Accredited Ranking SINTA 2
Decree of the Director General of Higher Education, Research, and Technology, No. 158/E/KPT/2021
Validity period from Volume 5 Number 2 of 2021 to Volume 10 Number 1 of 2026

Published online on: **http://jurnal.iaii.or.id**

JURNAL RESTI
(Rekayasa Sistem dan Teknologi Informasi)
Vol. 7 No. 1 (2023) 146 - 152 ISSN Media Electronic: 2580-0760

Sunflower Image Classification Using Multiclass Support Vector Machine Based on Histogram Characteristics

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Abstract

Sunflower is an important commodity in agriculture, besides being used as an ornamental plant, sunflower is an oil-producing plant and a source of industrial materials. In Indonesia, sunflower productivity is considered less than optimal, because knowledge and information about sunflowers are still lacking. Therefore, information is needed that can be used as an extension of knowledge about sunflowers itself, especially in Indonesia, which is a tropical region which is an area suitable for the growth of sunflowers. Sunflowers can actually be identified based on recognizable traits. However, the similar shape makes it difficult for some people to distinguish the types of sunflowers. This study aims to classify sunflower images using a first-order feature extraction algorithm using the characteristics of mean, skewness, variance, kurtosis, and entropy which are then used as input to the Multiclass SVM identification algorithm. Data points are mapped to dimensionless space using a Multiclass SVM to produce hyperplane-linear separation between each class. Based on the results of testing the accuracy of the model is able to perform classification with an average accuracy of 79%. These results show that the developed model can classify well.

Keywords: histogram characteristics; first order feature extraction; support vector machine; multiclass SVM

1. Introduction

The Sunflower, which in scientific language is Helianthus Annuus L., is a plant native to eastern North America that has applications and benefits for people. Sunflowers can be used in various fields, such as industry, food, health and as a cosmetic ingredient [1]. Sunflower is an important commodity in agriculture, besides being used as an ornamental plant, sunflower is an oil-producing plant and a source of industrial materials. Sunflower seeds contain 21% protein, 55% fat, 19% carbohydrates and 40-50% oil content [2]. In Indonesia, the productivity of sunflower cultivation is not optimal, this is due to several factors, one of which is the lack of information and descriptions of the types of sunflowers [2]. Therefore, information is needed that can be used as an extension of knowledge about sunflowers themselves, especially in Indonesia, which is a tropical area which is a suitable area for the growth and development of sunflowers. Sunflowers have many varieties and types. Because sunflowers have many types with different characteristics, knowledge about the classification of these types of sunflowers is important. For the general public, the classification of sunflower species can be useful for increasing knowledge if you are going to use this sunflower either as a food ingredient or as an ornamental plant. For sunflower cultivators, the classification of sunflower types can be useful for handling and processing because each type of sunflower has different characteristics in its cultivation. Sunflowers can actually be identified based on recognizable traits. However, their similar shape makes it difficult for some people to distinguish the types of sunflowers. Then the development of a digital image processing-based system that has the ability to classify sunflower types based on their images can be a solution.

Digital image processing is a field that investigates how images are created, managed, and analyzed to produce valuable information [3]. One form of image processing application is image classification. Image classification is the process of categorizing a variety of pixels or picture components into classes, with each class describing a distinct entity [4], [5]. Several studies related to flower identification or classification include research on flower classification using the Naïve Bayes algorithm with color and texture feature extraction [6].

