Mathematical Sciences and Informatics Journal
Vol. 3, No. 2, Nov. 2022, pp. 55-64
http://www.mijuitmjournal.com DOI: 10.24191/mij.v3i2.19322

Malay Festive Seasons Food Recognition for Calorie Detection Using SVM and ECOC Approaches

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Article Info

Article history:

Received July 18, 2022
Revised Sept 20, 2022
Accepted Oct 23 2022

Keywords (minimum 5):

Food Recognition
Calorie
Color Feature Extraction
Support Vector Machine
Error-Correcting Output Codes

ABSTRACT

The idea of adding an auto-recognition feature for Malay Festive Seasons Food based on images is a very challenging task in computer vision as it is something new and undiscovered until recently. However, this recognition is important for Malaysian users to manage calorie intake, especially during Hari Raya, one of Malaysia's biggest festive seasons and most celebrated festivals. As color plays an important role in differentiating the type of food, this research aims to implement Color Feature Extraction Method after performing segmentation techniques during the pre-processing phase, where each color from the images is extracted individually. Then the result from the Color Feature Extraction Method is used to identify the type of food by using Error-Correcting Output Codes (ECOC) classification, which is part of the Support Vector Machine (SVM) algorithm. The reliability and effectiveness of the classifier are evaluated through system testing, where the total overall percentage of correct recognition performed by the system is 82.5%, according to the correct and wrong recognition obtained. The ability to recognize the food correctly after classifying the image is crucial in this research to accurately perform the calorie estimation, whereby the calorie value will be auto generated after food recognition is performed.

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1. Introduction

Obesity and overweight are rising public health issues that have become worldwide epidemics. In many developing nations, obesity has reached epidemic proportions, and Malaysia is no exception [1]. Based on the World Population Review 2019, Malaysia has the highest rate of adult obesity in Southeast Asia, at 15.6%, followed by Brunei (14.1%), Thailand (10%), and Indonesia (6.9%). A discrepancy between food consumption and the energy people gets from their diet causes obesity [2]. A high-calorie diet can be harmful and contribute to a variety of illnesses. For instance, high-calorie intake can cause breast, colon, and prostate cancer as it is the second leading factor of

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cancer [3]. Dietitians have also determined that the standard calorie intake is necessary to maintain the proper calorie balance in the human body. Thus, calorie intake management is crucial for losing weight and maintaining a healthy diet and weight for normal people. By simply measuring daily food consumption in a timely manner can help obese people lose weight in a healthier manner, as well as make healthy people healthier.

Our lives would not be complete without food, which also significantly impacts our culture, preferences, behaviour, and many other areas of our life, including our health. One of the main causes of the various health problems common in society is dietary habits [4]. Because of how important food is to human survival, computer vision researchers have created new techniques for automatically recognizing food and monitoring food intake. A food recognition system is a system that can identify the type of food in an image captured by the user [5]. Before the recognition is performed, the image will go through some fundamental steps in image processing. The step consists of image acquisition, pre-processing, feature extraction and classification. However, recognizing food is not easy as it has always been a challenge for computers. Nevertheless, image recognition technology has improved tremendously over the years due to the development of better algorithms and tools.

Despite all the efforts to improve the food recognition systems that have been made over the past few years, the available choices for Malaysian foods are still restricted in some existing calorie estimation systems. Most of the time, they do not have the option to select traditional or globally uncommon food in Malaysia as they mainly focus on common food. This has caused difficulties for Malaysians to track their calorie intake when consuming unique and traditional food, especially food usually served during the festive seasons.

Currently, no existing commercialized food recognition system could recognize Malaysian festive season foods by just snapping a photo. Therefore, this research focuses on developing a system prototype to identify some of Malay's common foods, especially during Hari Raya, one of the biggest festive seasons. At the same time, it helps the users keep track of their calorie intake.

2. Literature Review

Recently, computer vision and pattern recognition techniques have improved significantly due to the evolvement of computer technologies. As a result, many object recognition or image recognition techniques have been proposed to be used in real applications. One of the applications that currently become popular is the automatic recognition of food images which is part of computer vision. According to [6], an auto food-log record system and automatically estimation of calories of the food can be developed automatically using food recognition techniques. This food recognition mainly comprises three main phases: the construction of food images database; the effective visual feature extraction in food images such as color and texture features; image classification using machine learning methods such as Bayesian, Support Vector Machine (SVM), and others.

