

Comparing Neural Networks, Support Vector Machines, and Naïve Bayes Algorithms for Classifying Banana Types

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ABSTRACT

One of the most significant fruits for human consumption is the banana. Fruit consumption not only promotes health but also lowers the risk of heart disease, stroke, digestive issues, hypertension, some cancers, bananaaracts in the eyes, skin ailments, cholesterol reduction, and, perhaps most importantly, boosts immunity. The study included secondary data, which is information gathered from online resources like Kaggle. Ten bananaegories of bananas will be identified from the 531 total varieties of bananas used as a train dataset: Ambon bananas, Stone bananas, Cavendish bananas, Kepok bananas, Mas bananas, Red bananas, plantains, Milk bananas, Horn bananas, and Varigata bananas. The development of information technology for image object recognition has become a very intriguing topic along with the rapid advancement of society, and it is undoubtedly directly tied to information data. In order to examine Naive Bayes, Support Vector Machine, and Neural Network techniques for classifying banana types, researchers will use the SqueezeNet Deep Learning model to extract features from photos. The study's findings will provide empirical evidence for the distinctions between each algorithm's accuracy, recall, and precision. Based on the collected results, the Neural Network (NN) method is the best in terms of classifibananaion, with accuracy of 72.3%, precision of 72.1%, and recall of 72.3%.

Keywords: Banana, Neural Network, SVM algorithm, Naïve Bayes, Classifibananaion

INTRODUCTION

Eating fruits can not only help you stay healthier, but it can also lower your risk of developing heart disease, stroke, digestive issues, hypertension, some cancers, eye bananaaracts, skin conditions, cholesterol reduction, and, most importantly, improve your immune system (Sidhu and Zafar 2018). The most essential component for human consumption is fruit, including bananas (Theodoridis and Kraemer n.d.). Remarkably, bananas are tropical fruits because they are more common in tropical rainforest regions. In addition to having flesh that is high in resistant starch, which becomes sugar when ripe, bananas are also well-known for being high in dietary fiber, carbohydrates, and specific vitamins and minerals. The banana is a flowering herbaceous plant in the family Musaceae, genus Musa, and edible fruit. In addition to being consumed raw, bananas can also be consumed cooked (Lestari, Nafi'iyah, and Susilo 2019). The two primary species of bananas are Musa acuminata Colla and Musa balbisiana Colla. Musa x paradisiaca L., the hybrid of these two species, is presently accessible as well. Bananas originated in Australia and Indo-Malaya, but Papua New Guinea was the first region to cultivate them. Nowadays, bananas are found in almost 135 nations worldwide. Based on data from 2016, China and India account for nearly 28% of global banana production. In Western countries, the term "Cavendish group bananas" usually refers to soft, sweet, dessert-type bananas; however, plantains have a hard, starchy fruit that can be cooked like a vegetable (Sidhu and Zafar 2018). It is well known that bananas are high in numerous health-promoting bioactive phytochemicals in addition to being high in carbohydrates, dietary fiber, certain vitamins, and minerals. The development of information technology for image object recognition has become a very interesting topic with the rapid advancement of society. It is undoubtedly closely related to information data from an object (Lestari, Nafi'iyah, and Susilo 2019). By using techniques in data mining, such as clustering and classifica, data mining is a technology for extracting information from vast amounts of data that can speed up the recognition and classifibananaion of types based on their labels / names (Hadianto, Novitasari, and Rahmawati 2019).

This research compares the performance of k-nearest neighbor (k-NN) and Naive Bayes (NB) in classifying teak wood images. With an accuracy value of 82.7%, the test results demonstrate that the NB method is superior to the k-NN method, which has an accuracy value of only 70%. (Waliyansyah and Fitriyah 2019)

This research compares the comparing the use of a non-parametric algorithm in Indonesian facial image

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classification by ethnicity. With an accuracy level of 37.5%, the test results demonstrate that the SVM method is the most effective; in comparison, the k-NN method, Adaboost 33.8%, and Decision Tree 28.2% all have accuracy levels lower than 37.5%. (Hartono, Perwitasari, and Sujaini 2020)