Accepted: 15-11-2022 | Received in revised: 16-01-2023 | Published: 03-02-2023

In this study, color feature extraction used the parameters hue, saturation and value, while feature extraction used the parameters contrast, correlation, energy and homogeneity. The results of the accuracy test show that Naïve Bayes is capable of producing the greatest accuracy of 77%. The Naïve Bayes algorithm takes advantage of probability with the assumption that between one class and another class are not interdependent, this causes an estimate of the probability of a class that is less accurate [7]. Next, research on identifying flower types with the K-Nearest Neighbor (K-NN) algorithm and using color and texture feature extraction is needed [8]. In this study, color feature extraction used the parameters hue, saturation and value, while texture feature extraction used the parameters contrast, correlation, energy and homogeneity. Based on the test results, it shows an accuracy value of 71%. The next research will concern the identification of orchid species by applying the K-NN algorithm and using texture feature extraction [9]. The parameters used in feature extraction are contrast, correlation, energy and homogeneity. Based on the test results the success rate of identification of orchid species reaches 80%. The K-NN algorithm performs classification based on pattern learning from data that has been previously classified, so that K-NN is very dependent on the value of the characteristics obtained, if the resulting features are redundant or irrelevant, it will affect the level of accuracy [10]. One of the important factors in computational algorithms is finding the right algorithm [11], [12]. For this reason, in classification problems, an algorithm is needed that is able to divide classes based on dimensional space with the right characteristics.

Usually used for classification, the Support Vector Machine (SVM) algorithm is a supervised learning technique. SVM is a classification algorithm that performs learning using dimensional space with linear functions into two classes [13]. The development of the SVM algorithm is continuously increasing, so that SVM can solve classification problems that use many classes by applying one against one and one against rest modeling that can perform multiclass classification or known as Multiclass SVM [14]. Multiclass SVM is an approach used to divide objects based on recognizable image sequences by utilizing hyperplanes which can isolate information into more than two classes by strengthening the edges between the two [15]. In addition to the algorithm factors used to identify the success of this process, it is also influenced by the use of feature extraction. Because feature extraction becomes input in the identification process, features that can provide information about the characteristics of an object make it easier to identify. First-order feature extraction is a technique that may be used to extract features from images. In this technique, the characteristics of the histogram serve as the foundation for extracting features from the image [16].

This study aims to classify sunflower images using Multiclass SVM with first-order feature extraction. First-order feature extraction uses histogram characteristics to determine features through parameters such as mean, skewness, variance, kurtosis, and entropy. The feature extraction results then become input for a classification algorithm, namely Multiclass SVM. Multiclass SVM has the ability to map data points to dimensional space in order to obtain a hyperplane as a separator which then groups them into classes. The developed model is implemented in MATLAB software to create an interface for the general classification system to make it easier to use.

2. Research Methods

It is vital to conduct research in stages that include the measures to be done to solve the problem in order to conduct research that is organized and in accordance with the objectives [17]. To classify food mushroom species based on their image using the Multiclass SVM algorithm) through the stages visualized in Figure 1.

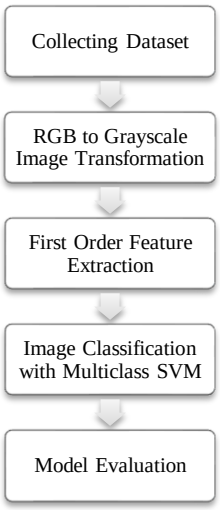

Figure 1. Research Stages

2.1 Collecting Dataset

At this stage, sunflower type images will be collected into a dataset, which will then be used as data for training and testing. There are 7 types of sunflowers used, including: Cherry Rose, Velvet Queen, Fiesta Del Sol, Sunny Smile, Teddy Bear, Early Russian and Red Sun. The images used as datasets are obtained from Internet sources, then processed and adjusted to the needs. This process is carried out by cropping the image so that it focuses on the object to be classified. The image used as the dataset is an image of the types of sunflowers with a single object. Use a ratio of 70% for training and 30% for testing for data distribution for training and testing. The dataset used contains 350

DOI: https://doi.org/10.29207/resti.v7i1.4673

images of sunflowers, of which 245 images are used for training and 105 images are used for testing.

2.2 RGB to Grayscale Image Transformation

Next is the stage of image transformation from RGB image to grayscale image. An image that is grayscale is one whose pixel intensity value is determined by the level of gray. To get simpler color values, RGB images are converted to grayscale images [18]. Where the grayscale color only has a color intensity of 0 - 255 for each pixel. This phase is beneficial since it makes it simpler to identify the traits of the image that needs to be categorized. There are many approaches to obtain grayscale images, one of which is the averaging technique. The average grayscale technique is performed by finding the average value of the total RGB values. This technique can be calculated using equation (1).

$$s = \frac{r + g + b}{3} \tag{1}$$

where *s* is the color's grayscale value, *r* is each pixel's red value, *g* is its green value, and *b* is its blue value.