Feature extraction converts pixel data into a higher-level representation of the face or its components' form, motion, colour, texture, and spatial configuration. Feature extraction also reduces dimensionality, and the extracted feature is called a feature vector, which acts as a representation of the provided image [7]. However, one of the most important aspects in food recognition is having an effective extraction of visual features of food images, such as colour and texture features [6]. Color is considered as one important feature descriptors for food recognition during the classification process. Color space is represented as color in form of intensity value. Color can be specified, visualized, and create using the color space methods. Therefore, there are many kinds of different color feature extraction methods [8]. One of the most frequently used method for extracting the colour feature from an image is the colour histogram [6]. The colour histogram shows the image from distinct viewpoints. Colour bins of a frequency distribution in the image are shown by colour histogram. It then counts similar pixels and stores it. Colour histogram examines each statistical colour frequency in an image. It solves the changes that occurred in translation, rotation, and angle of view and concentrates on each part of an image. The computation of the local colour histogram is simple and even resistant to slight changes in the image which is important for indexing and retrieving image database [8].

Image classification is known as the process of classifying pixels into a set of individual classes based on their data values. If a pixel fulfils a set of requirements to fit into a certain class, it is allocated to that class. The classes may or may not be well-known. The classes are known if the user can split them based on the training data; otherwise, they are unknown [9]. SVM is a linear model that can be used to solve classification and regression issues. It can handle linear and nonlinear problems and is useful for a wide range of practical uses. SVM acts as a parametric classifier in image classification. These classifiers are an example of supervised learning image classification techniques. Non-parametric classifiers are being used when there is no density function available. It estimates the probability density function for future use. Some examples of nonparametric classifiers include K-Nearest Neighbor, Logical Regression and Multilayer Perceptron. SVM is a binary classifier that uses a linear boundary to split the classes. This classifier assumes that there is no prior information on how to categorise the data to maximise the usage of training data [9].

Several researchers have been developing food recognition for calorie estimation systems in recent years. Therefore, various systems have been developed based on the current technology. [10] proposed a CNN-based food calorie estimation for multiple-dish food photos. Their system can estimate the food calories and detect the dishes simultaneously by using multi-task learning of food calorie estimation and food dish detection with a single Convolutional Neural Network (CNN). By implementing a single CNN, their system expects to achieve high speed and saves memory due to simultaneous estimation in a single network. This system is helpful for multiple-dish food photos as it creates a calorie-annotated food photo dataset for learning regression, which estimates food calories directly from food photos. However, the system still needs improvements, as in the paper, and they stated that they only prepared 120 calorie-annotated food photos for food detection, which surprisingly is not enough. They claimed it is not easy to prepare calorie-annotated food photos, even though many food photos are available on the web with no information on calories. Therefore, to build such a dataset, they need real foods and capture the photos, which is quite tedious if it is done in a large-scale way.

Another previous work that focuses on food recognition and calorie estimation system is proposed by [11] called Food Recognition and Calorie Measurement using Image Processing and CNN. The author has developed a calorie measurement system that requires the user to upload an image of a food item. As a result, the number of calories in the uploaded food image will be estimated. Furthermore, it also shows a statistical analysis of the user's calorie consumption. The author mentioned that they built their own CNN architecture of 6 layers to extract the features and classify the images since they claimed that CNN had been proven as one of the finest methods to be used for classification as it can achieve a promising result. However, there are some disadvantages with the system as it does not support calorie measurement for multi-food and complex food items, which was supposed to be helpful for people who want to fully understand the detailed food.

3. Methodology

Malay Festive Food Recognition for Calorie Detection System, which is focused on implementing image processing for food recognition, consists of six stages: image acquisition, image pre-processing, feature extraction, classification, training, and testing. Figure 1 illustrates the process involves during the recognition.

