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Automatic Image Segmentation using Sobel Operator and *k*-Means Clustering: A Case Study in Volume Measurement System for Food Products

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***Abstract*—Image segmentation plays an important role in automatic visual inspection of food product using computer vision system. However, segmentation of food product image is not easily performed if the image has low contrast with its background or the background in acquired image is not homogeneous. This paper proposes a method for automatic food product image segmentation using Sobel operator and *k*-means clustering. Sobel operator was used to determine region of interest (ROI). *k*-means clustering was then used to separate object and background in ROI. The area outside ROI was considered as background. The proposed method has been validated using 100 images of food product from ten different types. The experimental results show that the proposed method achieves good segmentation result.**

Keywords—food product; segmentation; Sobel operator; k-means clustering

I. INTRODUCTION

Automatic visual inspection (AVI) is a branch of computer vision used to control the quality of manufactured products automatically. [1, 2]. AVI system is very suitable for automatic visual inspection in agriculture and food industry, because it is non-destructive inspection method [3]. Food products visual inspection is performed by extracting geometric and surface features from the image of object, such as size, shape, color, and texture. Generally, visual inspection using a computer vision system (CVS) is usually achieved by using a camera connected to a computer and involves five steps, including image acquisition, pre-processing, segmentation, feature extraction, and classification [4].

In segmentation step, the image of object is decomposed into area of interest and background. The result of this step is a binary image consisted of white pixels for object and black pixels for background. Segmentation plays an important role in visual inspection. The results of next step depend on segmentation result. Inaccurate segmentation result will lead to inaccurate inspection result [5]. Segmentation techniques commonly used in visual quality inspection of food products can be divided into four approaches, namely thresholding-based, gradient based, region-based, and classification based segmentation. However, no one of these approaches can produce accurate segmentation result for wide range of different food products [4]. Therefore, the combination of several approaches can be considered to obtain accurate segmentation result.

Thresholding-based segmentation is a simplest approach. It is performed on a grayscale image by determining a threshold value T to separate objects from its background and to produce a binary image. A pixel in the grayscale image with intensity greater than T is set as object pixel with binary value of 1, otherwise as background pixel with binary value of 0. The threshold value can be determined manually by considering the distribution of pixel intensity or automatically. Otsu [6] has proposed a method to determine the threshold value automatically by maximizing between class variance in grayscale image. However, thresholding-based segmentation is not easily performed if the object has low contras with its background. Gradient-based segmentation is performed using convolute gradient operators, such as Sobel operator [7]. Sobel operator computes the approximation of gradient of image intensity both in vertical and horizontal directions. This approach only extracts the edge of object. Gradient-based segmentation is usually used in extracting size and shape features [8, 9].

During visual inspection using CVS, the image of inspected object is usually captured using homogenous background color, such as black [9-12] and white [8, 13-17]. The color of background is selected depending on the color of inspected object, such that image segmentation can be easily performed [9, 15]. However, the color of background in acquired image is not always homogenous due to the influence of illuminations or the presence of shadows. In this condition, segmentation will not be easily performed in the whole image. Therefore, segmentation in an area around the object could be considered to minimize inhomogeneity background.

Siswantoro, et al. [18] have proposed a CVS for volume measurement of irregularly shaped food product based on Monte Carlo method. The system consisted five cameras, a computer, a light source, and a black background. The images of measured object were acquired from five different views using five cameras, one from top view and four from surrounding views. The images were then processed to produce binary images. The binary images were used to perform volume measurement based on Monte Carlo method. To reduce measurement error, a heuristic adjustment was applied to the

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