2.3 First Order Feature Extraction

The process of identifying and searching for features in an image that are then utilized as a differentiator between one object and another is known as feature extraction [19]. The results of feature extraction are used for information and input for further processes so that they can be used as parameters in the classification [20]. Feature extraction has the goal of retrieving information from an object in an image so that it can be recognized or identified the differences between one object and another [21]. First-order feature extraction is a technique for locating features or traits in well-known images. First-order feature extraction is a technique that gathers features from the histogram of the image's visible elements [22]. Mean, skewness, variance, kurtosis, and entropy are the parameters utilized in feature extraction.

The first parameter is the mean (μ), where this parameter will calculate the degree of dispersion in an image. To get the Mean (μ) value, equation (2) is used.

$$\mu = \sum_{n=0}^{N} f_n \, p\,(f_n) \tag{2}$$

The variance (σ^2) is the average difference in the histogram values. To get the value of variance (σ^2) can calculate it with equation (3).

$$\sigma^2 = \sum_{n=0}^{N} (f_n - \mu)^2 \, p\,(f_n) \tag{3}$$

While skewness (α_3) measures the size of the relative slope of an image's histogram curve. To get the Skewness value (α_3), equation (2) is used for equation (4).

$$\alpha_3 = \frac{1}{\sigma^3} \sum_{n=0}^{N} (f_n - \mu)^3 \, p\,(f_n) \tag{4}$$

The relative sharpness of the histogram curve of a picture is measured by the kurtosis parameter (α_4). To get the kurtosis value (α4) it can be calculated through equation (5).

$$\alpha_4 = \frac{1}{\sigma^4} \sum_{n=0}^{N} (f_n - \mu)^4 \, p\,(f_n) - 3 \tag{5}$$

Entropy (*H*) is a parameter describing the size of an irregular image shape. To get the value of entropy (*H*) can be calculated using equation (6).

$$H = -\sum_{n=0}^{N} (f_n - \mu)^2 \log p\,(f_n) \tag{6}$$

2.5 Image Classification with Multiclass SVM

The Support Vector Machine (SVM) algorithm is one of several digital image processing algorithms that can be implemented in classification problems. SVM is a classification algorithm that performs learning using dimensional space with linear functions into two classes [13].

The development of the SVM algorithm is continuously improving, so that SVM can classify several classes by utilizing the one against one and one against rest approach which can carry out multiclass classification or what is known as Multiclass SVM [14].

A hyperplane that can divide data into two classes by maximizing the advantages between the two classes is the basis of the Multiclass SVM strategy, which is used to differentiate the proof and characterization of an image [23]. By predicting the edge of the hyperplane with the biggest tracking coordinates, the ideal hyperplane for each class is discovered [24]. Equation (7), can be used to find details about the *i*-th and *j*-th classes.

$$w^{ij}, b^{ij}, \xi^{ij} \frac{1}{2} (w^{ij})^T w^{ij} + C \sum_{T} \xi_t^{ij} \tag{7}$$

The SVM algorithm does not support multi-class, so multi-class SVM is required to do a split, namely using One-to-One and One-to-Rest techniques. In One-to-One, each student receives a sample pair of classes from the original training set and must learn to distinguish between these two classes.

Whereas the One-to-Rest method involves training one classifier per class, with that class sample as the positive sample and all other samples as the negative sample. This method requires the base classifier to generate a confidence score for its decision, not just a class label.

DOI: https://doi.org/10.29207/resti.v7i1.4673

2.6 Model Evaluation

The evaluation stage is the stage where the performance of the model will be measured [25]. This stage is the stage where testing is carried out on the accuracy of the developed algorithm. Testing for accuracy is done to determine how closely the test findings or average test results match the true value. The accuracy value can be calculated by equation (8).

$$Accuracy = \frac{Number\ of\ correct\ predictions}{Total\ number\ of\ predictions} \quad (8)$$

3. Results and Discussions

In this study classified sunflower images using 7 classes, including: Cherry Rose, Velvet Queen, Fiesta Del Sol, Sunny Smile, Teddy Bear, Early Russian and Red Sun. The process of collecting the dataset is by taking the image of the sunflower plant on the internet. The dataset used is 350 images. The training data used are 245 images or 50 images for each class. As for the test data as many as 105 images or for each class as many as 15 images.