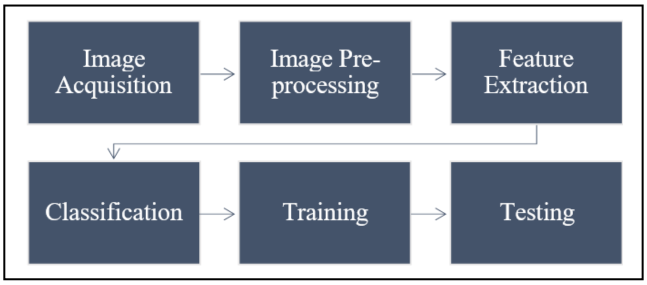

Figure 1. Stages in the research method

3.1 Image Acquisition

The implementation of feature extraction methods is tested and evaluated using Malay Festive Food, mainly served during Hari Raya. Five common food types have been identified for this research: Almond London, Bahulu, Ketupat, Lemang and Tart Nenas. The total original 10 images per category are retrieved from Google images in the form of JPG format, thereby bringing the total of 50 images that is used for training. For the testing process, a total of 8 images per category, which totals 40 images, is collected randomly from public sources in JPG format. The images used in testing are not the same as in training, which is important for validity purposes. All the images come with different angles and lighting, but the colour, shape, edge, and texture are different. However, for training purposes, image cleaning is performed by removing the images' background and leaving it with only the white plain background using an online background remover tool to achieve better results during the pre-processing process. Then, the size of the image is set to 227 x 227 pixel dimensions using the image processing function. Figure 2 illustrates images of Bahulu with rotation factors of 90^o, 180^o and 270^o.

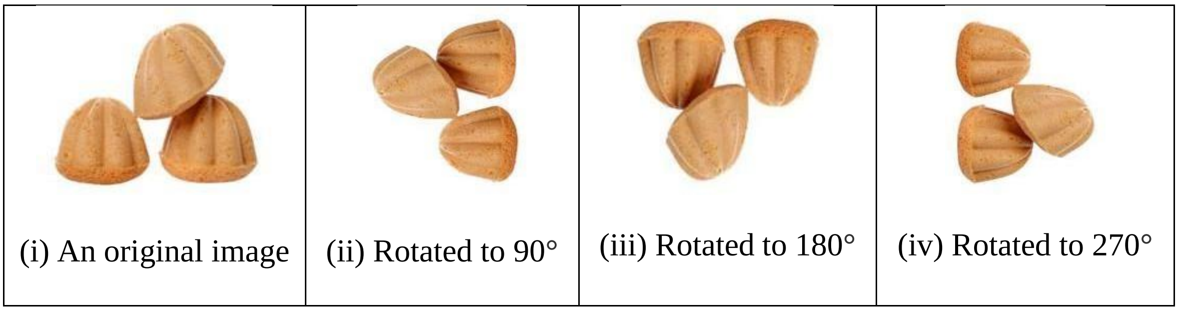

Figure 2. Bahulu images with its various rotations

3.2 Image Pre-processing

The purpose of image pre-processing techniques is to enhance the images for use in further image processing [12]. Pre-processing of food images before performing the recognition is one of the crucial steps in this research as the main purpose is to provide images that follow rotation factors. As a result, these images will become an input during the feature extraction phase. The images with different rotations are being evaluated with feature extraction techniques to examine the robustness of the feature extraction adopted, which brings to a total of 200 training images with various rotations. Pre-processing usually contains a set of sequential operations, including prescribing the image size, image rotation, and converting RGB images to grey-scale and binary images. A binary image is then converted to a complement image. Then, the noise of the image is reduced by eliminating the object that is presented in the image with a total area of the object below 50 pixels to improve the image segmentation needed for the feature extraction. Figure 3 shows the result of the complement of the binary image where the black will stay as the background while the white will focus only on the object.

