# Evaluation of image processing technique as an expert system in mulberry fruit grading based on ripeness level using artificial neural networks (ANNs) and support vector machine (SVM)

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## Abstract

Image processing and artificial intelligence (AI) techniques have been applied to analyze, evaluate and classify mulberry fruit according to their ripeness (unripe, ripe, and overripe). A total of 577 mulberries were graded by an expert and the images were captured by an imaging system. Then, the geometrical properties, color, and texture characteristics of each segmented mulberry was extracted using two feature reduction methods: Correlation-based Feature Selection subset (CFS) and Consistency subset (CONS). Artificial Neural Networks (ANN) and Support Vector Machine (SVM) were applied to classify mulberry fruit. ANN classification with the CFS subset feature extraction method resulted in the accuracy of 100 %, 100 %, and 99.1 % and the least mean square error (MSE) values of $9.2 \times 10^{-10}$, $3.0 \times 10^{-6}$, and $2.9 \times 10^{-3}$ for training, validation, and test sets, respectively. The ANN structure with the CONS subset feature extraction method resulted in the acceptable model with the accuracy of 100 %, 98.9 %, and 98.3 % and calculated MSE values of $4.9 \times 10^{-9}$, $3.0 \times 10^{-3}$, and $3.1 \times 10^{-3}$ for training, validation, and test sets, respectively. In general, the machine vision system combined with the ANN and SVM algorithms successfully classified mulberries based on maturity. Finally, the ANN model with four features (R, B, b*, and Cr) selected through the CONS subset method with the least number of inputs and acceptable high classification accuracy with low MSE value was proposed as the proper model for online applications.