The sunflower type classification model is implemented in MATLAB software, where the Multiclass SVM algorithm will be applied with first-order feature extraction through histogram characteristics. It starts by converting an RGB image into a grayscale image to do image categorization. To obtain a more straightforward color value, an RGB image is converted to a grayscale image. This process is carried out in order to facilitate the feature extraction stage.

Grayscale images can make it easier to retrieve features because they are simpler than RGB images. Where the grayscale color only has a color intensity of 0 - 255 for each pixel. The grayscale transformation technique used is the average, where the grayscale image is obtained from finding the average value of the total RGB value using equation (1). The results of the transformation from RGB images into grayscale images from several samples of sunflower images can be seen in Figure 2.

(a) (b)

Figure 2. (a) RGB Image and (b) Conversion Result of RGB Image to Grayscale Image

In Figure 2, you can see a sample of sunflower images that have been converted from RGB images to grayscale images to make it easier to represent information. The next stage, from the transformed grayscale image, feature extraction is performed. Feature extraction serves to identify characteristics or information that can be extracted from an image. The feature extraction stage is crucial because it yields data that machine learning will utilize to identify patterns in the objects to be recognized, aiding the classification process. First-order feature extraction is the technique used for feature extraction. Through the process of feature extraction, the characteristics of an item are derived from those of the image histogram. Parameters used to obtain image characteristics include: mean, skewness, variance, kurtosis, and entropy. This parameter is used to analyze the object to be classified. Through the MATLAB software, objects to be classified will be calculated based on the parameters that have been set. These parameters are displayed on the MATLAB GUI with the values that have been obtained through calculations using equations (2), (3), (4) and (5).

Here are a few illustrations of what first-order feature extraction on sunflower photos produced on the images in Figure 3.

	Feature	Value
1	Mean	90.2786
2	Entropy	6.995
3	Variance	1135.8282
4	Skewness	0.64625
5	Kurtosis	1.4073

(a) (b)

Figure 3. (a) Grayscale image and (b) MATLAB Output of Feature Extraction Results

Figure 3 shows the results of feature extraction using first order feature extraction based on histogram characteristics. The displayed values such as mean, skewness, variance, kurtosis, and entropy are then used as the basis for the classification process.

The Multiclass SVM algorithm is used to classify images after the feature extraction procedure. This algorithm utilizes a linear function, known as a hyperplane, which is used to separate data into several classes by optimizing the distance between classes. The hyperplane that is used to separate between classes is obtained from the hyperplane distance measurement and gets the optimal point.

Generalization is used to divide the data points into potential classes in n-dimensional space in order to find the best hyperplane. To form a hyperplane that separates into several classes using the One-to-Rest approach, which can be described as in Figure 4.

DOI: https://doi.org/10.29207/resti.v7i1.4673

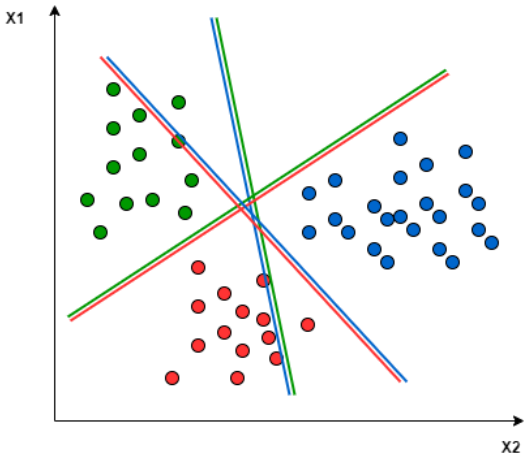

Figure 4. One-to-Rest on Multiclass SVM Algorithm

In Figure 3, it can be seen that the use of One-to-Rest serves to form a hyperplane that separates multi-classes. The One-to-Rest method involves training one classifier per class, with that class sample as positive samples and all other samples as negative samples. This method requires the base classifier to generate a confidence score for its decision, not just a class label. This happens when the split takes into account all the points, then divides them into groups. For example, shown in Figure 4 the green line tries to maximize the separation between the green dot and all the other points at once. Then Multiclass SVM is applied to MATLAB software to be used as a test. Figure 5 displays the outcomes of the Multiclass SVM implementation in MATLAB.

