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Real-time oil palm FFB ripeness grading system based on ANN, KNN and SVM classifiers

Real-time oil palm FFB ripeness grading system based on ANN, KNN and SVM classifiers

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Abstract. The high accuracy performance, cost and processing time are commonly the key factors for evaluate and validate the systems of agricultural crop quality inspections. External and internal grading system based on image and signal processing and analysis were implemented based on general steps as acquisition, pre-processing, segmentation, feature measurement, and classification for fruit maturity grading system. The classification step using supervised machine learning classifiers was commonly based on the method namely; two-thirds for training and the other third for testing. In the other hand, the purpose of the supervised machine learning is to construct predicted model for the training data of the distribution of the different class labels as known features which can be used for the further testing data as unknown features. In this paper, real-time oil palm FFB ripeness grading system based on ANN, KNN and SVM Classifiers was demonstrated. System training and testing were implemented in order to appropriately classify the ripeness of oil palm FFB based on the external feature of the fruit. System evaluation has been carried out based on the system performance, processing time and the system cost in order to enhance the system methodology for classification proficiency. The results show that the real-time oil palm FFB ripeness grading system has achieved the highest accuracy 93 % and the fastest image processing speed 0.40 (s) by using BGLAM texture feature based on ANN classifier compared to the other feature extraction techniques and machine learning classifiers.

1. Introduction
The old method of agricultural product quality evaluation is generally tedious and costly [1]. Traditional techniques have been employed for a long time, but they are greatly boring, costly, and time uncontrollable. Before used systems are supposed to suffer severely from subjective inferences leading to changeability [2]. Even with systems that are regarded as unbiased fail to support the large-scale production requirements of our current time. Within this context, high-technology keys are being sought to make use of machine vision for agro-based product quality grading, timely assessment, and accurate grading [3-6]. This technology is appropriate for surface or sub-surface imaging due to the incomplete penetration depth of the interrogating source. Researchers around the world have

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developed automated internal grading solutions [7-9].Machine learning is a procedure of learning a set of rules from examples called a training set to make a classifier that can be used to take a broad view using new instances. In this paper the authors going to investigate and compare the implementation efficiency of oil the machine learning classifiers for palm FFB grading system including all of the SVM, KNN, and ANN.

2. Materials and Methods

A real-time oil palm fresh fruit type's inspection and ripeness grading system was used to implement the comparative and evaluation for the supervised machine learning classifiers. Three different ripeness (under ripe, ripe and over ripe) of different types of oil palm FFB samples images were captured and used for system training and testing based on color, texture and thorn extracted feature models. The hardware and process of the oil palm FFB image acquisition of the indoor external grading system based on controlled illumination system is illustrated in Figure 1.

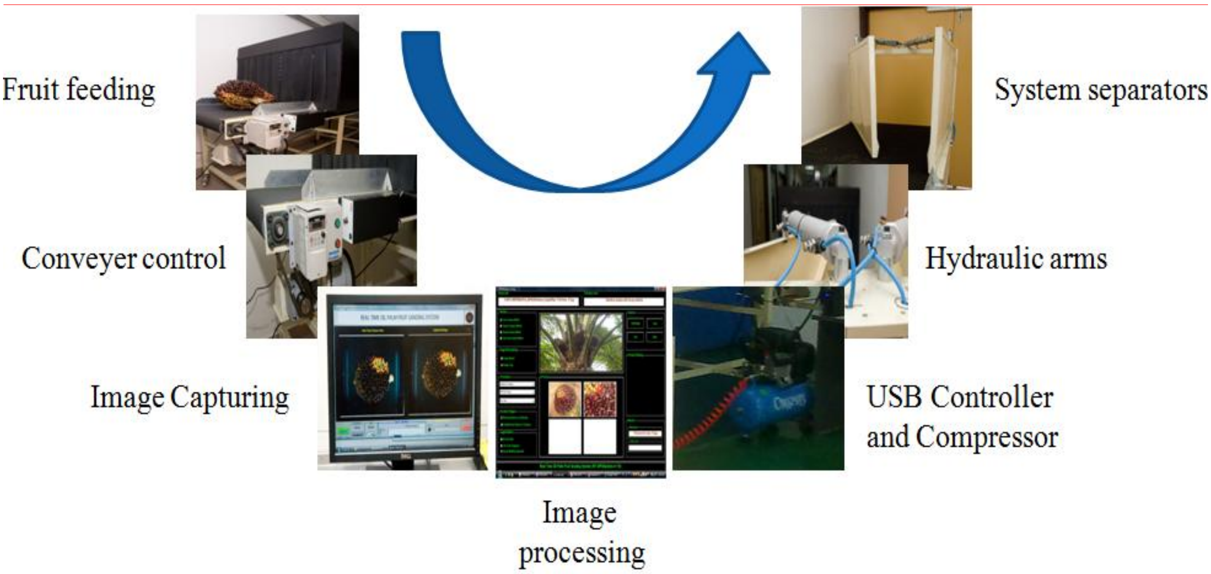

Figure 1. The hardware and process of the oil palm FFB image acquisition of the indoor external grading system.

