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Performance Analysis of Naive Bayes Variation Method in Spice Image Classification Using Histogram of Gradient Oriented (HOG) Feature Extraction

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Abstrak

Indonesia memiliki banyak sekali kekayaan alam berupa rempah-rempah. Keanekaragaman rempah merupakan aspek yang tidak terpisahkan dari sejarah Indonesia. Bumbu dan bumbu merupakan sumber daya hayati yang telah lama berperan penting dalam kehidupan manusia. Rempah-rempah Indonesia memiliki warna dan bentuk yang hampir sama. Tujuan dari penelitian ini adalah menganalisis kinerja metode variasi Naïve Bayes dalam mengklasifikasikan rempah-rempah menggunakan ekstraksi ciri Histogram Of Oriented Gradient (HOG). Berdasarkan 3 pengujian performansi keempat metode variasi Naïve Bayes yang dilakukan pada penelitian ini, dapat diketahui bahwa pengujian 5 jenis bumbu dengan menggunakan metode Gaussian Naïve Bayes memperoleh performansi terbaik dengan akurasi 0,946, presisi 0,95, recall 0,945, skor f1 0,947, skor f beta 0,946, dan skor Jaccard 0,90. Sedangkan dengan menggunakan metode Complement Naïve Bayes mendapatkan kinerja yang paling rendah. Dari hasil penelitian ini dapat disimpulkan bahwa dengan memanfaatkan ekstraksi ciri HOG dan metode variasi Naïve Bayes diperoleh hasil klasifikasi yang maksimal dalam mengklasifikasikan rempah-rempah. Untuk mendapatkan hasil klasifikasi yang lebih akurat, pertimbangkan untuk menggunakan metode lain dan ekstraksi fitur lainnya.

Keyword : ***Classification, Spices, Naïve Bayes, HOG***

Abstract

Indonesia has a lot of natural wealth of spices. The diversity of spices is an inseparable aspect of Indonesian history. Spices and seasonings are biological resources that have long played an important role in human life. Indonesian spices have almost the same color and shape. The purpose of this study was to analyze the performance of the Naïve Bayes variation method in classifying spices using a Histogram Of Oriented Gradient (HOG) feature extraction. Based on 3 tests, the performance of the four Naïve Bayes variation methods carried out in this study, it can be seen that testing 5 types of spices using the Gaussian Naïve Bayes method obtained the best performance with an accuracy of 0.946, a precision of 0.95, a recall of 0.945, f1 score of 0.947, f beta score of 0.946, and Jaccard score of 0.90. Where as using the Complement Naïve Bayes method gets the lowest performance. From the results of this study it can be concluded that by utilizing HOG feature extraction and the Naïve Bayes variation method, maximum classification results are obtained in classifying spices. To obtain more accurate classification results, consider using other methods and other feature extraction.

Keyword : Classification, Spices, Naïve Bayes, HOG

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I. INTRODUCTION

Indonesia has a lot of natural wealth of spices. The diversity of spices is an inseparable aspect of Indonesian history (Trimukti Chalid et al., 2018). as a producer of spices, Indonesia has the potential to

become a world exporter of spices which will benefit the economy. From 1989 to 2016, the trend of global demand for spices increased annually at a rate of 10.21% annually (Anggrasari & Mulyo, 2019). Herbs and spices have a long culinary history and have functions to prevent and treat chronic health problems due to their anti-oxidant, anti-biotic, anti-viral, anti-coagulant, anti-carcinogenic, and anti-inflammatory qualities (Adnan et al., 2022).

Spices and seasonings are biological resources that have long played an important role in human life. They have been applied to natural plant or vegetable products and seed mixtures in whole or ground form to enhance the taste or aroma of food or drink (Navia et al., 2020). Spices and herbal plants (aromatic herbs), as seasonings and spices, have long been an important part of cooking and drinks (Osman et al., 2019). The increasing use of spices as flavor enhancers in food is a major trend worldwide (Jiang, 2019).

Indonesian spices have turned out to be special foods that are rarely found outside Indonesia. The large number of spices in Indonesia makes the Indonesian people themselves still lack knowledge about the types of spices in Indonesia. Therefore, it is difficult for many individuals, including farmers, to differentiate between the various types of spices, especially for young people (Tanuwijaya et al., 2021). Based on research (Wulandari et al., 2020) the majority of students at SMKN 9 Bandung (47%) are not familiar with herbs and spices. Today's digital image processing technology makes it possible to automatically sort herbs and spices. One way to solve this problem is image classification. The goal of image classification is to simulate how humans perceive digital image data so that computers can identify the items represented by photographs in the same way humans do. Therefore, there are several ways to solve this problem, one of which is by using the Naïve Bayes classification method and HOG feature extraction as in research (Muhathir et al., 2023).

