Research Article

Classification of Cow's Milk Freshness Based on Color and Homogeneity Using the Support Vector Machines (SVM) Method

[1] Fitri Aulia Huzaini, [2,*]Anis Yusrotun Nadhiroh, [3] Wali Ja'far Shudiq

[1,2,3] Department of Informatics Engineering, Universitas Nurul Jadid, Probolinggo Regency, East Java 67291, Indonesia

* Corresponding Author: anis@unuja.ac.id

Abstract: Cow's milk is an important food ingredient in meeting human health needs, because cow's milk has high nutritional benefits and an overall healthy structure with very good nutritional proportions, so it has very important value for the younger generation, especially those who are still in school, who need protein. Animal origin from milk. Classifying milk that has various levels of suitability for consumption requires a method that has maximum accuracy so that accurate results are obtained so that we can distinguish between types of milk that can be consumed and those that cannot. This research proposes a Support Vector Machine (SVM) processing technique for classifying milk. The color and homogeneity of various kinds of milk in different positions and conditions of light contrast are used as data to classify types of milk. The results obtained by the SVM algorithm are efficient in classifying the color and homogeneity of milk. The resulting accuracy of applications using the SVM algorithm is 84.44%.

Keywords: Algorithm, Accuracy, Classification, Support Vector Machine, Cow's Milk

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1. Introduction

Cow's milk is one of the livestock products that comes from milking cows' udders. It has high nutritional content and is known as a complete and healthy source of nutrition for human consumption because it contains carbohydrates, fats, proteins, minerals, and vitamins needed by humans. Fresh milk is a liquid obtained from the udder of a milked cow and comes from a healthy and clean cow without any reduction or addition of any ingredients and has not undergone any other process except cooling. (Pazra & Wahyuningsih, 2022)

The high nutritional benefits make milk a good medium for bacteria and microorganisms to grow and develop so milk becomes unfit for use in a very short period if it is not cared for properly. The number of cases of infection caused by fresh cow's milk is quite high. Apart from that, humans also have a low body resistance to these infections. Thus, caring for fresh cow's milk is a very vital aspect of environmental health. Tuberculosis, typhoid, dysentery, throat infections transmitted by staphylococcus bacteria, salmonella, and brucellosis are diseases related to milk quality. In 1995, it was reported in America in the last three years that unpasteurized milk had been the cause of many cases of bloody diarrhea, also known as hemolytic uremic syndrome (HUS). It is suspected that the milk is contaminated by Escherichia coli either directly or indirectly, especially from cattle through industrial processing processes and other sources that have been contaminated by this bacteria (Hamzah et al., 2022)

Raw milk consumption has not been well documented, but in the context of the current trend towards "consuming natural" and "buying local", raw milk consumption is increasingly popular. This is driven by the view that heating can damage the nutrition and health benefits of milk, and is even thought to have detrimental effects.

Problems arise if these consumers consume natural fresh milk without undergoing any processing. Meanwhile, fresh milk is an excellent growth medium for various microorganisms. The growth of these microorganisms depends mainly on temperature and competition with other microorganisms and their metabolic products. To determine the quality of milk, color, and homogeneity are often used as indicators. Color helps in recognizing and identifying the quality of milk well. Fresh milk generally has a consistent white or cream color, without noticeable color changes. Homogeneity, or the thickness and uniformity of the milk, is also important. Good milk should appear homogeneous, with no lumps or noticeable liquid separation. Milk that is not homogeneous may indicate damage or decreased quality. However, relying on human vision to judge milk color and homogeneity has its drawbacks. The human eye can be less accurate due to various factors, such as age which reduces the sharpness of vision, as well as the many colors that must be distinguished so that perception can vary. Some of the weaknesses in the manual assessment of milk quality are that it is a long process, low level of accuracy, and tends to be less consistent.

Digital developments, especially computers, have a big role in increasing the role and benefits of images in human life. Image can be used in various aspects including in the fields of animal husbandry and feed. Therefore, technology is needed to overcome this problem so that we can easily differentiate between fresh milk that is good for consumption. By utilizing digital image processing to classify the freshness of cow's milk, it is hoped that it can help consumers choose fresh milk from that which has been contaminated with bacteria or is stale.

