Sinkron : Jurnal dan Penelitian Teknik Informatika
Volume 8, Number 2, April 2024
DOI : https://doi.org/10.33395/v8i2.13517
e-ISSN : 2541-2019
p-ISSN : 2541-044X

Classification of types Roasted Coffee Beans using Convolutional Neural Network Method

Halifa Sekar Metha
Universitas AMIKOM Yogyakarta, Indonesia
halifasekarmetha@students.amikom.ac.id

Submitted :Feb 21, 2024 | **Accepted** : Feb 29, 2024 | **Published** : Apr 1, 2024

Abstract: In the current digital era, the role of technology in the agricultural industry is very necessary to increase crop yields which can have an impact on the productivity and welfare of farmers. Coffee has been a very popular drink for many years. Due to the high demand for coffee beans, this research aims to develop a system that can classify types of roasted coffee beans based on images using the Convolution Neural Network (CNN) method. Coffee bean processing is the most important stage in the coffee industry, classifying coffee beans often requires more in-depth knowledge and extensive experience regarding coffee beans. Therefore, this system can be a more effective solution. The author collected a dataset containing types of roasted coffee beans, then a Convolutional Neural Network (CNN) could analyze each type of coffee bean in the form of visual patterns. This application is expected to help the coffee industry identify coffee beans quickly and accurately. The results obtained were during the training process using 100 epochs each. The MobileNetV2 architecture managed to achieve an accuracy of 94.79%, while the VGG19 architecture managed to achieve an accuracy of 90.4%.

Keywords: Automated Coffee Processing; Coffee Bean; Convolutional Neural Network; Image Classification; Roasted

INTRODUCTION

In the current Coffee is a drink liked by many groups, both men and women. Coffee is an important commodity and is sold freely on the international market. The results of the analysis state that coffee beans were exported at least around 7 tons per year in the last 5 years (FAO, 2019). The majority of coffee consumers prefer single-origin coffee compared to coffee that has been fermented with other flavorings (Moeis et al., 2020)

Initially, coffee bean classification was carried out based on human experience and knowledge using the human visual system (HVS). However, in the process, humans have limited stamina which affects the accuracy in classifying coffee beans, especially in distinguishing types of coffee that have been roasted. Therefore, image recognition technology is one way to help the classification process. One method that can be used in image recognition is Convolutional Neural Network (CNN).

A Convolutional Neural Network (CNN) is a network that is usually designed to extract features from data and classify certain high-dimensional data. CNNs are created to be able to rearrange a dimension with a high degree of respect, scaling, skew, and other forms of distortion. The structure of a CNN includes feature extraction, feature mapping, and subsampling layers. A CNN consists of several convolutional and subsampling layers optionally followed by a fully connected output layer. A backpropagation algorithm is used to train the model. The analysis results suggest that there are other models such as deep-learning that are designed to function on mobile devices. This model was created to classify the freshness of peaches and recognize three types of diseases that can be found in peaches with a model accuracy level of up to 96% (Assuncao et al., 2020). Various experiments were carried out to increase the accuracy of pre-processing so that high accurate power can be obtained.

Another model was also proposed by (Rashid et al., 2023) the analysis uses the same dataset using MobileNetV2 as the basic model. In line with research conducted by (Gulzar, 2023) conducted experiments and obtained data that the accuracy obtained from transfer learning with the model obtained an accuracy of 99%. Experiments were also carried out by (Nasir et al., 2020), who stated that the identification of fruit diseases using the VGG19 architecture as a basic model obtained an accuracy of 99%.

This research will present a deep learning approach for the classification and identification of roasted coffee beans. This article will explain about training accuracy in terms of training and validation of MobileNetV2

*name of corresponding author

Sinkron : Jurnal dan Penelitian Teknik Informatika
Volume 8, Number 2, April 2024
DOI : https://doi.org/10.33395/v8i2.13517
e-ISSN : 2541-2019
p-ISSN : 2541-044X

and VGG19 models. This research aims to determine the level of accuracy of MobileNetV2 and VGG19 in classifying roasted coffee beans.