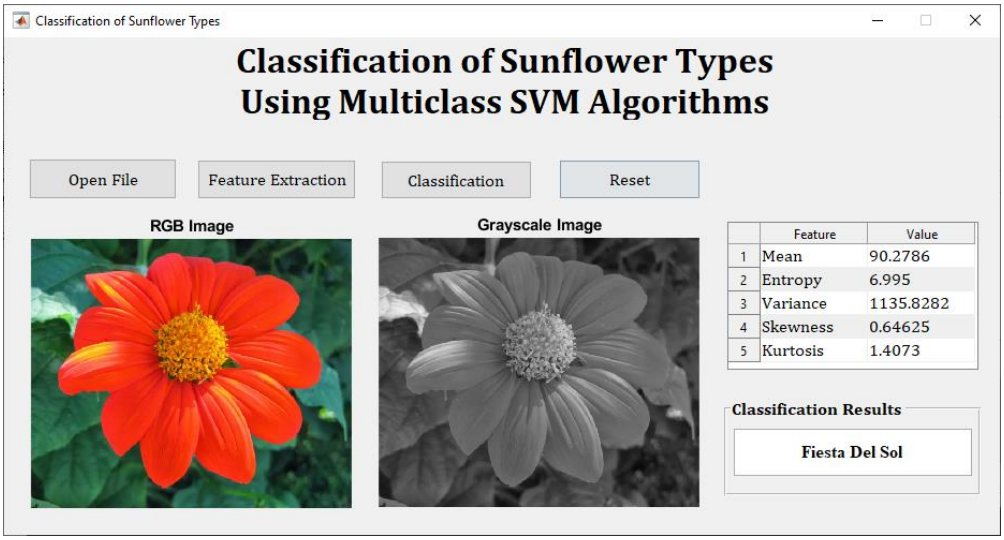

Figure 5. Sunflower Type Classification Interface Using SVM Multiclass Algorithm

In Figure 5, the results of implementing the model into MATLAB software are shown so that it is easy to use for the classification process. In the system built, users can enter sunflower images in the open file button, then after the sunflower images are displayed by the system, users can perform feature extraction. After feature extraction is performed, the histogram characteristic values in the image will be displayed. Furthermore, the user can classify via the Classification button then the system will display the classification results.

The constructed model will now be evaluated. To assess the model's performance, model evaluation is done. Performance measurement using accuracy test. The test data is 105 images, where for each class of sunflower species tested with 15 images. Testing is carried out by matching the results of the classification by the system with existing facts. Accuracy is obtained by using equation (8), where the correct classification results are divided by the total number of tests. The test results from the results of the classification of 7 types of sunflowers can be seen in Table 3.

Table 1. Accuracy Test Results

Types of Sunflowers	Correct Amount	Total Test Data	Accuracy (%)
Cherry Rose	12	15	80%
Velvet Queen	12	15	80%
Fiesta Del Sol	11	15	73%
Sunny Smile	11	15	73%
Teddy Bear	13	15	87%
Early Russian	12	15	80%
Red Sun	12	15	80%
Total	83	105	79%

From table 1 above, it is then entered into the graph of the accuracy test results. The graph of the accuracy test results is shown in Figure 6. In Table 1 and Figure 6, it shows that the highest accuracy value is for the Teddy Bear sunflower type with an accuracy value of 87%. This is because physically the Teddy Bear type of sunflower has different characteristics from other types of sunflowers. Meanwhile, the lowest accuracy is for Fiesta Del Sol and Sunny Smile sunflowers. This is because these flowers physically have characteristics that are almost the same as those of other types of sunflowers.