In conducting this research, several related studies have been carried out previously and can be used as a reference for conducting this research. This aims to be a form of comparison and measurement of the level of research success. The following is previous research that is relevant to the research to be conducted:

"*Identification of the Freshness Quality of Goat's Milk Through Digital Image Processing Using the Learning Vector Quantization (LVQ) Method*" This research was conducted because the increasing public interest in goat's milk has encouraged farmers to produce milk in various ways, including mixing other ingredients for profit. A method is needed to identify fresh and non-fresh goat milk effectively. This research uses Learning Vector Quantization (LVQ), an artificial neural network technique with one input layer connected directly to the output neurons. Image analysis of goat's milk was carried out to differentiate between original and mixed milk, with initial parameters Learning Rate (α) = 0.05 and MaxEpoch = 1. The results showed that LVQ could facilitate the identification of goat's milk with sufficient accuracy. The results of the smallest distance in the 1st weight indicate that the goat's milk test image is classified in class 2, namely mixed milk. This research shows that the LVQ algorithm can help ensure the quality of goat milk on the market is maintained with better accuracy, effectiveness, and efficiency. (Parahana et al., 2022)

"*Classification of Cow Milk Quality Using the Modified K-Nearest Neighbor (MKNN) Method*" This research aims to develop an application system that can classify the quality of cow's milk based on chemical composition. Cow's milk is a complex food ingredient that is important for the human body, so quality monitoring is crucial to producing high-quality dairy products. In developing this system, the method used is Modified K-Nearest Neighbor (K-NN). This application system uses data on the chemical composition of milk, including fat, non-fat dry matter, viscosity, lactose, and protein, taken with the Milkscore Julie C2 tool. This research utilized a dataset of 269 cow's milk quality data with 5 parameters and 2 yield classes. The test results show that the Modified K-Nearest Neighbor method has a high level of accuracy. The average test accuracy value for the K value is 91.1%, the influence of the amount of training data is 88.4%, and the balanced and unbalanced classes are 86.12%. Thus, the Modified K-Nearest Neighbor method can be implemented effectively in the cow's milk quality classification system, helping in monitoring and controlling the quality of dairy products. (Pradana et al., nd)

"*Fabric Type Classification System Based on Texture Using Support Vector Machine Method Based on Web Flask*" This research aims to implement and optimize the Support Vector Machine (SVM) model for classification of fabric texture with a high level of accuracy. The method used is Gray Level Co-occurrence Matrix (GLCM) feature extraction and

classification using SVM based on Web Flask. The dataset used consists of 600 images with 4 types of fabric, 150 images each. After preprocessing which changes the image to grayscale and a uniform size of 450x450, SVM is used for classification with 480 training data and 120 testing data, resulting in an accuracy of 47%. The fabric type prediction results are then implemented into Web Flask for online fabric type prediction.

"*Classification of Banana Types Based on Color, Texture, Image Shape Features Using SVM and KNN*" This research aims to identify and classify types of bananas in Indonesia based on image features such as color, texture, and shape using the SVM and KNN algorithms. The dataset used consists of 399 banana images, classified into 7 types of banana. Feature extraction includes color (RGB average, RGB standard deviation, RGB skewness, RGB entropy), texture (grayscale average, grayscale standard deviation, gray level co-occurrence matrix), and shape (area, perimeter, metric, major axis, minor axis, eccentricity). The test results show that the classification accuracy using SVM is 41.67% for color features, 33.3% for texture features, and 8.3% for shape features. Meanwhile, with KNN, the best accuracy is 55.95% for color features, 58.33% for texture features, and 45.24% for shape features with the best K value being 2. (Yana & Nafi'iyah, 2021)

These four studies have the main similarities in their focus on digital image processing and the use of machine learning methods for classification and identification. Research on goat's milk uses Learning Vector Quantization (LVQ), research on cow's milk quality uses Modified K-Nearest Neighbor (K-NN), research on fabric texture uses Support Vector Machine (SVM) (B. Pradito, et.al, 2024), (S. Islavath and C. R. Bhat, 2024), (G. S. Kumar and S. Loganayagi, 2024), (J. Silla and S. D. Raj, 2024), and research on banana classification uses SVM and K -NN. All of this research involves digital image processing for the extraction of features that vary according to the object being classified, such as color, texture, shape, and chemical composition features. The main goal is to classify the quality or type of object, such as identifying the freshness of goat's milk, classifying the quality of cow's milk based on chemical composition, classifying types of fabric based on texture, and classifying types of bananas based on image features. Each study uses image datasets which are then processed and analyzed, and measures the accuracy of the classification methods used to assess the effectiveness of the model in identifying or classifying the objects under study. Overall, these four studies show how machine learning and digital image processing methods can be applied to a variety of purposes for classification and identification purposes.