Histogram of Oriented Gradients (HOG), is a feature extraction method that is suitable for descriptors in image processing for computer vision and object recognition (Ningrum et al., 2023). Histogram of Oriented Gradients (HOG), has resistance to changes in lighting and achieves high computational accuracy in detecting various textured objects (Mizuno et al., 2012). HOG (Histogram of Oriented Gradients) is a gradient-based feature descriptor that is efficient for data identification and performs very well compared to other feature extraction (K V Greeshma & K Sreekumar, 2019). The HOG feature extraction process is First, to change the color image to grayscale. This process minimizes color information. Next, calculate the luminance gradient value of each pixel. Then, create a gradient orientation histogram for each block. This process can get a powerful quantity of features in changing shape. Then, feature normalization values are obtained for each block (Sultana et al., 2020).

The Naive-Bayes algorithm uses the Bayesian theorem as the foundation to determine the likelihood that an observation would have a particular feature inside each class (Jahangiri et al., 2023). Naive Bayes algorithm is a straightforward probability classifier that determines a set of probabilities by figuring out how frequently different values occur together and in what combinations in a given data set. In many classification tasks, the Naive Bayes method has the tendency to pick up new information quickly (Saritas & Yasar, 2019). Although each feature is regarded as a binary-valued variable, the Bernoulli Naive Bayes algorithm may classify data that is distributed with many features (Saraswati & Riminarsih, 2020). Gaussian Naïve Bayes is used for features of numeric type, the Gaussian distribution is usually chosen to represent the conditional probabilities of a class of continuous features. Multinomial Naive Bayes is a probabilistic condition that usually does not take into account word order and information that already exists in documents or sentences (Pratama et al., 2022).

The Naive Bayes Algorithm and HOG feature extraction have produced satisfactory results based on prior research. Therefore, by applying HOG feature extraction, researchers attempt to perform the study on the Nave Bayes Algorithm categorization of spice photos.

II. RELATED WORK

Research (Batubara Nadya et al., 2020) discusses the classification of spice rhizomes based on RGB color characteristics and GLCM textures using the Naïve Bayes Algorithm. The data used is 80 images. The results obtained by k-fold cross-validation K=10 get an accuracy rate of 52%. In research (Muhathir et al., 2023), HOG feature extraction is used to classify spices using the Boosting algorithm. The data used was 750. The results of the study using the XGB Classifier obtained an accuracy rate of 80.6%, precision of 81.1%, recall of 80.8%, F1-Score of 80.9%, F2-Score of 80.8%, and Jaccard Score of 69.5%. Research (Hajriansyah, 2023) discusses "Identification of types of spices using the Android-based CNN method".

This study uses data as much as 2700 images of spices. The results of the study using the CNN method obtained an accuracy of 75%. In (Ayalew et al., 2022) study entitled "Detection and classification of COVID-19 disease from X-ray images using convolutional neural networks and histogram of oriented gradients". The results of the study obtained 100% training accuracy and 98.5% test accuracy achieved by using the HOG.

III. RESEARCH METHOD

A. Data Collection

Spice image data collection was carried out by taking pictures using the Redmi 9 camera and taking a distance of 25 cm. Before being classified, the spices are collected first and then each spice must be photographed first. The shooting technique is done by placing spices on white HVS paper with different amounts of spices, different positions, and a random arrangement of spices.

B. Data Analysis

There were 15 different types of spices used in this study, namely anise, cloves, bay leaves, ginger, cumin, galangal, candlenut, cardamom, turmeric, coriander, aromatic ginger, pepper, nutmeg, lemongrass, curcuma. Each spice consisted of 150 samples. There are 2 categories of data used in this study, namely training data and testing data. The ratio used for training data and testing data is 80:20. The data used in this study were 2250.

Table 1. Comparison of training data and testing data

Spices	Training	Testing
Anise	120	30
Clove	120	30
Bay leaves	120	30
Ginger	120	30
Cumin	120	30
Galangal	120	30
Candlenut	120	30
Cardamon	120	30
Turmeric	120	30
Coriander	120	30
Aromatic ginger	120	30
Pepper	120	30
Nutmeg	120	30
Lemongrass	120	30
Curcuma	120	30

C. Research Architecture

An illustration of the research architecture is shown in Figure 1.