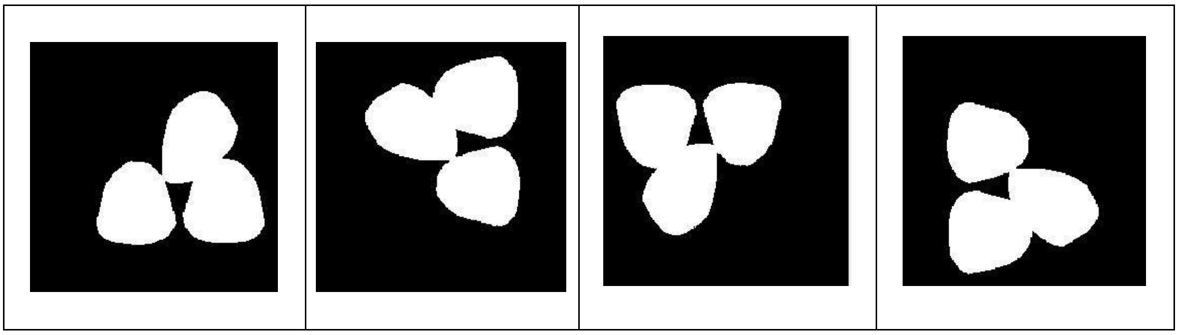

Figure 3. Complement images for Bahulu images

3.3 Feature Extraction

The next stage in this food recognition is the feature extraction phase. Due to its apparent effect on a system's recognition effectiveness, feature extraction is crucial in automated food recognition applications [13]. One of the main advantages of this phase is it removes redundancy from the image and represents the food image by a set of numerical features. The classifier uses these features to classify according to the type of food. Based on the type of input images being gathered, the only feature that maintains the same throughout the process of identifying the food is the colour of the food. Colour plays an important role in differentiating the type of food. Therefore, the colour extraction of an RGB image is performed during this phase. The output of pre-processing image is used to segment the R, G and B components for the images. Lastly, each R, G, and B value is combined at the third component to produce the segmentation image. Figure 4 shows the result of segmentation which implements RGB colour feature extraction. Finding significant objects in static ambient pictures using image segmentation, as seen in Figure 4, is an effective method. One common class of techniques used to split the interesting elements in a scene is the elimination of the background [14].

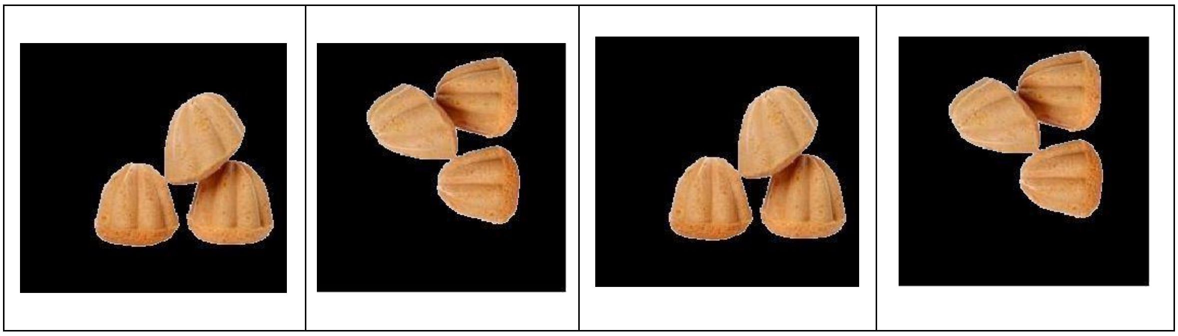

Figure 4. Result of image segmentation

The last feature extraction step is eliminating the black background from image segmentation before the extracted colour value can be trained. The total number of pixels on each colour component must be divided by the total number of pixels from the background, for which the pixel value is set to null. This is crucial to obtain the average pixel value for each colour after eliminating the segmentation for the black background. Then, the process is continued by assigning the target training class for five types of food. The assigned training class name needs to be matched correctly with the collected training dataset folder, consisting of 40 images for each type of food arranged sequentially.

3.4 Support Vector Machine (SVM) Classification

The Classification Learner app in MATLAB has been used to train models for classifying data. By using this app, various classifiers can be discovered for supervised machine learning. This includes SVM that has been proposed in this research. However, despite more than three classes of food used in this research, a fit multiclass model is used to classify the type of food called ClassificationECOC. It is a suitable model for SVM and other classifiers. ClassificationECOC is an error-correcting output code (ECOC) multiclass learning classifier composed of SVM binary learners, which is helpful to increase the accuracy and kernel-function choices on low-through medium-dimensional data sets [15]. This model has been trained to store training data, parameter values, prior probabilities, and coding matrices. These classifiers can be used to predict labels or posterior probabilities for the new data.

