of Multilayer Perceptron (MLP) which is designed and can be used to process structured or grid data in the form of two dimensions / 2D, such as images or sounds (Ilahiyah & Nilogiri, 2018). Convolutional Neural Networks is an application of Artificial Neural Networks (ANN) which is currently recognized as the best model for solving problems in object or image recognition. CNN is a convolution operation consisting of several stages or processing layers inspired by biological neural systems (Bertoni et al., 2022).

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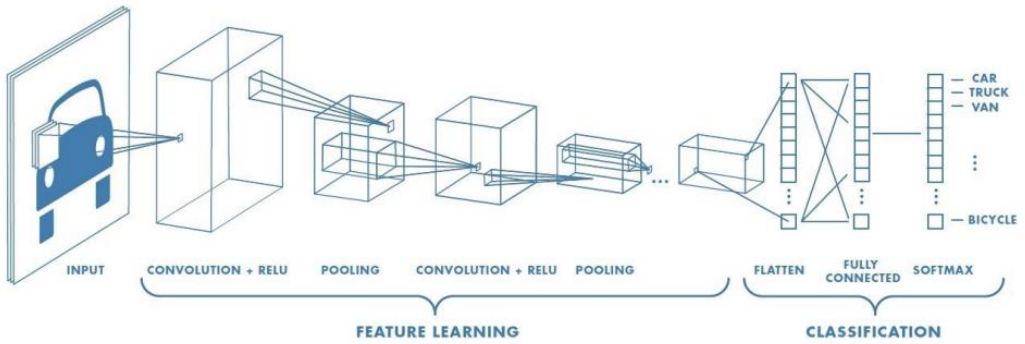

Fig. 2 CNN Architecture

Evaluation

Another very important process in identifying mung bean quality is model evaluation. The model will be tested against train data and data testing and evaluated using several parameters. As evaluation metrics: accuracy, precision, recall, and F1-scores are calculated from the confusion matrix.

Table 2. Confusion Matrix

		Predict	
		Positive	Negative
Actual	Positive	True positive (TP)	False negative (FN)
	Negative	False positive (FP)	True Negative (TN)

Precision (*P*) is the ratio of accurately predicted positive observations to total predicted positive observations (Karo et al., 2020) which are shown in the equation (1).

$$P = \frac{TP}{TP + FP} . 100\% \quad (1)$$

Recall (*R*) is the ratio of accurately predicted positive observations to the number of all relevant samples (Karo et al., 2020), which is shown in the equation (2).

$$R = \frac{TP}{TP + FN} . 100\% \quad (2)$$

F1 score, which is shown in equation (3), is the weighted average of Precision and Recall and a method used to measure the performance of the model.

$$F1\ score = \frac{2PR}{P + R} \quad (3)$$

The percentage of correctly classified instances is called accuracy, which is shown in equation (4). Accuracy is the most intuitive performance measure and it is simply a ratio of correctly predicted observation to the total observations (Karo et al., 2020).

$$Acc = \frac{TP + TN}{TP + TN + FP + FN} . 100\% \quad (4)$$

RESULT

There are five data setups used from the split dataset. The setup data aims to produce the best model in identifying the quality of mung beans. Data setup based on the composition of testing and training data that is commonly used in several studies (Karo Karo, Farhan, et al., 2022; Karo Karo, Fudzee, et al., 2022). Table 3 presents the composition of the data setup used in this study. Data setup I uses 80% of the dataset as training data to build the CNN model and the rest to be evaluated. Data setup II uses 60% of the dataset as training data to build

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the CNN model and the rest to evaluate. Data setup III uses half of the dataset each for building and evaluating the model. The data setup IV uses 40% of the dataset to build the model and the rest to evaluate.

Table 3 Data Setup

Data setup	Data composition (training: testing)
I	80:20
II	60:40
III	50:50
IV	40:60

There are ten parameter setups on CNN algorithm. This study sets the initial parameter setup. Table 2 shows the parameter setup on CNN algorithm in this study. By these parameters, the CNN algorithm trains the dataset to provide a model. The fundamental difference between this research and previous studies (Sari, 2020) is this study analyzes several activation functions on CNN algorithm. There are two activation functions that will be applied and analyzed on the CNN model, that is Rel U and Adam.

Table 4 Initial Parameter of CNN Algorithm

Layer	Output Shape	Parameter
Conv2d_21	148x148x16	448
Max_pooling2d_21	74x74x16	0
Conv2d_22	72x72x32	4640
Max_pooling2d_22	36x36x32	0
Conv2d_23	34x34x64	18496
Max_pooling2d_23	17x17x64	0
Flatten_6	18496	0
Dense_17	200	3699400
Dropout_12	200	0
Dense_18	500	100500
Dropout_13	500	0

Model CNN with Rel U Activation Function

This experiment presents the performance of the CNN algorithm model with Rel U activation function to identify the quality of mung beans. The performance results of the model are presented on Fig. The majority of model performance generated from 4 data setups is above 70%, only the precision, recall and F1 score values of the model from data setup IV are slightly below 70%. Thus, this study provides a temporary conclusion, that the CNN model with Rel U activation function is not too bad. Based on this experiment, Data setup I provides a model for CNN algorithm model with Rel U activation function with the highest accuracy, precision, recall and F1 score compared to the models generated by other data setups. In other words, the model generated by Data setup I is the best model on this experiment.