The current research titled "Classification of Cow's Milk Freshness Based on Color and Homogeneity Using the Support Vector Machines (SVM) Method", this research aims to classify the freshness of cow's milk using color and homogeneity parameters. The SVM method was chosen because of its high ability to process data with high complexity and provide accurate classification results. By implementing this method, it is hoped that it can help maintain the quality of cow's milk on the market, ensuring a fresh and quality product for consumers.

Support Vector Machine (SVM) is a supervised learning method used for classification. SVM works by finding the best line or plane (called a hyperplane) that separates data into two different classes with the largest margin. The margin is the distance between this dividing line and the closest data from both classes. SVM can handle data that can be separated linearly (straight line) and non-linearly (not a straight line) with the help of a special function called the kernel. The SVM algorithm involves calculating weights (w) and bias (b) to determine the optimal hyperplane position and uses an iterative process to achieve the best results. In simple terms, SVM is a powerful and efficient method for classifying data into different categories by finding optimal dividing lines or planes.

2. Theory

2.1 Cow's milk

Cow's milk is an important food ingredient in meeting human health needs, because cow's milk has high nutritional benefits and an overall healthy structure with very good nutritional proportions, so it has very important value for the younger generation, especially those who are still in school, who need protein. Animal origin from milk. (Hamzah et al., 2022)

An important perspective in surveying milk quality that shows the level of consumer recognition is that milk has a relationship between physical properties, chemical properties, and microbiological properties. The physical properties of milk such as color, smell, and taste of milk can be observed and tested through the five senses. (Pazra & Wahyuningsih, 2022) The color of fresh milk usually ranges from bluish-white to yellowish-white. This color variation is influenced by the amount of dry matter in the milk. The distinctive white color is caused by the reflection of light and colloidal particles of milk so milk is opaque. Cow's milk has a slightly sweet taste, the sweet taste is caused by the low lactose and chloride content. If it tastes sour, bitter, or has an unusual taste then the milk is not good for consumption. Milk also has a specific cow body odor. Other odors that are often encountered include the smell of drum waste or the odor of feed which is not expected, if these odors are present the milk is not good for consumption. Chemically, cow's milk is a complex mixture consisting of fat, casein, lactalbumin, lactoglobulin, lactose, and minerals. The chemical properties of milk are related to the acidity level of the milk. The content of various acidic compounds such as citric acid, phosphoric acid, amino acids, and dissolved carbon dioxide affects the chemical properties of milk. The chemical composition of milk, including the content of these acidic compounds, has a significant impact on the chemical characteristics of milk. (Hamzah et al., 2022) The microbiological properties of cow's milk refer to how many microbes from the bacterial group are found in cow's milk. This is an important factor in assessing milk quality because the maximum number of bacteria is the standard used as a reference for cow's milk. (Pazra & Wahyuningsih, 2022)

Cow's milk is recognized as containing high nutrients such as micronutrients, calcium, and phosphorus, as well as vitamins such as vitamin B and vitamin D. Cow's milk is also rich in high-quality protein such as casein protein and contains fatty acid composition from milk fat. (Hamzah et al., 2022)

2.2 Color and Homogeneous

Color is a visual perception produced by the wavelength of light reflected or emitted by an object, such as red, blue, or green. Homogeneous refers to a material or system that has uniform composition or characteristics throughout its parts, such as a salt solution in water that is evenly mixed. An example of homogeneous milk fat is milk that has gone through a homogenization process, where the fat globules are broken down into small particles and spread evenly so that the fat does not separate and the milk remains uniform.

2.3 Digital Image

An image is a combination of points, lines, planes, and colors which represents an object. In simple terms, an image can be explained as a picture, similarity, or imitation of an object. Images can be divided into two types, namely analog images and digital images. Analog images are continuous images such as images on a television screen or X-ray photos. Meanwhile, digital images are images that can be processed by a computer. Systematically, an image can be defined as a function f(x, y) which has dimensions of M rows and N columns, where x and y are spatial coordinates, and the amplitude f at the coordinate point (x, y) is referred to as the intensity or gray level of the image at that point. (Yanu F et al., 2022)

