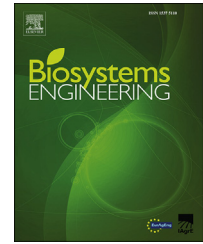


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Research Paper

A simple and efficient method for automatic strawberry shape and size estimation and classification



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In strawberry production farms, shape and size classification of harvested strawberry fruits is very important phase before packing and sending to the market. However, it is not only very labour-intensive but also time-consuming task for farmers. Computer vision-based automatic strawberry grading systems are capable to overcome this labour-intensive and time-consuming process. In this work, a simple and efficient image processing algorithm for automatic strawberry shape and size estimation and classification is presented. Being different from other existing methods in literature, the current method is based on the geometrical properties of 'right kite' and 'simple kite' which resemble to strawberry fruit shape. The proposed method is used to estimate diameter, length and apex angle from two-dimensional images of strawberry fruits. Then, these parameters are used as input data to a 3-layer neural network for class-A, B, C and D classification. The performance of proposed method is tested for a total of 337 strawberry samples with and without calyx occlusion. The results show that the accuracies for diameter and length estimations are 94% and 93% respectively for strawberries without calyx occlusion and 94% and 89% for that with calyx occlusion. The classification accuracy is between 94 and 97% and the average processing time for one strawberry (one piece) is below 0.45–0.5 s.

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1. Introduction

Strawberry is one of the most popular and high-valued fruits due to its flavour, taste, and nutrition. Strawberries are cultivated and also extensively traded in many cold-climatic countries such as Japan, Korea, China, United States and some European countries. Since it has a cold season, 'Shan' state and 'Pyin Oo Lwin' of Myanmar also grow and trade strawberry. For quality-based national marketing and/or

foreign exportation, strawberry producers need to grade harvested strawberry fruits before packing them. The quality of strawberries depends on their appearance (ripeness, shape and size, freedom from defect and decay) and flavour. Traditionally, strawberries are manually graded by farm-labours. However, manual classification is laborious, costly, time-consuming and destructive during handling by human labours. Besides, it cannot guarantee consistent grading due to human's vision error and the judgements often vary from one person to another person. Here, with the rapid development of

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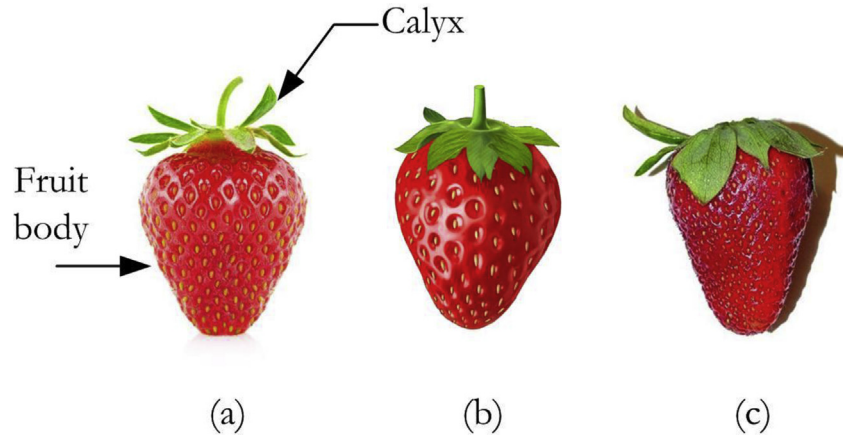


Fig. 1 – (a) Strawberries without calyx occlusion (b) Strawberry with less calyx occlusion (c) Strawberry with calyx occlusion.

computer vision technology, manual strawberry classification can be replaced by computer vision-based automated strawberry grading systems to increase the performance in all perspectives of the work. On the other hand, it is still a great challenge to obtain reliability and fast processing time in the automated grading systems. It is possible to overcome this challenge with improved vision-sensor systems by using robust image processing algorithms. For this reason, in recent

years, image processing-based strawberry classification methods (algorithms) have been proposed by many researchers.

Also, in the literature, many reliable image processing algorithms have been successfully implemented for recognising shape and size of many kinds of fruits and vegetable such as pomegranate fruit (Arends, Fawole, Magwaza, Opara, 2016), tomatoes (Edan et al., 1997; Jahns, Nielsen, Paul, 2001;

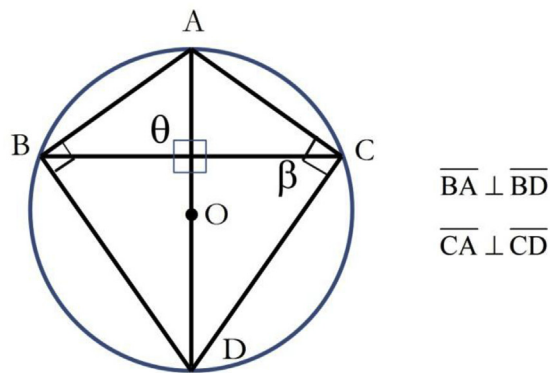
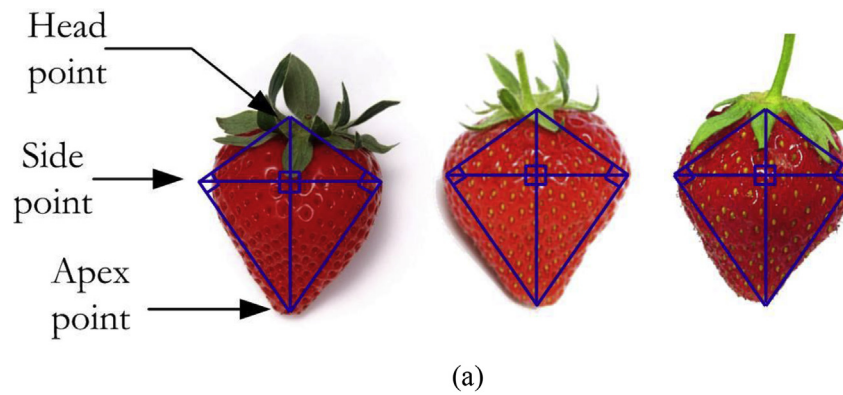


Fig. 2 – (a) Typical strawberry fruits (b) Right-kite geometry and its properties.

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