ABSTRACT

Machine vision based quality inspection system for sorting fruits solves many limitations of the manual inspection process. Machine vision inspection essentially involves image acquisition, image processing, measurement of quality parameters and decision making to grade fruits as per specified criteria. To achieve this goal, sub-systems of machine vision system like conveyor system, illumination system, imaging system must be suitably developed and integrated along with suitable image processing software to achieve optimum performance. The system should measure fruits' external quality parameters like size, shape and colour and generate output that closely matches with human graders.

The present thesis describes the design and development of a prototype online fruit sorter system based on machine vision. The system sorts fruits like apples based on external quality parameters like size, shape and colour.

An improved conveyer system singulates, orients, rotates and transports the fruits along the process line for imaging. Two types of orientation mechanisms have been developed. A horizontal orientation mechanism, which orients the fruits horizontally to stem - calyx axis has been integrated into the conveyer system. This maximises the contact of fruit with rollers and thus reduces slippage and increases imaging efficiency. This orientation scheme minimises the inclusion of stem in the captured images for easy analysis. This also offers nearly complete coverage of the fruit's surface for inspection.

An improved illumination system has been developed to provide diffused and uniform illumination across the field of view. This uses a combination of CFL and incandescent lamps to obtain illumination with fairly balanced primary colour components.

The developed imaging system employs a novel method for synchronizing image capture with fruit's rotation and movement. This also employs a novel method of colouring the mechanical conveyor parts for easy extraction of fruit images from the overall image.

Various image processing algorithms have been developed for determination of size, shape and colour of fruits.

For size determination, five new techniques namely circle, parabola, ellipse, principle axis and co-efficient of variation methods have been developed. The circle, parabola, and ellipse methods approximate the fruit image contour with their respective shapes and measure the size in terms of diameter, latus rectum and eccentricity respectively. Principal axis method quantifies the size of a fruit based on the asymmetry of the contour about its principal axis. The coefficient of variation method employs radius and area signatures of the image contour for size comparison.

For shape determination three different techniques namely, radius signature, area signature and boundary vectors methods have been developed. The signatures data provided by the above methods are analyzed using statistical methods namely coefficient of variation and Fast Fourier Transform (FFT). FFT analysis is used to derive a shape number useful for shape comparison.

For colour analysis two new methods namely hue histogram comparison and linear discriminant analysis have been developed. Hue histogram comparison method involves comparison of histograms using probability density function. Linear discriminant method classifies fruits based on Mahalanobis distance.

The developed sub-systems and software have been evaluated individually and integrated into a prototype fruit sorter for apples. Experiments have been carried out using large number of apples for validating the system's performance and typical results are presented.

Though this prototype has been developed for apple sorting, it can be adopted for other fruits with suitable modifications in some of the mechanical sub-systems.