2.4 Classification

Classification is used to group living things such as animals and plants. Plants can be classified into trees or herbs, while animals can be classified into vertebrates and invertebrates. The concept of classification was first introduced by Aristotle in 384-322 BC. In the context of discussions about machine learning, calcification refers to techniques used to build models that can predict unknown data classes from observed objects. This technique involves manipulating data to determine new data classes based on discovered rules. There are various classification methods used in machine learning such as Classification and Regression Trees (CART), Random Forest, Naïve Bayes, and Support Vector Machines (SVM). The data classification process involves several steps, including a training step for a classification model built using training data and a classification step

where the model that has been built is used to predict the class of test data. (Amrozi et al., 2022)

2.5 Support Vector Machine (SVM)

Vapnik first introduced a classification technique known as Support Vector Machine (SVM) in 1998. This technique works by limiting the distance between two classes that have the largest and shortest data distance between them. To obtain the most extreme boundary between layers, the best hyperplane (dividing line) must be framed in the info space obtained by estimating the edges of the hyperplane and tracking the largest point. The distance between the hyperplane and the closest point of each layer is the margin. Support Vector Machine (SVM) is the name given to this closest point. Data that can be separated linearly can be classified using a Support Vector Machine (SVM) (M. Sareenbanu and R. Senthil Kumar, 2024). (Udjulawa, 2023) Figure 2 depicts the Support Vector Machine (SVM) hyperplane.

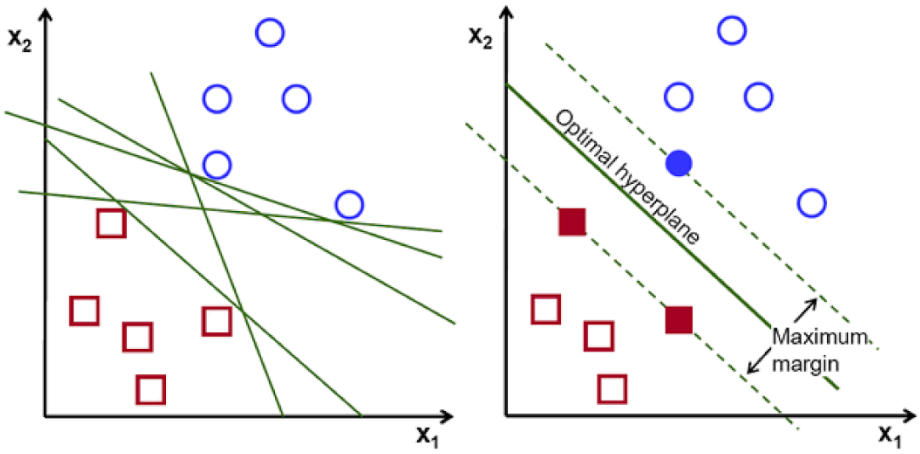

Figure 1. *Hyperplane* SVM

2.6 Google Colab

Google Colab or Google Colaboratory, is a cloud platform provided by Google for running and compiling Python code through programs without requiring any additional settings. The platform leverages Google's cloud infrastructure and gives developers access to free GPUs and TPUs (tensor processing units) in a powerful development environment. With collaboration features that allow clients to share notebooks and work together progressively, Google Colab has become a popular choice for engineers, specialists, and students to run their Python projects. Google Colab makes collaboration easier by allowing users to share notebooks directly with others. The platform is accessible via a web browser, requires no additional software installation, and leverages Google's cloud infrastructure. Developers, researchers, and novice programmers can run Python projects on this platform without worrying about setting up hardware. (Nazar, 2024)

2.7 Python

Python is a high-level programming language that is interpretive, interactive, and object-oriented. This language can be used on almost all platforms, including Windows, Mac, and the Linux family. Python is a high-level programming language that is easy to learn because its grammar is clear and beautiful, accompanied by the use of modules that have high-level data structures, are efficient, and are ready to be used quickly. In the Python programming language, application source code is usually compiled into byte code, an intermediate format that is then executed (Ratna, 2020).

3. Method

The research method in this study aims to simplify the research process for the milk freshness classification system based on color and texture. In designing research, several stages will be carried out. The stages of this research are depicted in the following diagram.