LITERATURE REVIEW

In this research, transfer learning techniques are used with the proposed model which aims to help overcome related obstacles. In this research, the well-known deep learning model, namely MobileNetV2, is the basis of this research (Sandler et al., 2018), but there are modifications with the addition of five different layers to increase accuracy and reduce the error rate during the classification process. A dataset consisting of 40 fruit varieties is used in training the proposed model. The research results show that the proposed model succeeded in achieving the highest level of accuracy in identifying various types of fruit.

The research carried out next examined how to group coffee beans based on color using the K-Nearest Neighbor (KNN) method. In this study, the data was divided into three groups, with a total of 90 coffee beans, with each group totaling 30 coffee beans. The experimental results show an accuracy rate of 83%, there is no room to improve the quality of this research (Adiwijaya et al., 2022)

Furthermore, research discusses the classification of coffee bean quality using the Convolutional Neural Network (CNN) method. In this research, a mobile application was developed using a model-based model to classify the quality of coffee beans automatically via a cellphone camera and using the ResNet-152 and VGG16 architecture. The results show that ResNet-152 achieved the highest accuracy of 73.3% (Janandi & Cenggoro, 2020). Another research is entitled Deep Convolutional Neural Network for Coffee Bean Inspection (Wang et al., 2021).

Other research discusses how to overcome the problem of selecting coffee beans which is still done manually, making it time consuming and labor intensive for specialty coffee production. They use image processing and data augmentation technologies to handle the data and use deep learning from convolutional neural networks to analyze image information. The Inception V2 architecture model was used, and the false positive rate was 0.1007, with an overall coffee bean recognition rate of 93% (Huang et al., 2020).

Subsequent research detected types of coffee with high accuracy, requiring many images for training. The data collected includes 4 types of coffee from Indonesia (Garut, Gayo, Kerinci, Temanggung) with a total of 617 images of coffee beans. After testing, the system was able to recognize objects with an accuracy of 74.26% carried out by (Rivalto et al., 2020).

Another study discusses the classification of three types of Indonesian Arabica coffee beans, namely Gayo Aceh, Kintamani Bali, and Toraja Tongkonan using computer vision tools. The analysis was carried out using the AlexNet Convolutional Neural Network classification method with sensitivity analysis using several variations of optimizers such as SGDm, Adam, and RMSProp with learning rates of 0.00005 and 0.0001. Each type of coffee uses 500 data for training and validation with a distribution of 70% training and 30% validation. The analysis results show that all AlexNet models achieve perfect validation accuracy of 100% in 1,040 iterations. This research also involved testing with 100 data tests for each type of coffee, and in the Confusion Matrix test the accuracy reached 99.6% (Hendrawan et al., 2021).

METHOD

This research uses a quantitative research approach. Quantitative research methods which can be defined as "research methods that are based on positivist philosophy, are used to analyze certain populations or samples, collect data using research tools, quantitative/statistical data analysis, with the aim of testing predetermined hypotheses (Sartika & Mulyani, 2020). Data collection is carried out to obtain various kinds of data needed in research. The dataset used comes from Kaggle.com with the following link (https://www.kaggle.com/datasets/gpiosenka/coffee-bean-dataset-resized-224-x-224). After the data is collected, preprocessing of the data is then carried out and then entered into the MobileNetV2 and VGG19 architectural models. Next is the image processing stage, using the CNN architecture which is very popular in image processing and image classification, namely MobileNetV2 and VGG19. The following is the classification process flow carried out by the system:

*name of corresponding author

Sinkron : Jurnal dan Penelitian Teknik Informatika
Volume 8, Number 2, April 2024
DOI : https://doi.org/10.33395/v8i2.13517
e-ISSN : 2541-2019
p-ISSN : 2541-044X

