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

F Fahmi*, H Palti M, S Emerson P and S Suherman

Electrical Engineering Department, Universitas Sumatera Utara, Medan, Indonesia

*fhahmimn@usu.ac.id

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.](image)

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.
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.
The next step is finding weights for both back propagation and LVQ. Afterwards, the back propagation and LVQ are examining 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 specificity 1.

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

| 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.

References

[1] Prabha D S and J S Kumar 2015 Assessment of banana fruit maturity by image processing technique J. Food Sci. Technol. 52(3) pp. 1316–1327
[2] Sladojevic S, Arsenovic M, Anderla A, Culibrk D and Stefanovic D 2016 Deep neural networks based recognition of plant diseases by leaf image classification Comput. Intell. Neurosci.
[3] Ball D, Ross P, English A, Patten T, Upcroft B, Fitch R and Corke P 2015 Robotics for sustainable broad-acre agriculture F. Serv. Robot pp. 439–453
[4] Jhuria M, Kumar A and Borse R 2013 Image Processing for Smart Farming :Detection of Disease and Fruit Grading in Second International Conference on Image Information Processing (ICIIP) pp. 521–526
[5] Nuske S, Wilshusen K, Achar S, Yoder L, Narasimhan S and Singh S 2014 Automated visual yield estimation in vineyards J. F. Robot. 31(5) pp. 837–860
[6] Fauzi R and Maulana R 2017 Designing and Characterizing Periodic Image Monitoring Device for Remote Surveillance Purpose J. Phys. Conf. Ser. 801(1) p. 12082
[7] May Z and Amaran M H 2011 Automated oil palm fruit grading system using artificial intelligence Int. J. Eng. Sci. 11 p. 3035.21
[8] Jamil N, Mohamed A and Abdullah S 2009 Automated grading of palm oil fresh fruit bunches (FFB) using neuro-fuzzy technique in In. Soft. Computing and Pattern Recognition, SOCPAR’09 International Conference of 2009 pp. 245–249
[9] Fadilah N, Saleh J M, Ibrahim H and Halim Z A 2012 Oil palm fresh fruit bunch ripeness classification using artificial neural network in IEEE Intelligent and Advanced Systems (ICIAS) 2012 4th International Conference on 2012 pp. 18–21
[10] Sagala R S, Fahmi F and Suherman S 2017 Implementasi Learning Vector dan K-Nearest Neighbor untuk Aplikasi Fruit Sorting J. Ilm. Teknol. Harapan 6(2) pp. 40–45
[11] T Fawcett 2006 An introduction to ROC analysis Pattern Recognit. Lett. 27(8) pp. 861–874