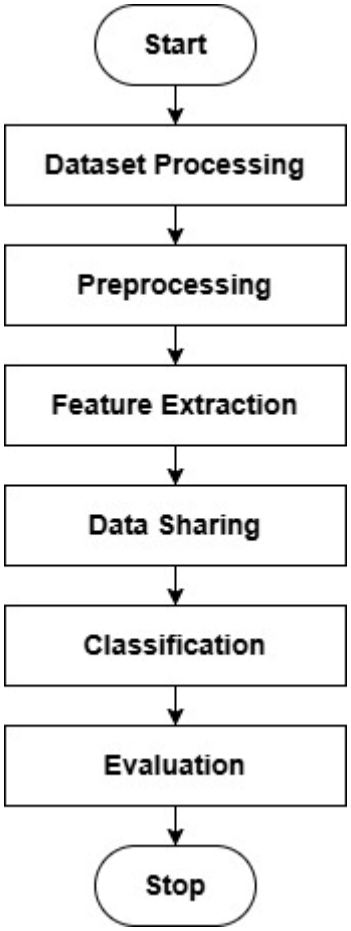

Figure 2. Research Method

4. Result and Analyzes

Furthermore, in producing a detailed analysis, we present several steps that need to be done, namely Dataset Processing, Preprocessing, Feature Extraction, Data Sharing, Classification, and Evaluation. Evaluation is very important to review the results and whether they are optimal or need to be improved again. In detail, we describe it again as follows:

4.1 Dataset Processing

Using previously collected image data, milk types are categorized based on color and homogeneity. The main goal of this process is to improve image data. It consists of changing the pixel size of the image such as display, storage, and transmission of the image. The process of separating objects in an image based on certain characteristics is known as image segmentation. To make images easier to analyze, segmentation aims to simplify its representation. Type identification and classification, preprocessing, feature extraction, and classification are all part of this process.

4.2 Preprocessing

100 images of fresh milk, 100 images of damaged milk, and 100 images of stale milk. A total of 300 data are three classes or types of milk that make up the data used. This data comes from field research. To ensure there are no obvious differences in the data, the

image will be scaled or normalized first within a certain range of values. In addition, this speeds up the algorithm's calculations.

4.3 Feature Extraction

Feature extraction takes data that is expected to recognize the type of milk fruit. Color and homogeneity are features that need to be extracted. In this program, a sample of 100 images representing three types of milk is displayed to show the differences using the sense of sight before application of the method system. The following is a visualization:

Figure 3. Fresh milk

Figure 4. Spoiled milk

Figure 5. Stale milk

4.4 Data Sharing

Data will be divided into training data and testing data, with training data aimed at creating a model and testing data aimed at determining model accuracy. A total of 70% of the training data, or 210 milk images, was used for testing, and 30% of the testing data, or 70 milk images.

4.5 Classification

Support Vector Machine (SVM) is one of the best techniques for classifying. This technique works by limiting the distance between two classes that have the largest and shortest data distance between them. To obtain the most extreme boundary between layers, the best hyperplane (dividing line) must be framed in the info space obtained by estimating the edges of the hyperplane and tracking the largest point. The distance between the hyperplane and the closest point of each layer is the margin. (Udjulawa, 2023)

4.6 Evaluation

This stage aims to find out whether the classification model that has been created is running optimally or not. At this stage, a confusion matrix is used. The confusion matrix is a performance measurement tool for the classification model created where the output can consist of two or more classes.

4.7 Analysis

4.7.1 Datasets

The dataset used in this research is images of 3 types of milk. There are 300 images in the dataset. For each class, the dataset is divided into 70% testing data and 30% training data, with 70 fresh milk data, 70 stale milk data, and 70 stale milk data for testing and 30 fresh milk data, 30 stale milk data, and 30 milk data stale for training, with a total of 210 testing data and 90 training data.

rusak-4-_jpg.rf.78b2978f84e42e21bef4599d987b701b.jpg	400	400	rusak	67	19	385	347
basi-58-_jpg.rf.80adc8ee192295500c5edf53962ac678.jpg	400	400	basi	35	52	329	353
basi-97-_jpg.rf.5e318c91192f0c7485db31e7b844ffee.jpg	400	400	basi	45	21	344	331
segar-6-_jpg.rf.6290beaddd24bafb8f6136c8ec66fb0b.jpg	400	400	segar	53	41	354	363
rusak-47-_jpg.rf.004b71c8930821b17ddfbf2610e6751f.jpg	400	400	rusak	53	17	379	329
...	...	...	...	...	...	...	...
basi-44-_jpg.rf.24861b3ab036cfc2c6a1984ca374bebe.jpg	400	400	basi	49	32	358	323
basi-4-_jpg.rf.39da855ba65ffca8ad181acdfc0a35bd.jpg	400	400	basi	37	42	352	321
basi-79-_jpg.rf.2925a0884f084ac2fdf46c41b224da33.jpg	400	400	basi	47	36	346	344
rusak-8-_jpg.rf.2c1130dc29c4942f2815608a006a85e6.jpg	400	400	rusak	66	13	386	338
rusak-63-_jpg.rf.355c8200c6af3b1ff3f6ff1eb2afc2f5.jpg	400	400	rusak	63	25	367	346

300 rows × 7 columns

Figure 6. Classifying milk types. Types of milk are divided into three classes, namely fresh milk, spoiled milk, and stale milk.