The research Naïve Bayes algorithm and Support Vector Machine are the classification techniques that will be covered in this research study. Accuracy outcomes are determined by features. Support Vector Machine and Naive Bayes use a Genetic Algorithm to select features that will improve classification accuracy. The research's findings include the categorization of text in either positive or negative patterns from the West Java gubernatorial candidate for 2018–2023. The Support Vector Machine yields an AUC of 0.950 and an average accuracy of 92.61% on an unbalanced dataset. Support Vector Machine based on a Genetic Algorithm yields an average accuracy of 93.03% with an AUC of 0.869, Naive Bayes based on a Genetic Algorithm yields an average accuracy of 92.85% with an AUC of 0.543, and Naive Bayes produces an average accuracy of 93.29% with an AUC of 0.525. These findings demonstrate the high degree of accuracy that can be achieved in tweet classification both positive and negative by using the Support Vector Machine. (Normah et al. 2022)

The research outcome of the Convolutional Neural Network algorithm for banana type classification. Three different types of bananas provide accuracy results for the application that range from 60% to 70%. The training model produced accuracy results of 99.94%, while the testing model produced accuracy results of 86.56%. (Gampur et al. n.d.)

The research between the Support Vector Machine (SVM) and Naive Bayes (NB) algorithms in image classification of banana breeds by using the Deep Learning SqueezeNet model as a feature extraction process in images. The results of this research will empirically prove the difference between accuracy, precision and recall of each algorithm. The results obtained show that, in terms of classification, the best is the Support Vector Machine (SVM) algorithm with an accuracy value of 88.4%, precision 88.5% and recall 88.4%, while the lowest is the Naive Bayes (NB) algorithm with an accuracy value of 79.5%, precision 79.9% and recall 79.5%. (Kusuma et al. 2022)

There have been a number of prior investigations on picture classification. The dataset and classification technique employed in each prior study typically account for the majority of the differences.

The researcher will use the SqueezeNet Deep Learning model as a feature extraction process in the image to compare the performance of the Naive Bayes algorithm, Support Vector Machine, and Neural Network on banana type classification based on the presentation from the previous study. The study's findings will provide empirical evidence for the distinctions between each algorithm's accuracy, recall, and precision.

LITERATURE REVIEW

One classification technique that bases Bayes' theorem on probability values is the naive Bayes algorithm. Equation 4 can be used to calculate the probability value of event A to event B if there are still two events, A and B, in the condition. (Hermanto, Mustopa, and Kuntoro 2020).

$$p(A|B) = \frac{p(B|A) \times p(A)}{p(B)} \quad (\text{Mukminin and Riana 2017}).$$

In this case, $p(A|B)$ represents the conditional probability that event A will cause event B to change, and $p(B|A)$ represents the conditional probability that event B will cause event A to change. Whereas the probabilities of events A and B are denoted by $p(A)$ and $p(B)$. Equation 5 represents the Naïve Bayes algorithm for classifying data if A is a group and B is data as per equation 4. (Hermanto, Mustopa, and Kuntoro 2020).

$$p(\text{kategori} | \text{dokumen}) = \frac{p(\text{dokumen} | \text{kategori}) \times p(\text{kategori})}{p(\text{Dokumen})} \quad (\text{Nurajijah and Riana 2019}).$$

Data is represented as d , and bananaegories are represented as c_j , where c_j is the text that needs to be classified. Thus, the probability p (bananaegory), which is determined by the text bananaegory, can be expressed as $p(c_j)$, and the probability $p(\text{data})$, which is determined by the data, can be expressed as $p(d)$. Thus, equation 6 becomes the following. (Mukminin and Riana 2017).

$$p(c_j | d) = \frac{p(d | c_j) \times p(c_j)}{p(d)} \quad (\text{Nurajijah and Riana 2019}).$$

A supervised machine learning algorithm that can be used to determine regression or classification is called Support Vector Machine (SVM). It is primarily utilized, nevertheless, to determine classification problems. The SVM algorithm method converts the dataset into a point in n -dimensional space for each data item, thereby converting

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each item's value into a specific coordinate value. Subsequently, the algorithm carries out classification in order to define hyper-planes that effectively distinguish the two classes. (Yana and Nafi'iyah 2021)

Systems for processing information are called neural networks. Neural networks are generally regarded as black-box systems that process input from their surroundings and generate output. Processing and weighting components are interconnected in neural networks. Groups of functional elements comprise each layer of the network. (Emanuella, Musfita, and Lawi 2021)