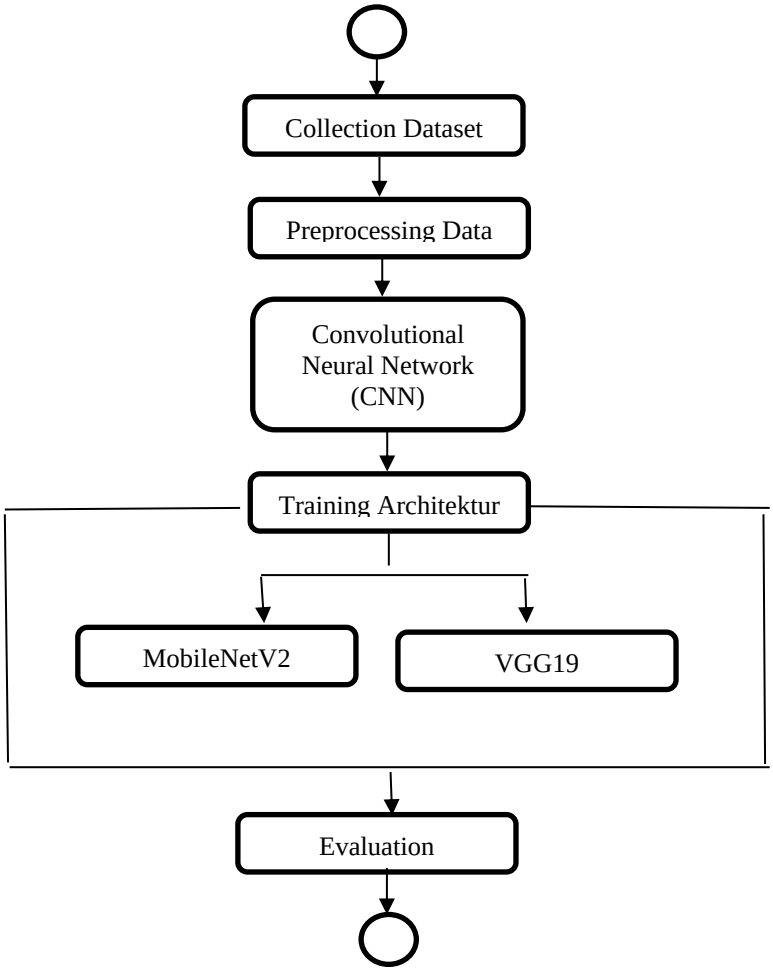

Fig. 1 Workflow

This process will start from a collection of datasets that have been compiled in a CSV folder. When the start process begins the system will process data selecting data between VGG199 or MobileNetV2. In this research, we classify images of 4 different types of coffee using a Convolutional Neural Network architecture with two experimental scenarios. The results can later be evaluated to assess the accuracy in classifying coffee bean images from each experiment to see the facts of the research results. Data collection below is a picture of some of the coffee beans that will be tested. Classification will be carried out using 1600 images. The table below is a collection of data that will later be processed:

Table 1. Dataset detail Coffee

	class index	filepaths	labels	data set
0	0	train/Dark/dark (1).png	Dark	train
1	0	train/Dark/dark (10).png	Dark	train
2	0	train/Dark/dark (100).png	Dark	train
3	0	train/Dark/dark (101).png	Dark	train
4	0	train/Dark/dark (102).png	Dark	train
…	…	…	…	…
1595	3	test/Medium/medium (95).png	Medium	test
1596	3	test/Medium/medium (95).png	Medium	test
1597	3	test/Medium/medium (95).png	Medium	test
1598	3	test/Medium/medium (95).png	Medium	test
1599	3	test/Medium/medium (95).png	Medium	test

*name of corresponding author

Sinkron : Jurnal dan Penelitian Teknik Informatika
Volume 8, Number 2, April 2024
DOI : https://doi.org/10.33395/v8i2.13517
e-ISSN : 2541-2019
p-ISSN : 2541-044X