Numerous experiments were implemented using the oil palm FFB grading system based on the external fruit features with the different feature extraction techniques, such as a mean, standard deviation, color histogram techniques, Gabor wavelet (GW), grey level co-occurrence matrix (GLCM), and basic grey level aura matrix (BGLAM) techniques). The suitable methodology of the grading system for oil palm FFB ripeness was investigated and recognized experimentally based on the implementation of the three different supervised machine-learning techniques, namely, ANN, KNN, and SVM, with each unique test.

The Common image processing system configuration including the five components: image acquisition, pre-processing, image segmentation, object measurement, classification for the external grading system process in the computer vision application is performed as illustrated in Figure 2. [1, 10-12]. The image acquisition and pre-processing as low level processing; segmentation, representation and description as intermediate level processes, while the high level processes entail object recognition and image classification.

Figure 2. Common image processing system configuration including the five components: image acquisition, pre-processing, image segmentation, object measurement, classification.

The final stage in the image processing algorithm of the grading system for the oil palm FFB types and ripeness determination is the image classification (decision making) based on the supervised machine learning classifiers. Machine learning is a method of learning a set of rules from cases called a training set to make a classifier that can be used to take a broad view using new instances [13, 14]. A classification system identifies objects by classifying them into one limited set of classes [15, 16]. This process encompasses comparing the measured features of a new object with the features of a identified object or other known standards, and determining whether the new object belongs to a particular category of objects. In particular, the oil palm FFB ripeness grading system classification using training and testing was accomplished based on oil palm FFB external features such as color, texture, and the thorn. In addition, the procedure employed different supervised machine learning (ML) techniques such as (1) ANN, (2) KNN, and (3) SVM. The objective of supervised learning is to create a concise model of the distribution of class labels in terms of predictor features.

The training stage includes data collection, data analysis, and a training model. Accordingly, fruit image type and ripeness classification techniques based on the training model were created by analyzing 180 fruit samples of oil palm FFB. According to differences in the physical features and characteristics of each oil palm FFB, different databases with different algorithms were built and used for training the classifier by analyzing the fruit sample of the different ripeness categories for the different types based on specific features and characteristics of each oil palm FFB. Furthermore, 90 samples for each class were used to test the oil palm FFB ripeness grading system. Finally, the ANN, KNN, and SVM training models of the color model, texture model, and thorn model features for all the oil palm FFB types and classes were built and used for testing the classifiers of the system.

The ANN, KNN, and SVM as different SML techniques were applied with the real-time oil palm FFB types and ripeness grading system in order to investigate and optimize the best classifier for accurately classify the close ripeness classes (under ripe, ripe and overripe) of the different oil palm types. The classifier model result is then accustomed to allocate class labels to the new class where the values of the predictor features are known, and the value of the new class label is unknown.

3. Results and Discussions

Designing an effective grading system is essential for performing the oil palm FFB maturity classification and sorting. The oil palm FFB features were extracted by using color model algorithms (statistical color feature and color histogram), and texture model algorithms (Gabor, GLCM, and BGLAM). Three different supervised machine-learning techniques ANN, KNN, and SVM were integrated with the extracted features to make decisions regarding FFB type and ripeness. Furthermore, investigation experiments were conducted on the classifiers (ANN, KNN, and SVM) to properly select the training model for the oil palm FFB grading system, and then ensure high quality classification results. The oil palm grading system was built to classify the three different ripeness classes of the different FFB types. The different types of oil palm FFB have different external and internal features and properties. Thus, different databases were built for the oil palm FFB grading system has been done prior to ripeness classification for oil palm FFB grading and sorting.

The complete picture of the threshold between the sensitivity and 1- specificity is displayed by plotting the receiver operating characteristics (ROC) curve across a series of threshold points. The area under curve (AUC) is considered to be as an effective measurement of the inherent validity of a grading system test. This curve is suitable in (a) assessing the discriminatory ability of a test to pick correctly the under ripe, ripe, and overripe classes; (b) finding the optimal threshold point to minimize class misclassification; and (c) comparing the efficacy of different region of interests (ROIs) for assessing the same sample or class, as illustrated in Figure 3.