The process of classifying involves machine learning from a set of training data to a model, with the model's introduction results being used to predict classification on test data. Generally speaking, there are two types of classification techniques: supervised and unsupervised. Learning via a supervisor is known as supervised classification (learning by example). The opposite of the supervised approach is the unsupervised classification method, which is known as unsupervised learning (learning by observation). (Chaugule and Mali 2014)

METHOD

The goal of this study is to compare three different classification algorithm techniques: neural networks, support vector machines, and naive bayes. The approach employed in this study is shown in figure 1:

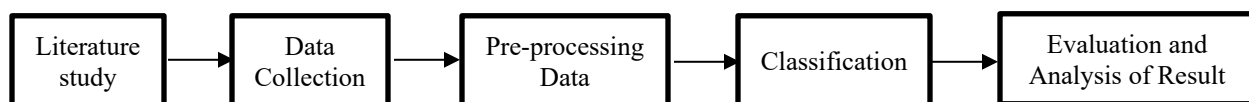


Figure 1 : Research Methodology

A. Literature Study

The purpose of a literature study is to examine information and sources from different books and journals that are relevant to the research that will be done in the future. The literature study's objective is to serve as a supplement to rigorous research by examining earlier research sources. Prior research topics included machine learning, classification, support vector machines, neural networks, naïve bayes algorithms, and learning how to use confusion matrices for testing and evaluating results.

B. Data Collection

The study employed secondary data, which is information gathered from online resources like Kaggle. A total of 540 images representing the various banana varieties were utilized as the train dataset. These images will be categorized into 10 banana categories: Ambon, Stone, Cavendish, Kepok, Mas, Red, plantains, Milk, Horn, and Varigata bananas.



Figure 2 : Banana Type Image Dataset

C. Pre-preprocessing Data

During the data pre-processing phase, the SqueezeNet deep learning model is utilized by researchers to extract features from images. The orange data mining application's image embedding widget includes this procedure.

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Banana category information, image names, image sizes, and file sizes for each image are what this process will yield. Figure 3 displays the embedding results in this instance.

	category	image name	image	size	width	height	n0	n1	n2	n3	n4	n5	n6
1	pisang ambon	1.1	pisang ambo...	25962	65	274	5.90146	9.44536	9.57929	13.4197	10.2907	15.7653	14.1721
2	pisang ambon	1.2	pisang ambo...	26265	59	280	8.13631	10.0408	12.3648	14.2104	11.1539	20.1106	16.7759
3	pisang ambon	10	pisang ambo...	78231	1600	1067	5.72126	5.74478	4.29899	5.71256	8.92933	12.4406	6.25788
4	pisang ambon	2.1	pisang ambo...	26079	80	181	7.83298	9.27325	10.129	13.62	9.49718	18.241	16.7198
5	pisang ambon	2.2	pisang ambo...	24476	66	191	7.10185	12.4416	16.3705	15.8174	13.7207	18.1537	15.8076
6	pisang ambon	2.3	pisang ambo...	22396	41	164	6.29654	9.2721	13.0232	15.7169	8.61082	17.4387	17.3515
7	pisang ambon	2.4	pisang ambo...	24239	56	184	5.72124	9.1822	9.76504	12.1634	10.1889	17.3817	14.0788
8	pisang ambon	2.5	pisang ambo...	24934	59	198	6.45025	11.8503	14.3677	15.7592	12.936	18.8601	17.8018
9	pisang ambon	2.6	pisang ambo...	23912	58	183	8.44158	11.1919	15.0945	17.421	11.3272	19.3038	14.3638
10	pisang ambon	2.7	pisang ambo...	23019	49	181	7.66	15.1412	15.2888	16.0432	13.5979	20.0237	14.5832
11	pisang ambon	2.8	pisang ambo...	24193	60	184	9.23821	11.157	11.8111	16.7318	11.7788	18.8373	17.0077
12	pisang ambon	2.9	pisang ambo...	24323	57	190	11.7182	11.2112	16.9871	17.6898	15.3452	18.8688	19.8602
13	pisang ambon	2.3	pisang ambo...	25312	959	800	8.58005	10.2868	2.24713	0.07026...	2.64138	7.75074	1.66192
14	pisang ambon	3.0	pisang ambo...	27626	92	186	7.42631	8.70707	8.0756	11.3407	9.35022	14.2439	12.6436
15	pisang ambon	3.1	pisang ambo...	36924	169	208	11.2362	10.9681	9.58177	12.3603	9.03912	12.4019	9.17793

Figure 3 : Banana Image Embedding Results

D. Classification

Orange data mining is the application that researchers use to classify neural networks, support vector machines, and naïve bayes algorithms. Figure 4 shows the process used for classifying banana breeds.