4.7.2 Research result

The method testing stage to determine whether the system recognizes fruit images correctly is known as the research stage. Python is used along with Support Vector Machine techniques to classify milk types. The three types of milk are differentiated based on their texture and color.

First, the data will be read in its original state, then the data will be resized from a revolution of 2944 x 2944 pixels to a resolution of 450 x 450 pixels. Image resizing is the process of reducing the fabric image which aims to simplify the calculation process in the system. The second stage is Object Labeling, which is giving labels to certain objects in the image based on their color and homogeneity. After Object Labeling, the labels that have been created will be converted into CSV format. Thus, researchers use the Support Vector Machine (SVM) method to build a model from the specified data. Accuracy will be evaluated and then assessed based on the results obtained. The Confusion Matrix will also be used to evaluate the results obtained to determine the percentage of correct and incorrect predictions. An accuracy of 84.44% was achieved in research tests using the Support Vector Machine (SVM) algorithm. This shows that images can be used to represent the milk surface using the resulting features.

Table 1. The SVM algorithm

Actual Values	Precision	Recall	F1-score	support
Stale	0.87	0.76	0.81	34
Fresh	0.96	0.88	0.92	26
Damaged	0.75	0.90	0.82	30
Accuracy			0.84	90
Macro avg	0.97	0.85	0.85	90
Weighted avg	0.97	0.84	0.85	90

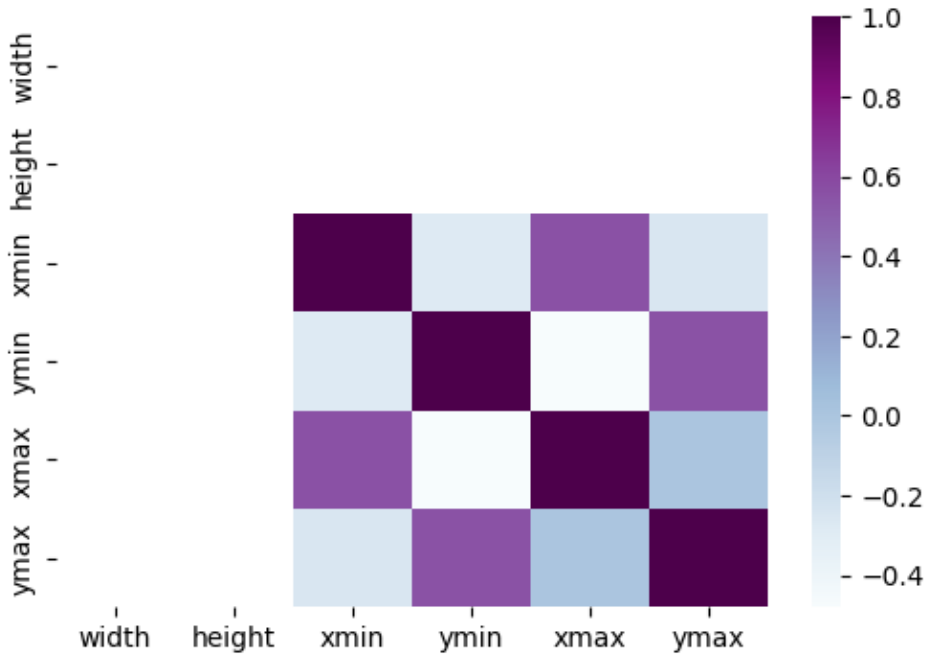

Figure 7. Normalized confusion matrix from milk type classification using SVM

5. Conclusions

Research on the Classification of Cow's Milk Freshness Based on Color and Homogeneity Using the Support Vector Machines (SVM) Method resulted in the conclusion that the SVM process with a total of 300 image data, consisting of 210 testing data and 90 training data, produced an accuracy value of 84.44%. For testing classification systems. There are still shortcomings in this research. Utilizing other methods to assess the level of accuracy of feature extraction methods is one suggestion for further research. Take pictures with a better camera to improve image quality.

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