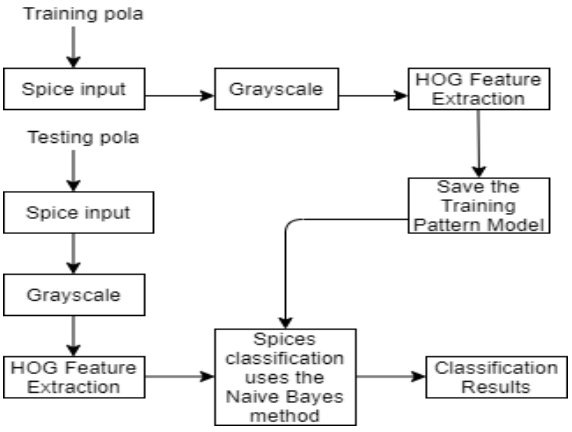


Figure 1 Research Architecture

Figure 1 is a research architecture, with two processes, namely training and testing. In pattern training, the process of inputting image data is carried out in the form of images from research results on spice images, then the spice images are converted to grayscale, after being modified, they will enter the feature extraction process using the HOG, then the results will be stored in the pattern model that will be used in the testing process. Furthermore, in the testing process, namely the process of matching pattern models that have been trained using the Naïve Bayes method as a classification.

D. Confusion Matrix

The confusion matrix is a useful tool for evaluating how well a classifier can distinguish between tuples belonging to various classes. TP and TN convey information when the classifier is accurate, while FP and FN provide a warning when the classifier is inaccurate (Ali Muhammad et al., 2022).

The confusion matrix is a visual assessment tool used in machine learning. To list every potential example of a classification problem, the columns of the confusion matrix represent the predictions for the class results, while the rows show the actual class results (Ridhovan & Suharso, 2022). In the confusion matrix, there are several types of evaluation models, namely accuracy, precision, recall, f1 score, f beta score, and Jaccard score.

$$Accuracy = \frac{\mathrm{TN} + \mathrm{TP}}{\mathrm{TN} + \mathrm{FP} + \mathrm{TP} + \mathrm{FN}}$$

$$Precision = \frac{\mathrm{TP}}{\mathrm{TP} + \mathrm{FP}}$$

$$Recall = \frac{\mathrm{TP}}{\mathrm{TP} + \mathrm{FN}}$$

$$F1 = \frac{2 * Presicion * Recall}{\mathrm{Presicion} + \mathrm{Recall}}$$

$$F_\beta = (1 + \beta^2)\frac{Precision\ x\ Recall}{(\beta^2 x\ Precision) + Recall}$$

$$Jaccard\ (X,Y) = \frac{|X \cap Y|}{|X \cup Y|}$$

IV. RESULT AND DISCUSSION

A. Spice Samples

Figure 2 displays a sample of the spices used in this study with the types of spices used as many as 15 types of spices.

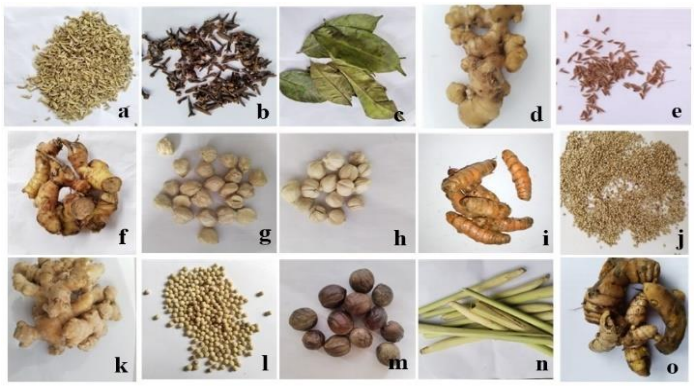


Figure 2 Spices samples (a) anise, (b) cloves, (c) bay leaves, (d) ginger, (e) cumin, (f) galangal, (g) candlenut, (h) cardamom, (i) turmeric, (j) coriander, (k) aromatic ginger, (l) pepper, (m) nutmeg, (n) lemongrass, (o) curcuma

B. HOG Feature Extraction

Figure 3 is the result of feature extraction that has been carried out using a Histogram of Oriented Gradient (HOG) with grayscale images.