DOI: https://doi.org/10.29207/resti.v7i1.4673

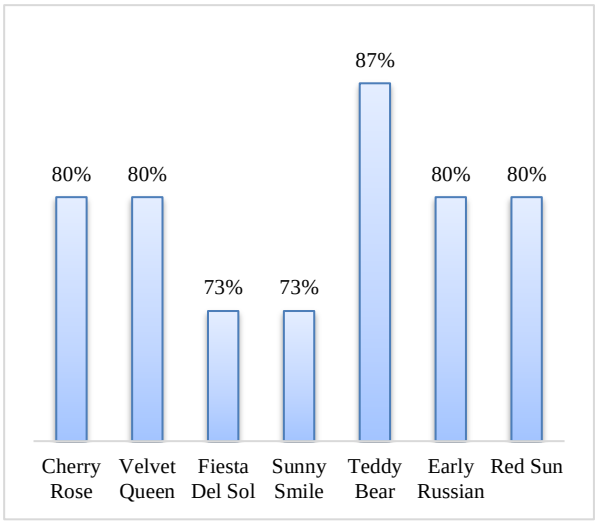

Figure 6. Graph of Test Results for Each Type of Sunflower

On average, the results of the sunflower type classification accuracy test using the Multiclass SVM algorithm yield a value of 79%. These results are then converted according to the following criteria: Good, i.e., yielding a value of 76% to 100%; Enough, 56% to 5%; Less Good, 40% to 55%, and Less Good, results < 40% [26]. The Multiclass SVM approach and the created first-order feature extraction fall under the "Good" category based on these standards. This demonstrates how the Multiclass SVM algorithm may transfer data points to dimensional space and get hyperplane linear separation between each class for classification by first-order feature extraction using feature retrieval based on picture histogram characteristics. Multiclass SVM utilizes a linear function known as a hyperplane, which is used to separate data into several classes by optimizing the distance between classes. Feature extraction by utilizing histogram characteristics based on first-order features is able to provide information to the classification algorithm regarding the features or properties of the histogram of visible image elements.

However, based on the model's average misclassification, it reaches 21%. In evaluating, there are several failure factors. These factors include the results of feature extraction using first-order feature extraction or histogram-based features, depending on the frequency of the intensity value in the pixels of an image. As a result, it produces good accuracy when the image is clear, but it is difficult for the model to obtain the desired feature when the image is unclear or noisy. In addition, images with different backgrounds and different viewpoints will affect the feature acquisition process in the image. The dataset used comes from the internet, so the images obtained need to be processed again through cropping or editing in order to get a clear object. Not only that, the light intensity level of the image greatly affects the classification results because the features used rely on the histogram characteristics. As a result, the dataset must be taken independently so that the dataset obtained shows the actual image. The current use of training and testing data is still relatively small; therefore, it has an impact on the accuracy of the results. This is because the dataset greatly influences the pattern of learning. Several varieties of sunflower have almost the same characteristics; therefore, other feature extraction is needed to be able to provide optimal input to the classification algorithm.

4. Conclusion

This study classifies sunflower species by applying the Multiclass SVM algorithm using feature extraction based on histogram characteristics, or first-order feature extraction. This feature extraction obtains features through the frequency of the intensity values in pixels from the image histogram. The values obtained from the feature extraction parameters then become information for pattern recognition by the Multiclass SVM algorithm. Data points can be mapped to a three-dimensional space using Multiclass SVM to provide linear hyperplane separation for classifying each class. The model created is then used in MATLAB software to make it easier for users to classify sunflower image types. The model can classify with an average accuracy of 79%, according to the results of the accuracy test. These findings indicate good model classification ability. This is because Multiclass SVM has the ability to map data points to a dimensional space to get a hyperplane that is used for class grouping.

There are several suggestions for future research as consideration for improving further research. The following are suggestions for future research, including: increasing the quantity of testing and training data and creating datasets based on images taken independently with various light levels; using feature extraction based on shape and texture; can utilize deep learning algorithms to obtain more optimal learning patterns.

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DOI: https://doi.org/10.29207/resti.v7i1.4673