Fig. 2 Type Coffee
Source : Property Researcher

RESULT

The stages in conducting this research start from collecting the dataset, after that preprocessing the data, then choosing a method, namely Convolutional Neural Network (CNN), then architectural training, here using 2 architectures, namely VGG19 and MobileNetV2, the final stage is carrying out evaluation. This stage provides a discussion of how the model flows to obtain accuracy and validation values, as done using MobileNetV2 and VGG19. MobileNet itself is usually designed specifically for use in mobile applications with limited resources or capacity. Mobile net's priorities are speed and efficiency so it is suitable for use on mobile devices or edge computing devices. Meanwhile, VGG has a high and complex convolutional layer structure so that it has more parameters than MobilenetV2. This research will use sample data of roasted coffee beans that have been photographed, to classify them based on visual patterns in the form of images. by using MobileNetV2 and VGG19 which have been previously programmed to find out how much accuracy is obtained. Following are the test results using MobileNetV2 and also VGG19.

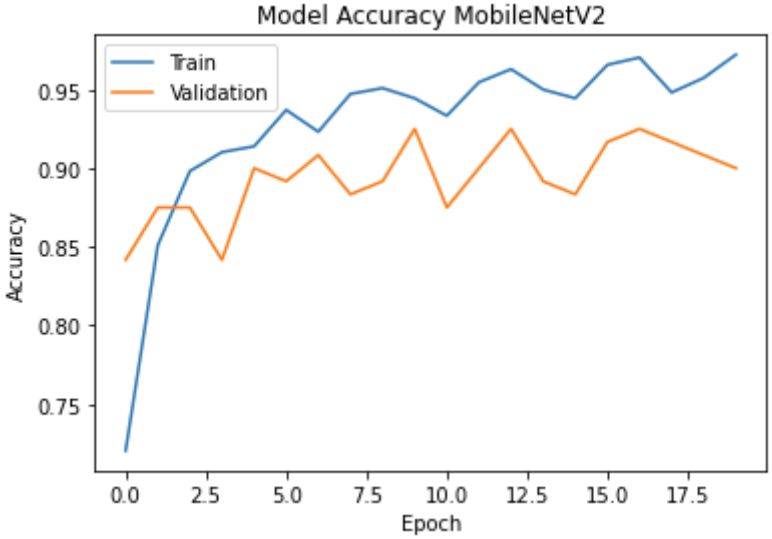

Fig. 3 Training accuracy in terms of training and validation of the MobileNetV2 model
Source : Experiment Research

During the training process with 100 epoch, the model managed to achieve an accuracy of 94.79%. In Fig 3, we can see a graph showing the development of training accuracy over those 100 epoch. The model iteratively improves its capabilities by adjusting parameters based on training data. As a result, accuracy continued to improve steadily, reaching 94.79% after 100 epoch. This shows that the model successfully understands patterns and features in the training data, allowing it to make correct predictions on data it has never seen before. The graph in Fig 3 provides a visual representation of how training accuracy progresses over 100 epoch, providing valuable insight into the model's learning process. This helps researchers to analyze how the model converges and performs during training, and ensures that the model does not overfit or underfit the data. The accuracy of the data displayed in the graph helps in determining the right number of rounds to achieve optimal model performance (Suryana & Nurezka, 2023).

*name of corresponding author

Sinkron : Jurnal dan Penelitian Teknik Informatika
Volume 8, Number 2, April 2024
DOI : https://doi.org/10.33395/v8i2.13517
e-ISSN : 2541-2019
p-ISSN : 2541-044X