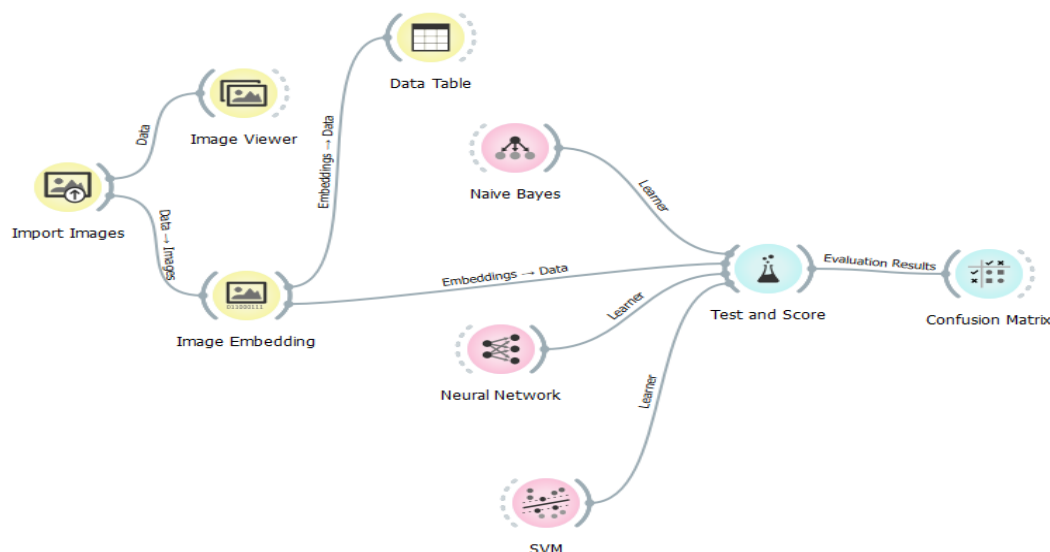


Figure 4 : Workflow of banana type classification

E. Evaluation and Analysis of Results

Neural networks, Support Vector Machine, and the Naive Bayes algorithm are the three algorithms that are evaluated as a step in the application of the comparative level of accuracy of the algorithm under test. The assessment is done in order to determine the accuracy, recall, and precision values. examination of the outcomes derived from each algorithm's confusion matrix.

RESULT

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Accuracy (CA), Recall, and Precision are the performance measures used to calculate the specifibananaions in the classifibananaion.

A correctly valued classifier model's accuracy and performance values are described by its accuracy (CA). The ratio of accurate forecasts to all training data is known as the CA (Ibrahim et al. 2019).

$$\text{Accuracy} = (\text{TP} + \text{TN}) / (\text{TP} + \text{FP} + \text{FN} + \text{TN})$$

(Asha Kiranmai and Jaya Laxmi 2018).

The ratio of accurate positive predictions to total positive outcomes is known as precision (Emanuella, Musfita, and Lawi 2021).

$$\text{Precision} = (\text{TP}) / (\text{TP} + \text{FP})$$

(Kusuma et al. 2022)

The ratio of accurate positive predictions to total data, or the correct positive ratio, is known as recall (Emanuella, Musfita, and Lawi 2021).

$$\text{Recall} = (\text{TP}) / (\text{TP} + \text{FN})$$

(Kusuma et al. 2022)

Information:

TP : True Positive

TN : True Negative

FP : False Positive

FN : False Negatif

Figure V displays the analysis results. The results show that the Neural Network (NN) algorithm performs best in terms of classifibananaion, with an accuracy value of 72.8%, precision value of 72.6%, and recall value of 72.8%. The Support Vector Machine (SVM) algorithm, on the other hand, has 72.2% accuracy, 72.3% precision, and 72.2% recall. The Naive Bayes (NB) algorithm, on the other hand, has the lowest accuracy 62.0%, precision 67.0%, and recall 62.0%.