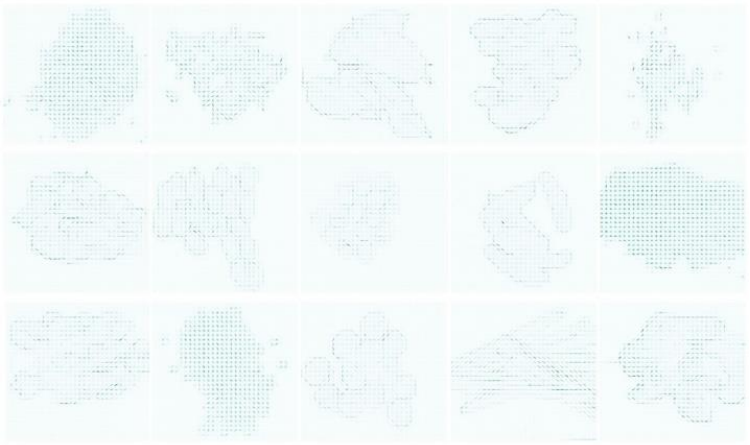


Figure. 3 HOG Feature Extraction Results

C. Experiment

Three (three) tests using five different types of spices, ten different types of spices, and fifteen different types of spices were conducted for this study. The classification techniques employed in this work are the Gaussian Naïve Bayes, Bernoulli Naïve Bayes, Multinomial Naïve Bayes methods and Complement Naïve Bayes methods.

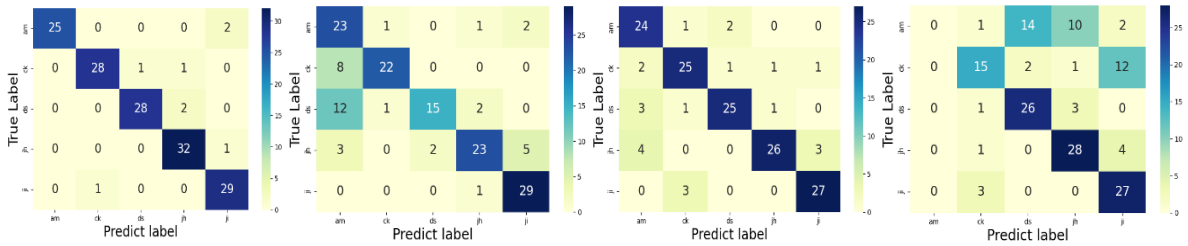
a) Experiment with 5 Different Types of Spices

Table 2. Test Results Of 5 Types Of Spice

Method	Accuracy	Precision	Recall	F1-Score	F-Beta Score	Jaccard-Score
Gaussian Naïve Bayes	0.946	0.95	0.945	0.947	0.946	0.90
Bernoulli Naïve Bayes	0.746	0.791	0.749	0.745	0.742	0.604
Multinomial Naïve Bayes	0.846	0.85	0.848	0.846	0.847	0.735
Complement Naïve	0.64	0.52	0.623	0.555	0.591	0.428

Bayes						

In testing 5 different types of spices, the spices used were anise, cloves, bay leaves, ginger, and cumin. The accuracy results obtained using the Gaussian Naïve Bayes method were 94.6%, the Bernoulli Naïve Bayes method obtained an accuracy result of 74.6%, using the Multinomial Naïve Bayes method obtained an accuracy result of 84.6%, and using the Complement Naïve Bayes method obtained accuracy results of 64%.



(a) (b) (c) (d)

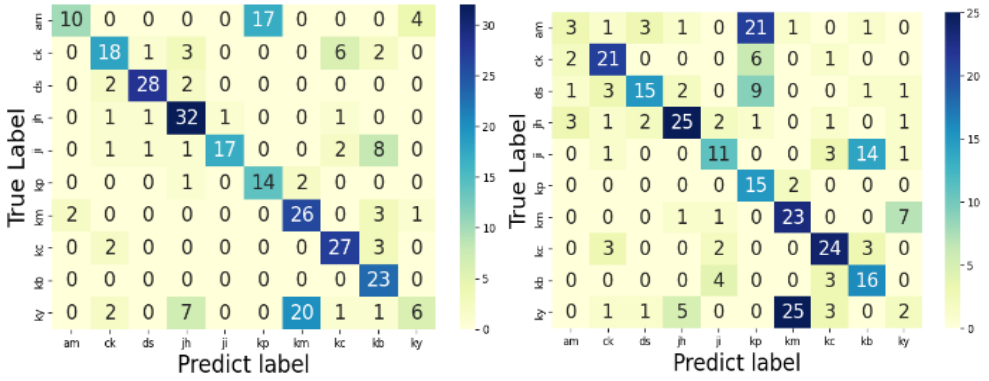
Figure 4 Confusion Matrix Result (a) Gaussian Naïve Bayes, (b) Bernoulli Naïve Bayes, (c) Multinomial Naïve Bayes, (d) Complement Naïve Bayes