3.5 Model Training

The next phase in this research is model training. This phase is intended to train the model to enhance its performance for a better result for the problem. The previous step's input is used to train the model using the ClassificationECOC function mentioned in the classification process. Training the model to recognize and understand the various patterns, rules, and features is necessary. The training model's accuracy also being tested in this phase to ensure the training is well-performed. The training images used for training are about 80%, equal to 200 images (with rotation).

3.6 Model Testing

Once the training model has been developed using ECOC, then it is tested. The model's accuracy is tested in this phase, which is done by providing it with a separate dataset for testing. It is necessary to test the model since it evaluates the percentage accuracy of the model in accordance with the project's requirements. The trained model from ECOC classification is called to predict the class name for the food images. The result of colour pixel extracted from the testing images during the feature extraction process will be assigned as the input to produce the class output.

4. Results and Discussion

The idea of introducing auto food recognition for Malay Festive Seasons Food is still challenging as it is something new and has never been discovered before. However, this recognition system is important to cater the Malaysian users for their calorie intake management. The image pre-processing techniques have been performed using segmentation methods to obtain better results when extracting the images' colour features. The comparison result between original and various rotation food datasets for the training also has been generated to test the robustness of colour feature extraction adopted during the recognition. After obtaining the colour feature value from the extracted images, SVM algorithm is used to classify the food images. SVM algorithm, which constitutes of ECOC classification, has been used to classify the type of food, which consists of Almond London, Bahulu, Ketupat Palas, Lemang and Tart Nenas. The reliability and effectiveness of the classifier have been measured through system testing. The ability to recognize the food after the classification process is crucial so that the calorie estimation can be performed effectively. After implementing the research methods for food recognition, it aims to determine the calorie value of the recognized food. The research on calorie value for each food has been done thoroughly to ensure the user can benefit from the system.

4.1 Calorie Estimation System Prototype

The user should be able to upload the food image from the testing dataset to perform the food recognition after the testing model has been developed. Once the system recognizes the class name of the food, it will detect the calorie value of one piece for the recognized food, where the calorie value of one piece is set according to the class name of the food. The calorie value is taken from the MyFitnessPal website. Then, the user can enter the quantity of pieces or servings consumed to calculate the grand total of calorie intake by multiplying the number of quantities with the calorie value of one piece for the recognized food and this can be shown in the Figure 5.