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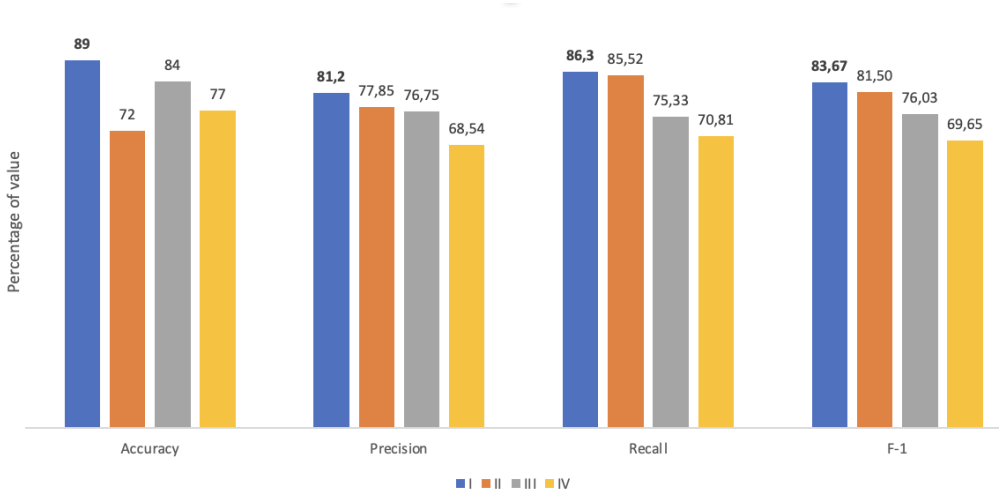

Fig. 3 Performance of CNN Model with Rel U Activation Function

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Model CNN with Adam Activation Function

This experiment presents the performance of the CNN algorithm model with Adam activation function to identify the quality of mung beans. The performance results of the model are presented on Fig. The majority of model performance generated from 4 data setups is above 75%, even some model performance above 90%. Based on this experiment, Data setup I provides a model for CNN algorithm model with Adam activation function with the highest accuracy, precision, recall and F1 score compared to the models generated by other data setups. In other words, the model generated by Data setup I is the best model on this experiment.

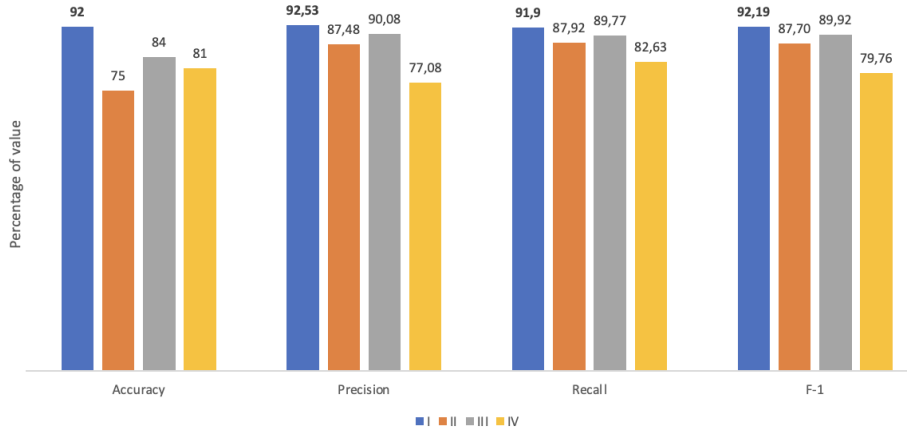

Fig. 4 Performance of CNN Model with Adam Activation Function

DISCUSSIONS

The previous section has presented the results of two experiments. The main objective of this study is to provide a model which is able to classify the quality of mung bean. This section presents a comparative study of two experiments. First experiment used Rel U activation function and second experiment used Adam activation function. In other words, this section presents a comparison of Rel U and Adam activation function performance on CNN algorithm. Fig.5 presents a comparison of the performance of both activation functions on CNN algorithm. In general, the accuracy, precision, recall and F1 score of the model generated by CNN algorithm with Adam activation function are higher than the model generated by CNN algorithm with Rel U activation function on every data setup. Furthermore, to provide the best model, this study presents the best model of experiments through Fig. 5. The accuracy of this model in this study is better than the previous study. Furthermore, the best model of the first experiment and second experiment came from data setup I. In other words, 80% of the dataset has been able to produce the best model to identify the quality of mung beans.

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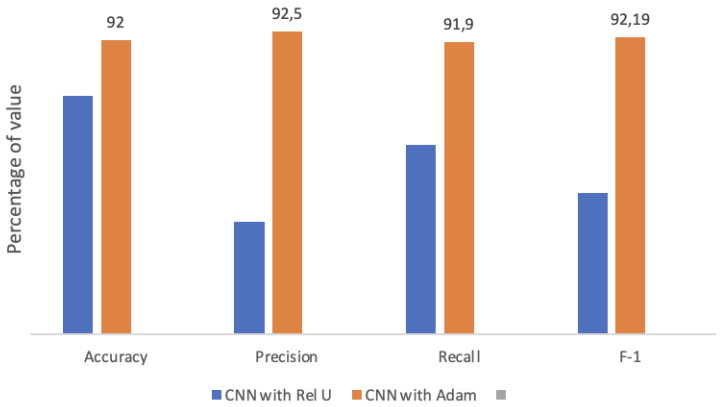

Fig. 5 Comparison Adam and Rel U Activation Function on CNN Performance

CONCLUSION

Based on the results of the analysis that has been done, several conclusions are obtained on this study. CNN algorithm with setup parameters and activation function is successfully applied as a model for classifying the quality of green beans. The size and color of green beans are the main indicators in feature extraction. There are two activation functions on CNN algorithm analyzed, that is Rel U and Adam. Both produce models with good performance for classifying the quality of green beans. This study also analyzes the performance of the two activation functions on CNN algorithm. The analysis results show that the performance of Adam activation function on CNN is better than Rel U activation function on CNN.

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