b) Experiment with 10 Different Types of Spices

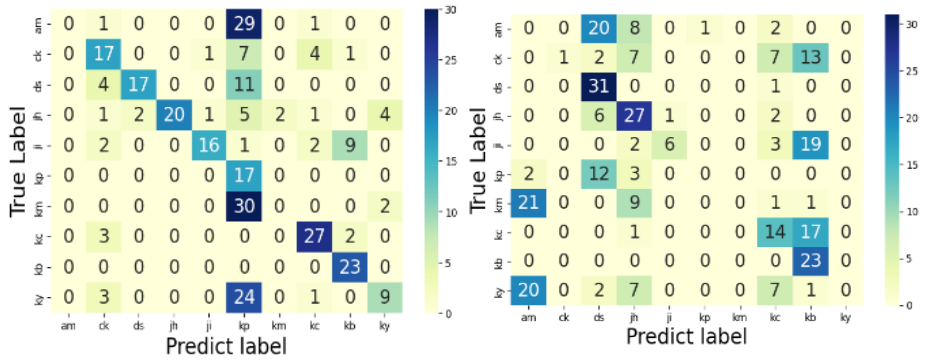
In testing 10 different types of spices, the spices used were aniseed, cloves, bay leaves, ginger, cumin, cardamom, candlenut, aromatic ginger, coriander, and turmeric. The accuracy results obtained using the Gaussian Naïve Bayes method are 67%, the Bernoulli Naïve Bayes method obtains an accuracy result of 51.6%, using the Multinomial Naïve Bayes method obtains an accuracy result of 48.6%, and using the Complement Naïve Bayes method obtains accuracy results by 34%.

Table 3. Test Result 10 Types of Spices

Method	Accuracy	Precision	Recall	F1-Score	F-Beta Score	Jaccard-Score
Gaussian Naïve Bayes	0.67	0.69	0.689	0.648	0.664	0.50
Bernoulli Naïve Bayes	0.516	0.505	0.542	0.489	0.51	0.348
Multinomial Naïve Bayes	0.486	0.547	0.527	0.477	0.477	0.36
Complement Naïve Bayes	0.34	0.339	0.338	0.239	0.28	0.158



(a) (b)



(c) (d)

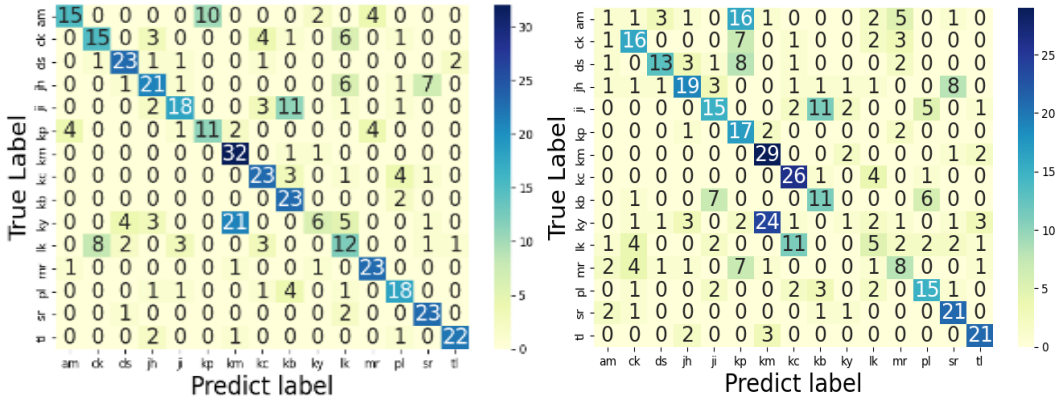
Figure 5 Confusion Matrix Result (a) Gaussian Naïve Bayes, (b) Bernoulli Naïve Bayes, (c) Multinomial Naïve Bayes, (d) Complement Naïve Bayes