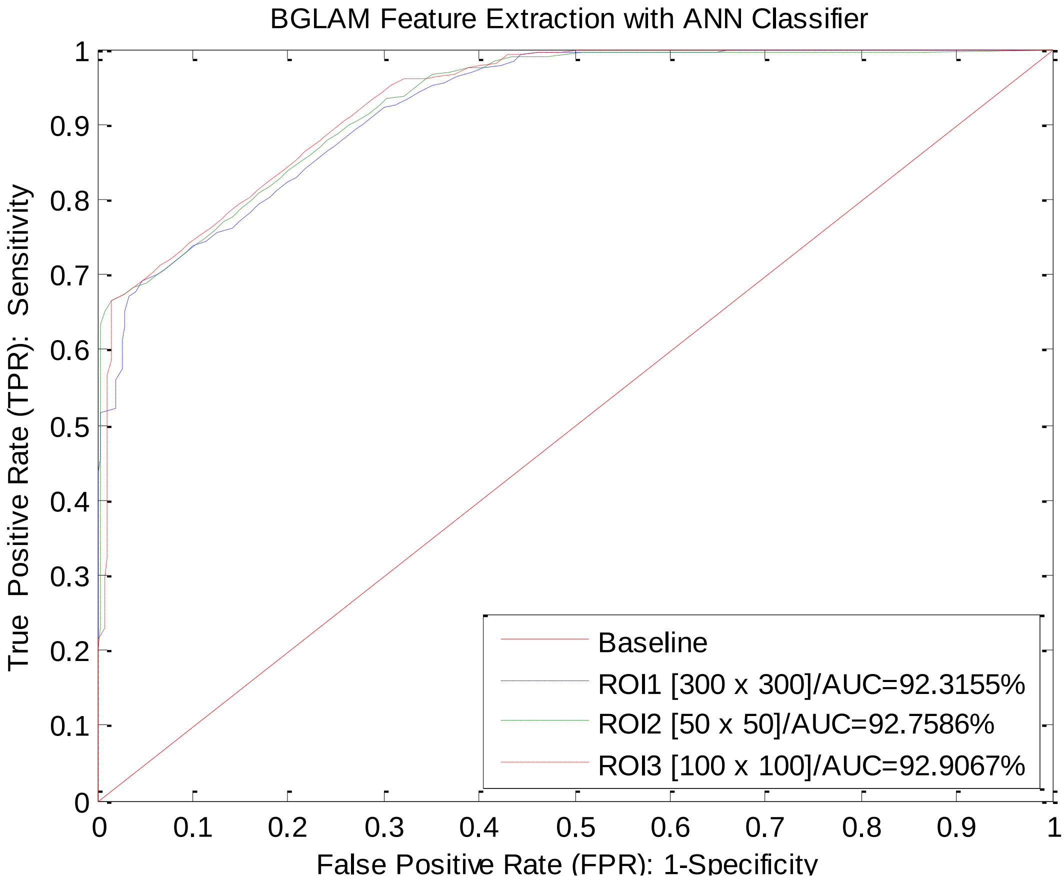

Figure 3. Oil palm FFB types classification based on BGLAM and ANN classifier

Generally, the FFB ripeness classification performed by the oil palm grading system to grade the oil palm FFB classes based on the BGLAM technique and the ANN supervised machine learning showed the best algorithm for oil palm grading system based on their high accuracy performance 93 % and the high image processing speed 0.40 (s). The image processing speed limitation was raised with the performance of the thorn model. An accuracy limitation increased due to the variance of the thorn features in the same oil palm FFB type and class.

4. Conclusions

A fruit ripeness grading system based on image processing techniques was designed to ensure the ripeness classes of different types of oil palm FFB according to external features. The image processing methods and techniques and image classification was applied by training and testing the system based on the SVM, KNN, and ANN supervised machine learning classifiers. Common method namely two-thirds for training and the other third for estimating the performance and statistical measurement of efficiency were used as measure indexes to test and to validate the performance of classifiers to accurately classify the different ripeness classes (under ripe, ripe and over ripe) of different oil palm FFB types based on the external features. The results The results show that the real-time oil palm FFB ripeness grading system has achieved the highest accuracy 93 % and the fastest image processing speed 0.40 (s) by using BGLAM texture feature based on ANN classifier compared to the other feature extraction techniques and machine learning classifiers.

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