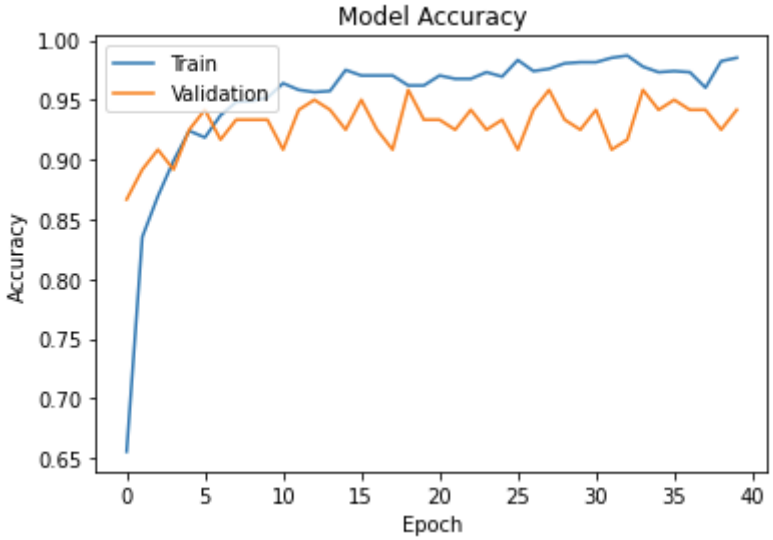

Fig. 4 Training accuracy in terms of training and validation of the VGG19 model.
Source : Experiment Researcher

In training with 100 epoch, the VGG19 model managed to achieve an accuracy of 90.4%. These results show that the model consistently improves its performance during the training process. The VGG19 architecture is characterized by large depth with a total of 19 layers, and its ability to extract features hierarchically can help in overcoming the complexity of image classification tasks. Research by (Simonyan & Zisserman, 2015) introduced the VGG19 architecture. In the study, they showed that the large depth of the VGG19 architecture can provide better feature representation for image recognition tasks.

DISCUSSIONS

To compare the performance of MobileNetV2 and VGG19, it can be seen using the performance metrics used in this research as shown in Table 2 which displays the precision, recall and F1-Score values of each model. Based on the results of this research, the MobileNetV2 and VGG19. Architecture models succeeded in classifying types of roasted coffee beans using 100 epochs. The best results for MobileNetV2 accuracy were 94.79%, precision 0.89, recall 0.91, and F1-Score 0.89. Meanwhile, on VGG19, the best accuracy results were 90.4%, precision 0.94, recall 0.80, and F1-Score 0.80.

Table 2. Implementation Result

Models	**Precisions**	**Recall**	**F1-Score**
MobileNetV2	0.89	0.91	0.89
VGG19	0.94	0.80	0.80

In identifying the type of roasted coffee beans, the results obtained in this study succeeded in obtaining more optimal accuracy compared to previous research (Rivalto et al., 2020). Details of the accuracy comparison can be seen in Table 3.

Table 3. Accuracy Comparison

Method	Accuracy
CNN (Rivalto et al., 2020)	74.26%
MobileNetV2 (Proposed Method)	**94.79%**
VGG19 (Proposed Method)	**90.4%**

CONCLUSION

In this study, we compare the performance of MobileNetV2 and VGG19 for classification of roasted coffee bean types. The dataset in this study consists of 1600 images of roasted coffee beans. Using 100 epochs shows that MobileNetV2 obtains the highest accuracy with an accuracy of 94.79%, while VGG19 obtains an accuracy of 90.4%.

*name of corresponding author

e-ISSN : 2541-2019
p-ISSN : 2541-044X

REFERENCES

Adiwijaya, N. O., Romadhon, H. I., Putra, J. A., & Kuswanto, D. P. (2022). The quality of coffee bean classification system based on color by using k-nearest neighbor method. *Journal of Physics: Conference Series*, *2157*(1). https://doi.org/10.1088/1742-6596/2157/1/012034

Assuncao, E., Diniz, C., Gaspar, P. D., & Proenca, H. (2020). Decision-making support system for fruit diseases classification using Deep Learning. *2020 International Conference on Decision Aid Sciences and Application, DASA 2020*, *November*, 652–656. https://doi.org/10.1109/DASA51403.2020.9317219

FAO. (2019). *FAO. Food and Agriculture Organization of the United Nations. World food and agriculture statistical pocketbook 2019.*

Gulzar, Y. (2023). Fruit Image Classification Model Based on MobileNetV2 with Deep Transfer Learning Technique. *Sustainability (Switzerland)*, *15*(3). https://doi.org/10.3390/su15031906