c) Experimet with 15 Different Types of Spices

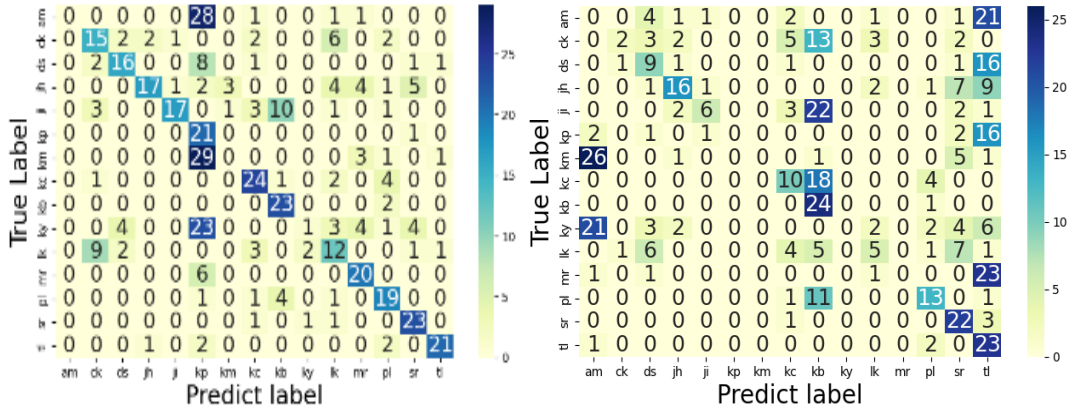
In testing 15 different types of spices, the spices used were anise, cloves, bay leaves, ginger, cumin, cardamom, candlenut, aromatic ginger, coriander, turmeric, galangal, pepper, nutmeg, lemongrass, and curcuma. The accuracy results obtained using the Gaussian Naïve Bayes method were 63.3%, the Bernoulli Naïve Bayes method obtained an accuracy result of 48.4%, using the Multinomial Naïve Bayes method obtained an accuracy result of 50.8%, and using the Complement Naïve Bayes method obtained accuracy results of 28.8%.

Table 4. Test Result 10 Types of Spices

Method	Accuracy	Precision	Recall	F1-Score	F-Beta Score	Jaccard-Score
Gaussian Naïve Bayes	0.633	0.644	0.652	0.627	0.638	0.475
Bernoulli Naïve Bayes	0.484	0.453	0.50	0.457	0.477	0.319
Multinomial Naïve Bayes	0.508	0.515	0.548	0.494	0.511	0.368
Complement Naïve Bayes	0.288	0.283	0.309	0.238	0.259	0.15



(a) (b)



(c) (d)

Figure 6 Confusion Matrix Result (a) Gaussian Naïve Bayes, (b) Bernoulli Naïve Bayes, (c) Multinomial Naïve Bayes, (d) Complement Naïve Bayes

D. Discusses

Based on 3 tests, the performance of the four Naïve Bayes variation methods carried out in this study, it can be seen that testing 5 types of spices using the Gaussian Naïve Bayes method obtained the best performance with an accuracy of 0.946, a precision of 0.95, a recall of 0.945, f1 score of 0.947, f beta score of 0.946, and Jaccard score of 0.90. where as using the Complement Naïve Bayes method gets the lowest performance.

Overall, it can be concluded that by utilizing HOG feature extraction and the Naïve Bayes variation method, maximum classification results are obtained in classifying spices. To obtain more accurate classification results, consider using other methods and other feature extraction.

Method	Extraction Feature	Accuracy	Precision	Recall	F1-Score	F-Beta Score	Jaccard -Score
Naïve Bayes (Batubara Nadya et al., 2020)	GLCM	0.52	-	-	-	-	-
Random Forests (Muhathir et al., 2019)	HOG	0.8733	0.8610	0.8633	0.8587	0.8607	0.7694
XGB classifier (Muhathir et al., 2019)	HOG	0.806	0.811	0.808	0.809	0.808	0.695
Naïve Bayes (Safira & Muhathir, 2023)	SURF	0.773	0.775	0.775	0.764	0.768	0.633
K-Nearest Neighbor (M. Melisah & M. Muhathir, 2023)	HOG	0.87	0.87	0.87	0.87	0.87	0.77

Naïve Bayes	HOG	0.946	0.95	0.945	0.947	0.946	0.90

Table 5. Comparison of Previous Research

V. CONCLUSION

In evaluating five different types of spices, the results showed that the Gaussian Nave Bayes technique produced the greatest results with an accuracy of 94.6%, while the Complement Nave Bayes method produced the poorest results

According to the study's findings, the Naive Bayes variation approach and HOG feature extraction together produce the best classification results for categorizing spices. Consider employing alternative techniques and feature extraction to produce more accurate categorization results.

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