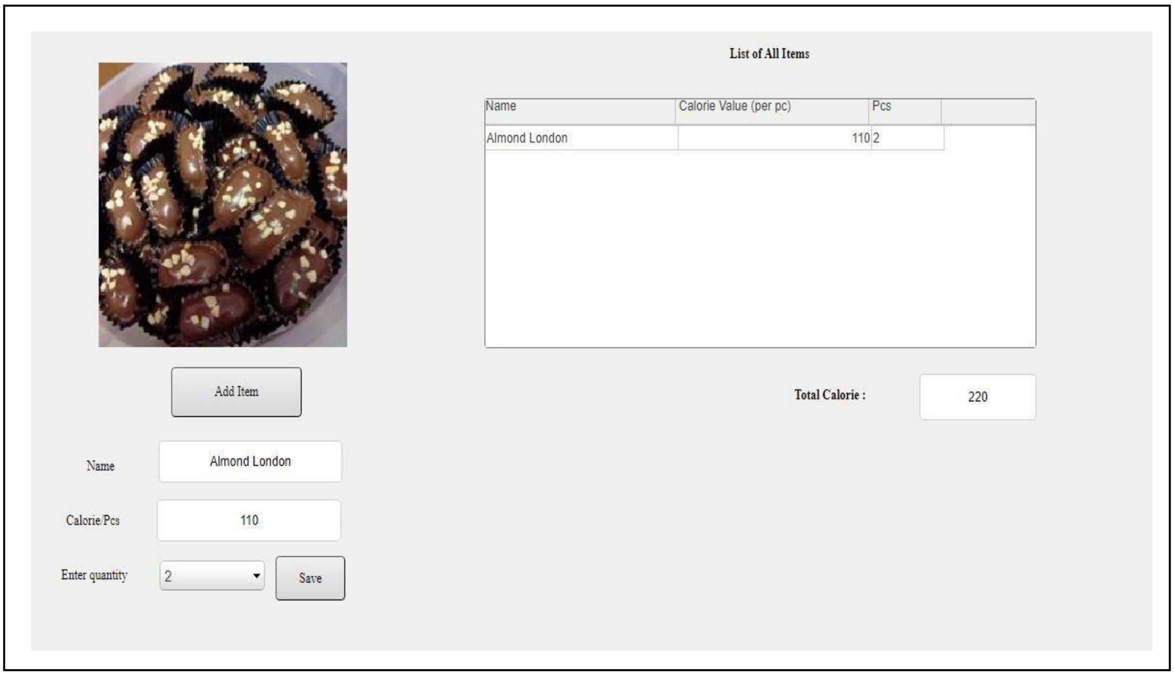

Figure 5. Calorie estimation performed for Almond London

Users can also upload another type of food from testing datasets if the user consumes more than one food at a time. Then, the total overall calorie food intake will be calculated automatically by implementing the iteration algorithm, as portrayed in Figure 6.

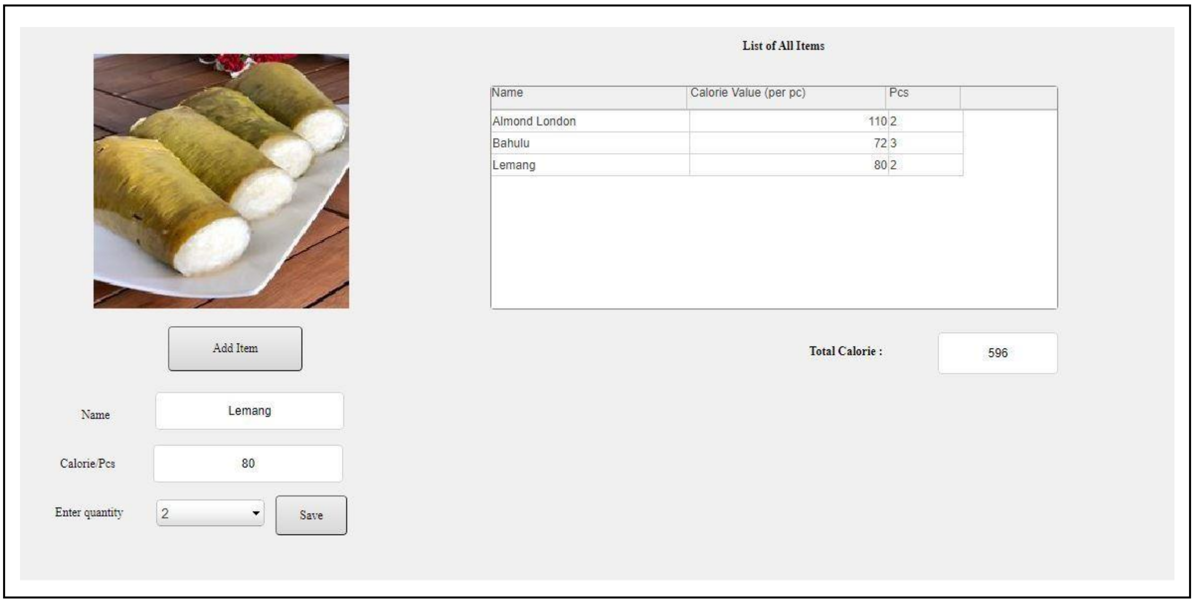

Figure 6. Calorie Estimation performed for Almond London, Bahulu and Lemang

4.2 Colour Feature Extraction Result

Each training image will undergo colour feature extraction after performing the complete segmentation to acquire the average pixel value for each colour in the form of RGB in the image. Table 1 shows colour feature extraction values for various rotation factors obtained from the segmentation result of Bahulu, Almond Londons, Ketupat Palas, Lemang and Tart Nenas.