Evaluation results for target (None, show average)			
Model	CA	Prec	Recall
Neural Network	0.728	0.726	0.728
SVM	0.722	0.723	0.722
Naive Bayes	0.620	0.670	0.620

Figure 5 : Test and Score Algorithm neural network ,support vector maching and naive bayes

Using a confusion matrix, the tree implemented algorithm Neural Network,Support Vector Machine and Naive Bayes—were tested for performance. The following figure displays the outcomes of the confusion matrix for each of the three algorithms:

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		Predicted										
		pisang ambon	pisang batu	pisang cavend...	pisang kepok	pisang mas	pisang merah	pisang raja	pisang susu	pisang tanduk	pisang varigata	Σ
Actual	pisang ambon	34	0	1	2	1	0	6	5	0	2	51
	pisang batu	1	38	2	2	2	1	0	5	0	3	54
	pisang cavend...	0	4	21	2	1	0	3	0	0	0	31
	pisang kepok	3	1	5	18	1	3	7	3	0	0	41
	pisang mas	3	2	1	3	12	0	4	10	0	0	35
	pisang merah	0	0	0	1	0	30	0	3	0	0	34
	pisang raja	6	0	2	5	3	1	9	4	0	0	30
	pisang susu	7	5	1	2	7	2	3	34	0	0	61
	pisang tanduk	1	0	0	0	0	0	0	0	99	0	100
	pisang varigata	0	3	1	1	0	0	0	0	0	98	103
	Σ	55	53	34	36	27	37	32	64	99	103	540

Figure 6 : Confusion Matrix Algorithm Neural Networks

Information about the Neural Networks algorithm is gleaned from the confusion matrix results, which show that:

- There are 34 images with predictions that correspond to actual of the 55 images of banana species with the classification of Ambon bananas.
- There are 38 images with predictions that correspond to actual of the 53 images of banana species with the classification of Batu bananas.
- There are 21 images with predictions that correspond to actual of the 34 images of banana species with the classification of Cavendish bananas.
- There are 18 images with predictions that correspond to actual of the 36 images of banana species with the classification of Kepok bananas.
- There are 12 images with predictions that correspond to actual of the 27 images of banana species with the classification of Mas bananas.
- There are 30 images with predictions that correspond to actual of the 37 images of banana species with the classification of Merah bananas.
- There are 9 images with predictions that correspond to actual of the 32 images of banana species with the classification of Raja bananas.
- There are 34 images with predictions that correspond to actual of the 64 images of banana species with the classification of Susu bananas.
- There are 99 images with predictions that correspond to actual of the 99 images of banana species with the classification of Tanduk bananas.
- There are 98 images with predictions that correspond to actual of the 103 images of banana species with the classification of Varigata bananas.

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		Predicted										Σ
		pisang ambon	pisang batu	pisang cavend...	pisang kepok	pisang mas	pisang merah	pisang raja	pisang susu	pisang tanduk	pisang varigata	
Actual	pisang ambon	31	1	1	3	0	0	1	12	0	2	51
	pisang batu	1	36	2	0	3	0	0	8	0	4	54
	pisang cavend...	0	1	26	1	1	0	0	0	0	2	31
	pisang kepok	2	4	4	20	1	0	2	6	0	2	41
	pisang mas	1	4	3	3	15	0	2	7	0	0	35
	pisang merah	2	0	0	1	0	21	0	10	0	0	34
	pisang raja	4	2	3	11	2	0	2	4	0	2	30
	pisang susu	1	7	1	1	6	0	2	43	0	0	61
	pisang tanduk	0	0	0	0	0	0	0	1	99	0	100
	pisang varigata	0	2	2	0	1	0	0	1	0	97	103
	Σ	42	57	42	40	29	21	9	92	99	109	540

Figure 7 : Confusion Matrix Algorithm SVM

From the results of the confusion matrix on the SVM algorithm, information is obtained that:

