A Robust Algorithm for Fruit-Sorting under Variable Illumination

Janakiraman L. Kausik¹ and Gopal Aravamudhan²

¹ Department of Electrical & Electronics Engineering, Birla Institute of Technology & Science, Pilani 333 031, Rajasthan, India
kaushik_l@yahoo.com

² Central Electronics Engineering Research Institute, CSIR Madras Complex, Taramani, Chennai 600 013, Tamil Nadu, India

Abstract. Computer vision techniques are essential for defect segmentation in any automatized fruit-sorting system. Conventional sorting methods employ algorithms that are specific to standard illumination conditions and may produce undesirable results if ideal conditions are not maintained. This paper outlines a scheme that employs adaptive filters for pre-processing to negate the effect of varying illumination followed by defect segmentation using a localized adaptive threshold in an apple sorting experimental system based on a reference image. This technique has been compared with other methods and the results indicate an improved sorting performance. This can also be applied to other fruits with curved contours.

Keywords: Computer Vision, On-line fruit sorting, Surface defect, Adaptive thresholding.

1 Introduction

Fruit inspection and grading is an indispensable horticultural procedure. Uniformity in size, shape and colour are few of the many parameters that are vital in determining consumer acceptance. While the task at hand is to develop a machine vision system that identifies defective fruits based on odd shapes and surface defects, and to categorize them depending on consumer acceptability, the objective has to be accomplished with certain constraints [1]. Such a system has to be operable at high speeds suitable for real-time processing yielding a high throughput, must inspect the entire fruit surface, must be adaptable to varying fruit size, shape etc., and be applicable under various physical conditions like brightness, luminance etc.

Over the past decade, various techniques have been proposed for defect segmentation and grading. Reference [2] uses flooding algorithm to identify and characterize different types of defects based on perimeter, area etc. The snake algorithm discussed in [3] can be used to localize the defect and reduce false positives. Reference [4] employs a raw approach based on colour frequency distribution to associate pixels to a specific class while [5] accomplishes the same using ‘Linear discriminant analysis’.
Hyper-spectral and multispectral imaging systems have also been proposed for sorting various food commodities as discussed in [6]-[7].

An inherent limitation in most of the existing techniques is their sensitivity to changing illumination conditions. Any flash of external stimulus can result in bright patches in the captured image which could result in misclassification. Practical considerations dictate that any technique should be immune to occasional changes in external conditions and deliver acceptable performance. This paper incorporates the use of adaptive filters based on the conventional LMS algorithm as a pre-processing step prior to segmenting defects using an adaptive threshold. This paper has been organized as follows. Section 2 explains the components of the practical set-up used to capture images of the fruit to be sorted. Section 3 discusses the proposed methodology for pre-processing and defect segmentation. Results of the experiment have been tabulated and discussed towards the end.

2 Experimental Set-Up

The prototype system[8] used for testing apples comprises of individually designed and integrated sub-systems which include a system for fruit separation, a conveyor system, illumination and imaging system, a processor for computing and a sorting system.

The fruits are dumped for sorting in an open container which forms the head of the feeding system, where a baffle mechanism is employed to guide the fruit, one at a time. A singulating drum feeds each fruit to the orienting section. The conveyor chain consists of a series of axles bearing aluminium rollers rotating freely about their axes. This roller mechanism ensures that apples are aligned to the stem-calyx position for ease of processing. The imaging system is placed in the illumination chamber towards one end of the conveyor.

The illumination unit consists of incandescent lamps and compact fluorescent lamps to provide uniform lighting. However, illumination may vary with time due to voltage fluctuations, ambient temperature etc. The camera and lens system captures 6 orientations of each fruit 60° apart. A frame grabber controlled by a series of rectangular pulses synchronised with the fruit movement, captures one frame per trigger. A standard personal computer is used to run the algorithm for processing the captured image. This involves a series of steps summarized in the next section. In the final model, this unit may be replaced by a dedicated Digital signal processor equipped to handle specialized image processing functions efficiently. A series of cups aligned and molded with solenoid actuated strips controlled by the computing system is used to sort fruits into different grades. Each fruit is categorized and the solenoid associated with the corresponding grade gets activated and enables the collection of the fruit into the cup using a tilting mechanism.

3 Methodology

The captured image goes through a pre-processing routine before defect segmentation and grading. These steps are discussed below: