Oil palm fresh fruit bunch ripeness classification using back propagation and learning vector quantization

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Abstract. Fresh fruit bunch analysis has been research interest for many years. Various techniques have been proposed. However, complex techniques may exert problem in implementation, This article report the fresh fruit bunch ripeness identification by using back propagation and learning vector quantification to identify whether the fruits ripen or not. Simple analysis methods are used so that application such as drone based identification can be easily implemented. The fruit sample contains fresh ripe fruit bunch (RFB) and fresh unripe fruit bunch (UFB). By using 20 RFBs and 20 UFBs, the classification results at least 95% precision, 98% accuracy, sensitivity 1, and specificity 0.95.

1. Introduction

Image analyses on farm application have been research interest for sometimes. Fruit classification for orange, grapes and palm oil are the examples. Besides estimating the number of fruits to be harvested [1], exploring and detecting diseases on plants and fruits [2], image analysis is popular for classifying the fruits harvesting selection [3]. These facts show that digital image applications contributing in smart farming and processing model [4].

Research shows that digital image applications are able to predict the intended fruit harvesting more than 90% [5]. The detection of the ripeness can be performed while fruits are still on the trees by using manual observation or by using additional tool such as distance camera [6] or drone.

Some techniques may be able to predict by using a single shot image, but interpolations of some images that are taken from different angle may produce better results. The later requires image retrieval technology such as drone which is controlled remotely.

There are many artificial intelligence techniques that are employed in determining the right fruits to be harvested. Among the proposed techniques are fuzzy logic [7], neuro-fuzzy [8], and multilayer perceptron neural network [9]. May and Amaran [7] proposed an oil palm fruit grading system by using fuzzy logic algorithm, which exerted 86.67% accuracy.

Used RGB values of the 45 fruit images utilizing Hebb algorithm and fuzzy logic which yielded 73.33% correct classification [8]. Fadilah [9] employed multilayer perceptron (MLP) Neural Network classifier and classified the ripeness with 86.67% correct classification. While Romulo et al [10] uses K-NN and LVQ to classify oranges with 95% accuracy.

This paper focuses on the use back propagation and learning vector quantization (LVQ) for classifying ripe fruit bunch (RFB) and fresh unripe fruit bunch (UFB). Back propagation propagates backward based on error value while LVQ uses competition and linear values. Both methods are considered to be simple methods that easily implemented on embedded system, so they are applicable for future mobile application such as drone based harvesting system.

2. Research methods

Research steps are shown in figure 1. Research starts from image pre-processing by adjusting its size through image cropping and quality enhancement. Images contain sample from RFB and UFB. Segmentation step is following by removing background and threshold saturation adjustment from 0.2 to 0.7.

40 images of ripe fruit bunches (RFBs) and fresh unripe fruit bunches (UFBs) are analysed by using Matlab. Feature extraction is based on colour image.

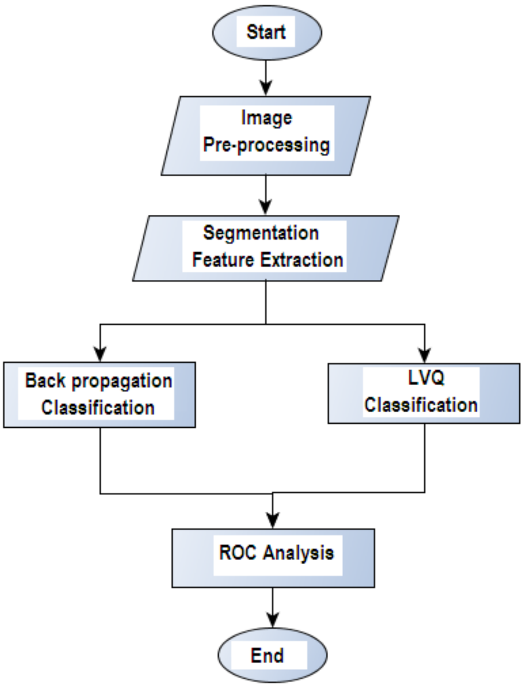

Figure 1. Research steps.

The extraction of 40 fruit bunch features is performed to RGB colour code of the images. The features are mapped into the following forms:

Feature Fruit Bunch 1 = [C1 C2 C3]
Feature Fruit Bunch 2 = [C1 C2 C3]
up to
Feature Fruit Bunch 40 = [C1 C2 C3]

Image classifications are performed by using both back propagation and LVQ methods. The ROC analysis is then performed for both methods.

3. Results and discussion

Figure 2 shows the results of image pre-processing for both RFB and UFB. The 40 images of RFB and UFB are pre-processed by applying background removal with threshold Saturation 0.2 to 0.7.

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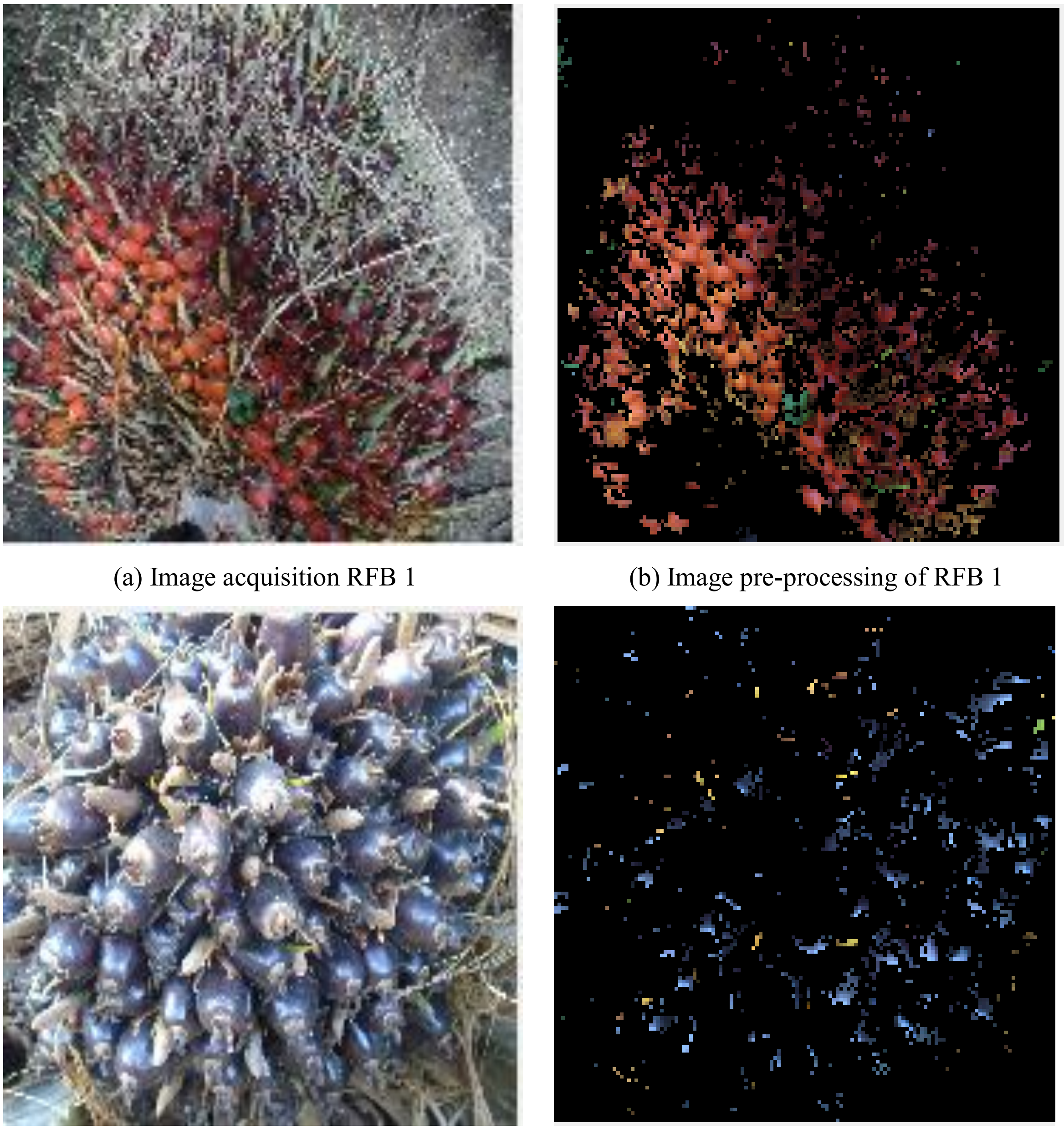


(a) Image acquisition RFB 1

(b) Image pre-processing of RFB 1

(c) Image acquisition UFB 1

(d) Image pre-processing of UFB 1

Figure 2. RFB and UFB image pre-processing.

The 20 pre-processing images are then extracted to get RGB features as the training data. The extraction is to find more features from all generated RGB pixels. The RGB extractions are shown in figure 3.