- There are 31 images with predictions that correspond to actual of the 42 images of banana species with the classification of Ambon bananas.
- There are 36 images with predictions that correspond to actual of the 57 images of banana species with the classification of Batu bananas.
- There are 26 images with predictions that correspond to actual of the 42 images of banana species with the classification of Cavendish bananas.
- There are 20 images with predictions that correspond to actual of the 40 images of banana species with the classification of Kepok bananas.
- There are 15 images with predictions that correspond to actual of the 29 images of banana species with the classification of Mas bananas.
- There are 21 images with predictions that correspond to actual of the 21 images of banana species with the classification of Merah bananas.
- There are 2 images with predictions that correspond to actual of the 9 images of banana species with the classification of Raja bananas.
- There are 43 images with predictions that correspond to actual of the 92 images of banana species with the classification of Susu bananas.
- There are 99 images with predictions that correspond to actual of the 99 images of banana species with the classification of Tanduk bananas.
- There are 97 images with predictions that correspond to actual of the 109 images of banana species with the classification of Varigata bananas.

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		Predicted										Σ
		pisang ambon	pisang batu	pisang cavend...	pisang kepok	pisang mas	pisang merah	pisang raja	pisang susu	pisang tanduk	pisang varigata	
Actual	pisang ambon	15	4	1	5	2	4	11	9	0	0	51
	pisang batu	3	26	3	1	6	2	5	7	0	1	54
	pisang cavend...	0	1	28	0	1	0	1	0	0	0	31
	pisang kepok	1	2	7	11	2	0	13	4	0	1	41
	pisang mas	1	0	8	1	20	0	3	2	0	0	35
	pisang merah	1	0	1	0	3	23	2	4	0	0	34
	pisang raja	4	0	5	3	3	1	13	0	0	1	30
	pisang susu	2	6	2	1	8	6	6	30	0	0	61
	pisang tanduk	0	0	0	0	0	1	0	0	99	0	100
	pisang varigata	1	6	8	2	7	1	6	2	0	70	103
	Σ	28	45	63	24	52	38	60	58	99	73	540

Figure 8 : Confusion Matrix Algorithm Naïve Bayes

From the results of the confusion matrix on the Naïve Bayes algorithm, information is obtained that:

- There are 15 images with predictions that correspond to actual of the 28 images of banana species with the classification of Ambon bananas.
- There are 26 images with predictions that correspond to actual of the 45 images of banana species with the classification of Batu bananas.
- There are 28 images with predictions that correspond to actual of the 63 images of banana species with the classification of Cavendish bananas.
- There are 11 images with predictions that correspond to actual of the 24 images of banana species with the classification of Kepok bananas.
- There are 20 images with predictions that correspond to actual of the 52 images of banana species with the classification of Mas bananas.
- There are 23 images with predictions that correspond to actual of the 38 images of banana species with the classification of Merah bananas.
- There are 13 images with predictions that correspond to actual of the 60 images of banana species with the classification of Raja bananas.
- There are 30 images with predictions that correspond to actual of the 58 images of banana species with the classification of Susu bananas.
- There are 99 images with predictions that correspond to actual of the 99 images of banana species with the classification of Tanduk bananas.
- There are 70 images with predictions that correspond to actual of the 73 images of banana species with the classification of Varigata bananas.

DISCUSSIONS

In this research, there are several suggestions that can be used as a reference for the future, such as combining other methods that can be combined with supervised learning and unsupervised learning algorithm methods to get different results.

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CONCLUSION

Using the orange data mining applibananai, researchers were able to classify supervised images of different banana types during the analysis process. Ten different types of bananas, including Ambon, Stone, Cavendish, Kepok, Mas, Red, plantain, Milk, Horn, and Varigata bananas, are included in the dataset of banana images that was used. In all, 531 pictures. In image classifibananaion, researchers use the SqueezeNet deep learning model to extract features from images and then compare Naive Bayes, Support Vector Maching, and Neural Network algorithms. The results show that the Neural Network (NN) algorithm performs best in terms of classifibananaion, with an accuracy value of 72.8%, precision value of 72.6%, and recall value of 72.8%. The Support Vector Machine (SVM) algorithm, on the other hand, has 72.2% accuracy, 72.3% precision, and 72.2% recall. The Naive Bayes (NB) algorithm, on the other hand, has the lowest accuracy 62.0%, precision 67.0%, and recall 62.0%.

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