Hendrawan, Y., Rohmatulloh, B., Ilmi, F. I., Fauzy, M. R., Damayanti, R., Al Riza, D. F., Hermanto, M. B., & Sandra. (2021). AlexNet convolutional neural network to classify the types of Indonesian coffee beans. *IOP Conference Series: Earth and Environmental Science*, *905*(1). https://doi.org/10.1088/1755-1315/905/1/012059

Huang, N. F., Chou, D. L., Lee, C. A., Wu, F. P., Chuang, A. C., Chen, Y. H., & Tsai, Y. C. (2020). Smart agriculture: real-time classification of green coffee beans by using a convolutional neural network. *IET Smart Cities*, *2*(4), 167–172. https://doi.org/10.1049/iet-smc.2020.0068

Janandi, R., & Cenggoro, T. W. (2020). An Implementation of Convolutional Neural Network for Coffee Beans Quality Classification in a Mobile Information System. *Proceedings of 2020 International Conference on Information Management and Technology, ICIMTech 2020*, *August*, 218–222. https://doi.org/10.1109/ICIMTech50083.2020.9211257

Moeis, F. R., Dartanto, T., Moeis, J. P., & Ikhsan, M. (2020). A longitudinal study of agriculture households in Indonesia: The effect of land and labor mobility on welfare and poverty dynamics. *World Development Perspectives*, *20*(August), 100261. https://doi.org/10.1016/j.wdp.2020.100261

Nasir, I. M., Bibi, A., Shah, J. H., Khan, M. A., Sharif, M., Iqbal, K., Nam, Y., & Kadry, S. (2020). Deep learning-based classification of fruit diseases: An application for precision agriculture. *Computers, Materials and Continua*, *66*(2), 1949–1962. https://doi.org/10.32604/cmc.2020.012945

Rashid, J., Khan, I., Abbasi, I. A., Saeed, M. R., Saddique, M., & Abbas, M. (2023). A Hybrid Deep Learning Approach to Classify the Plant Leaf Species. *Computers, Materials and Continua*, *76*(3), 3897–3920. https://doi.org/10.32604/cmc.2023.040356

Rivalto, A., Pranowo, & Santoso, A. J. (2020). Classification of Indonesian coffee types with deep learning. *AIP Conference Proceedings*, *2217*(April). https://doi.org/10.1063/5.0000678

Sandler, M., Howard, A., Zhu, M., Zhmoginov, A., & Chen, L. C. (2018). MobileNetV2: Inverted Residuals and Linear Bottlenecks. *Proceedings of the IEEE Computer Society Conference on Computer Vision and Pattern Recognition*, 4510–4520. https://doi.org/10.1109/CVPR.2018.00474

Sartika, D., & Mulyani, F. (2020). Pengaruh Sifat Machiavellian, Lingkungan Etika, Komitmen Organisasi, dan Tingkat Keseriusan Kecurangan Terhadap Niat Melakukan Whistleblowing (Studi Empiris pada BPKAD di Kota Padang). *MENARA Ilmu*, *XIV*(01), 24–39.

Shimizu, H., & Nakayama, K. I. (2020). Artificial intelligence in oncology. *Cancer Science*, *111*(5), 1452–1460. https://doi.org/10.1111/cas.14377

Simonyan, K., & Zisserman, A. (2015). Very deep convolutional networks for large-scale image recognition. *3rd International Conference on Learning Representations, ICLR 2015 - Conference Track Proceedings*, 1–14.

Suryana, A. A. H., & Nurezka, K. (2023). Economic Mapping of Small-Scale Fishers in Dadap Village, Juntinyuat District, Indramayu Regency, Indonesia. *Asian Journal of Fisheries and Aquatic Research*, *25*(3), 50–66. https://doi.org/10.9734/ajfar/2023/v25i3667

Wang, P., Tseng, H. W., Chen, T. C., & Hsia, C. H. (2021). Deep convolutional neural network for coffee bean inspection. *Sensors and Materials*, *33*(7), 2299–2310. https://doi.org/10.18494/SAM.2021.3277

*name of corresponding author