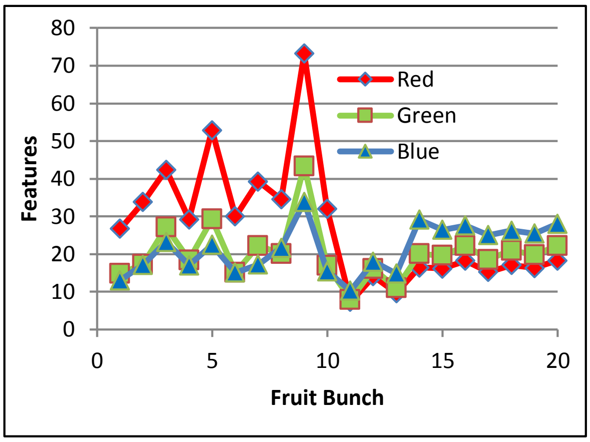
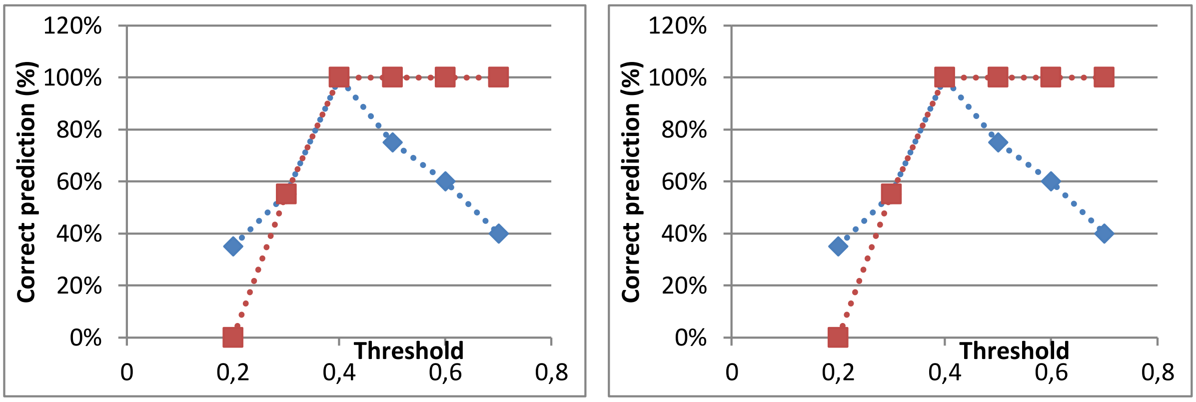


Figure 3. RGB Features.

The next step is finding weights for both back propagation and LVQ. Afterwards, the back propagation and LVQ are examing the 20 test fruit bunches. As the result, correct prediction percentages are plotted in figure 4.

The ROC analysis [11] of back propagation and LVQ produce FPR and FPR values for threshold from 0.2 to 0.7 as in table 1 and table 2. Based on the results as shown in figure 4, table 1 and table 2, the back propagation classification is best in threshold saturation 0.4, which exerts 100% precision, 100% accuracy, sensitivity 1 and specificity1.



a) RFB (b) UFB

Figure 4. Correct prediction percentages.

Likewise, LVQ is best in threshold saturation 0.4 with precision 95%, accuracy 98%, sensitivity 1 and specificity 0.95.

Table 1. The ROC analysis of back propagation.

Threshold Saturation	FPR	TPR	Precision	Accuracy	Sensitivity	Specificity
0.2	0	0.6	1	0.68	0.6	1
0.3	0.15	0.67	0.9	0.73	0.67	0.85
0.4	0	1	1	1	1	1
0.5	0.29	0.74	0.7	0.73	0.74	0.1
0.6	0.29	0.65	0.75	0.68	0.65	0.71
0.7	0.53	0.65	0.55	0.73	0.65	0.27

Table 2. The ROC analysis of LVQ.

Threshold Saturation	FPR	TPR	Precision	Accuracy	Sensitivity	Specificity
0.2	0	0.5	1	0.5	0.5	1
0.3	0	0.69	1	0.78	0.69	1
0.4	0.05	1	0.95	0.98	1	0.95
0.5	0.55	1	0.2	0.7	1	0.25
0.6	0.27	1	0.1	0.55	1	0.53
0.7	0.5	0	0	0.5	0	0.5

4. Conclusions

This research has performed fruit bunch classification into ripen and unripen fruit bunch (RFB or UFB) by using both back propagation and LVQ. Back propagation results 100% accuracy and LVQ 95% accuracy. Although both methods are simple enough, pre-processing requires cropping and background removal which are not efficient for live classification by using drone.

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