Advance Journal of Food Science and Technology 2(6): 325-327, 2010
ISSN: 2042-4876

Submitted date: October 22, 2010 Accepted date: November 13, 2010 Published date: November 30, 2010

Apple Fruits Recognition Under Natural Luminance Using Machine Vision

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Abstract: In this study, edge detection and combination of color and shape analyses was utilized to segment images of red apples obtained under natural lighting. Thirty images were acquired from an orchard in order to find an apple in each image and to determine its location. Two algorithms (edge detection-based and color-shape based) were developed to process the images. They were filtered, converted to binary images, and noise-reduced. Edge detection based algorithm was not successful, while color-shape based algorithm could detect apple fruits in 83.33% of images.

Key words: Apple harvesting, color-shape based algorithm, edge detection, machine vision

INTRODUCTION

Fresh fruits harvesting is a sensitive operation. Its profitability may be influenced by labor inaptitude, costs and unavailability, low quality harvesting, and operation untimeliness. So, mechanized harvesting operation may solve the problems.

Mechanization of apple fruits harvesting in countries like Iran that is the 4th apple producer in the world (FAO, 2009) is an essential need. Mechanized fruit harvesting may be mechanically or automatically.

Problems accompanying with mechanical harvesting resulted in development of robotic harvesting methods, thereby prototype machine vision based harvesters has been increasingly being developed. Parrish and Goksel (1977) and Bulanon and Kataoka (2010) studied robotic apple fruit harvesting.

The automated harvesting system should perform the following operations: (1) recognize and locate the fruit; (2) reach for the fruit; (3) detach the fruit without causing damage both to the fruit and the tree; and (4) move easily in the orchard (Sarig, 1990).

The first operation needs development of appropriate methods to detect and locate the fruits. Using photometric information based (Schertz and Brown, 1968) and infrared laser range finding (Jimenez *et al*., 2000) methods were developed. While, image processing based methods have been used to detect and located the fruits (Bulanon and Kataoka, 2010; Satish, 2007; Harrel *et al*., 1989).

Both intensity/color pixel-based and shape-based analysis methods were appropriate strategies for the recognition of fruits, but some problems arose from the variability of the sensed image itself when using CCD cameras, which are very sensitive to changes in sunlight intensity as well as shadows produced by the leaves (Jimenez *et al*., 2000).

Since no research has been reported on robotic apple harvesting in Iran, this paper focuses on recognition of apples, as the first stage of apple robotic harvesting.

Recognition of apple fruits using machine vision under natural daylight conditions was the objective of this study. Thirty images of Red Delicious apple canopy were selected randomly from photos taken of apple trees in autumn. The images were taken from Hamedan groves, in Iran.

MATERIALS AND METHODS

Thirty digital images were obtained under uncontrolled daylight conditions. Image frames were 3072×2304 pixels in the JPEG format. A digital camera (Sony, DSC-H5, Color CCD Camera) was used to acquire the RGB images.

Image processing algorithm: The goal was finding an apple in each image obtained in uncontrolled lighting conditions. In order to segment the acquired images, two algorithms were developed: edge detection based and color-shape based.

Edge detection-based algorithm: Initial considerations showed that the green gray-scale image included most of

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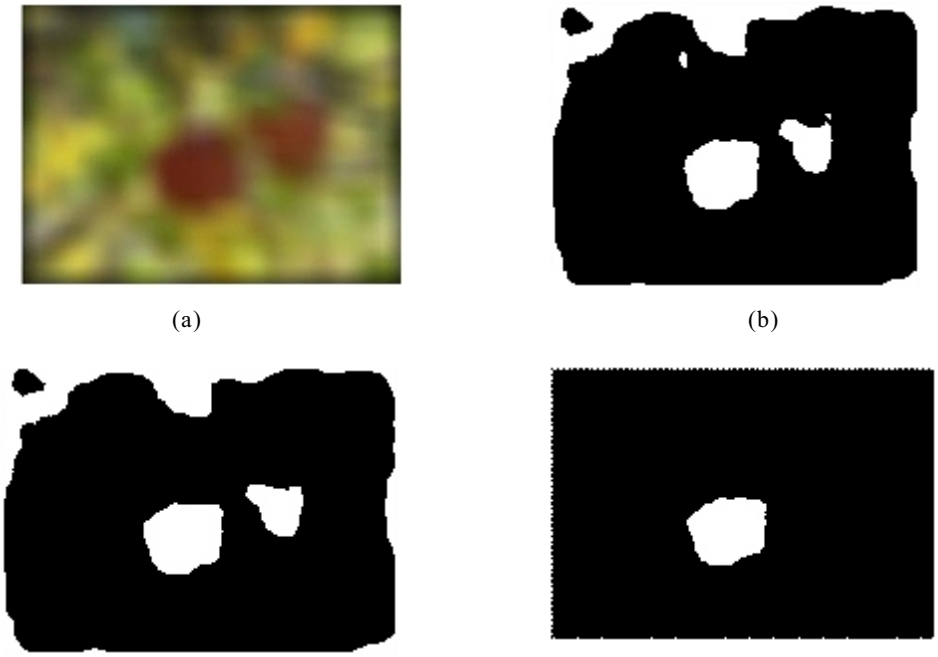
the desired objects. Canny (1986) method was used to determine the edges of apples in green gray-scale image (Fig. 1b).

Color-shape based algorithm: The algorithm was implemented based on the following steps:

- The images were first enhanced. A Gaussian low-pass filter was used to reduce the noise as much as possible. Noise portends to unequal color intensity distribution in the original images that formed shades and shiny regions in the images
  The Gaussian filter was a 250×250 pixel matrix with standard deviations of 200, which limit image frequencies to less than 200 Mega Hertz (MHz). Filtered images were noise-reduced by removing high frequencies (more than 200 MHz). Filtering the image caused blurring which noise was reduced (Fig. 2a)
- Filtered images were then converted to binary form in order to be processed (Fig. 2b)
- Binary images were processed to reduce the existing noise after converting images. In this stage, noise was defined as the areas detected as features other than apples. This stage of the project is shape-based processing of color-based processed images (Fig. 2c)
- Binary, noise-removed images were labeled to extract the apple (Fig. 2d)

(a) (b)

Fig. 1: Edge detection based algorithm. a) Original image, b) Edge-detected image



(a) (b)

(c) (d)

Fig. 2: Color-shape based algorithm. a) Filtered image, b) Binary image, c) Noise-reduced binary image, d) Labeled image

RESULTS AND DISCUSSION

The main idea was to develop a general algorithm under various natural lighting conditions. Thereby, no supplemental lighting source was used to control the luminance.

Since the images were acquired under uncontrolled natural daylight conditions, they included tree canopies including tree branches, leaves, fruits, sky, etc. Each object of the image has its own edges, making image sets of edges of which the apple is just a subset. So, edge detection algorithm was not successful (Fig. 1).

Color-shape based algorithm detected the image objects in the images better; however, it was more complicated than the edge detection. The stage of color processing blurred the image and its output was an image with low contrast having distributed colors (Fig. 2a). Thus, the image was noise-reduced in which the number of objects were less than that the original image.

Converting the image to binary form and shape-based analysis made the noise as low as possible (Fig. 2b, c). Color-shape based algorithm was able to detect the apples in 25 of 30 images. In other words, the accuracy of the algorithm was 83.33%. Figure 2 shows the procedure of color-shape based algorithm.

CONCLUSION

In this study, two algorithms were developed and compared to detect one apple in each image. No lighting control was exercised to standardize luminance of the acquired images. However, edge detection based method was not successful; color-shape based algorithm was able to detect apples in 83.33% of images.

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