Table 1. Value of colour feature extraction for training

Food Type	Features	R (Red)	G (Green)	B (Blue)
Bahulu	Original	207.1082	146.4489	91.4267
	90º	206.8409	146.6839	92.3219
	180º	206.6362	146.9137	92.3051
	270º	207.1082	146.4489	91.4267
Almond London	Original	109.2807	87.0292	70.7196
	90º	109.1188	87.2627	71.0954
	180º	109.2073	87.1867	71.0066
	270º	109.3142	87.2946	71.1338
Ketupat Palas	Original	180.6081	161.2159	116.8895
	90º	180.5117	161.1891	116.9344
	180º	180.5247	161.2564	117.017
	270º	180.549	161.2013	117.0184
Lemang	Original	171.4834	154.3581	132.192
	90º	171.2917	154.2054	132.3895
	180º	171.3322	154.3995	132.3162
	270º	171.3714	154.3242	132.3523
Tart Nenas	Original	212.7562	170.0911	76.0199
	90º	212.4577	170.0873	76.7351
	180º	212.3787	170.2238	76.7165
	270º	212.4637	170.152	76.7067

4.3 Training Result

As previously mentioned, the training datasets with original datasets and the original with various rotation factor datasets are used to evaluate whether the feature extraction techniques adopted will affect the training accuracy. Based on Table 2, it can be concluded that training datasets that undergo image pre-processing and feature extraction influence the training accuracy. The percentage of original training datasets is a bit lower compared to the mixture of original with various rotation training datasets, which apparently affects the testing result.

Table 2. The accuracy training according to type of training sets

Training Datasets	Percentage (%)	Number of correct images	Number of incorrect images
Original	90	45	5
Original + Various rotation (90º, 180º, 270º)	94	188	12

4.4 System Testing Result

The trained model was exported and performed on the test set to evaluate the performance of the proposed method. The confusion matrix with the input data is presented in Figure 7.

	Almond London	Bahulu	Ketupat Palas	Lemang	Tart Nenas	Classification Overall	Precision
Almond London	8	0	0	0	0	8	100.00%
Bahulu	0	7	1	0	0	8	87.50%
Ketupat Palas	0	0	7	1	0	8	87.50%
Lemang	0	0	1	7	0	8	87.50%
Tart Nenas	0	0	4	0	4	8	50.00%
Truth Overall	8	7	13	8	4	40	
Recall	100.00%	100.00%	53.846%	87.50%	100.00%		
						Overall accuracy	82.50%

Figure 7. Confusion Matrix

Based on Figure 7, the total overall percentage of correct recognition performed by the system is 82.5%, according to the correct and wrong recognition obtained. The most accurate recognition is made for Almond London as the food colour is contrasting and contradicting compared to others. However, the incorrect recognition is mostly categorized as Ketupat Palas as most foods are confused with the colour distribution of Ketupat Palas during the training process, which is not consistent.

5. Conclusion

Food recognition in this study has involved two major phases which are feature extraction and classification that are challenging in image processing. Since no general feature extraction method is available for all types of images, an experiment needs to be conducted to determine the suitable methods for the food images. Therefore, an investigation of ECOC classification and colour feature extraction has been implemented to perform the recognition on the food. There were some limitations present while conducting this study. One of the limitations is the small datasets for the food images, as it only uses a total of 8 images for each type of food. This is because of the limited food images since most food is not globally known. Despite image cleaning, the background, lighting, and other unnecessary objects that are still visible in the image can distort the recognition process.

Nevertheless, some suggestions could improve food recognition and possible points that could lead to future research. Since the prototype needs a large training dataset, images from public resources such as Google images are unreliable as most images are not constant in terms of angles and backgrounds. Therefore, the online community can collaborate by uploading food images based on the requirements. The dataset can then be organized and made public like any other food database. Besides colour that differentiates the food, other factors such as shape and texture play an important role in distinguishing the type of food. Therefore, shape, texture and colour features extraction should be considered to increase the accuracy of training datasets to achieve better results.

Acknowledgements

The authors gratefully acknowledge the Universiti Teknologi MARA (UiTM), Perak branch.

Conflict of Interest

The authors declare no conflict of interest in the subject matter or materials discussed in this manuscript.

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