Journal of Fiber Bioengineering and Informatics 7:3 (2014) 441–452
doi:10.3993/jfbi09201413

Computation Model on Image Segmentation Threshold of Litchi Cluster Based on Exploratory Analysis

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Received 19 May 2014; accepted (in revised version) 2 August 2014; available online 23 September 2014

Abstract

To construct a litchi harvesting robot, the first key part is the machine vision system which is used to recognize ripe litchi clusters and their main fruit bearing branch. It selects and locates picking points. Hence, in order to establish a threshold computation model used to recognize litchi cluster, the research focus is in recognizing all parts of the litchi image. In this paper, a procedure on how to develop an automatic recognition of litchi cluster, fruits and their main fruit bearing branch guided for litchi harvesting robot is proposed. Firstly, according to the analysis on the specialty of litchi fruits and their main fruit bearing branch, particularity and uncertainty of illumination and environment, an overall scheme on the threshold computation model is used to recognize the litchi cluster based on exploratory analysis and its' application are provided. Secondly, after analyzing and comparing all thresholds, running time and effect on image segmentation by threshold computation methods of the maximum entropy, iterative, Otsu and histogram bimodal method, the interval for recognizing all sorts of litchi clusters is obtained, and a mathematical model for computing threshold to segment litchi cluster is put forward. Finally, all ripe litchi clusters of testing images from 6 groups (all together 120) of differently illuminated (in high light, normal light and backlighting) litchi images from differently-colored main fruit bearing branches (partial red, partial brown and partial brown) collected in natural circumstance are effectively recognized with the threshold segmentation method based on the given computing model, with recognition ratio of 88.89%, 92.0%, 88.24%, and 95.45%, 90.0%, 83.33%, which can satisfy the request of image segmentation on litchi-picking robots in complicated environment.

Keywords: Exploratory Analysis; Main Fruit Bearing Branch of Litchi; Image Threshold Segmentation; Vision Location

1 Introduction

For fruit-vegetable harvesting robots, recognition on picking object is a key to achieve exact location and successful picking [1-5]. As a characteristic fruit, litchi is widely grown in province

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of Guangdong, Fujian, and other southern part of China. Traditional hand worked means of litchi picking not only demands intensive labor, it also requires an extortionate harvest cost. To effectively resolve the mentioned problems faced by litchi production, the research and exploitation on intelligentized litchi-picking robot is an inevitable trend, in which the recognition of litchi cluster, litchi fruits and their main fruit bearing branch has become the research focus of litchi picking robots vision systems [6-8].

Recognition is the separation of the object of interest (the fruit) from the background (leaves, branches, sky, and soil). This is an image processing procedure called image segmentation [9]. Image segmentation is a fundamental and difficult task in many image and vision applications. It has been studied extensively over the past several decades with a huge number of segmentation algorithms being published in the literature. Those image segmentation approaches can be divided broadly into four categories: thresholding, clustering, edge detection and region extraction [10]. They also can be used in the field of high-speed fabric defect detection [11] and textile printing design [12]. A ripe litchi cluster however consists of many litchi fruits, with the main fruit bearing branch acting as a main pole and some leaves existing in its background which makes the recognition of all parts of litchi very difficult. An effective color image segmentation algorithm based on ant colony and fuzzy c-means (FCM) clustering using the suitable L*a*b* color space was proposed to recognize litchi fruits in [13] by segmenting image with loose threshold. After analyzing color characteristics of litchi image and translating litchi image of RGB (Red Green Blue) color space into HSV (Hue Saturation Value) color space, another recognition method on litchi fruits by segmenting the H component image of HSV was proposed in [14]. The process however as of yet could not resolve the problem of distinguishing litchi main fruit bearing branch for its cluster, ie, and could not meet the goal of positioning for litchi picking robot. For the vision system of the litchi picking robot, calculation and locating on litchi picking point process in the part of litchi main fruit bearing branch, and recognition of litchi cluster and their main fruit bearing branch is the key technology. A method which combines the experiential threshold with FCM(Fuzzy C-means Clustering) algorithm for recognizing litchi fruits and their main fruit bearing branch was proposed in [7, 8], using the Cr component image of YCbCr color space, which also provides a method on picking point calculation and locating with preferable effect. It however didn't give the conception of classification recognition of litchi cluster, litchi fruits and their main fruit bearing branch, and it didn't give an effective method on calculating the threshold for segmenting litchi cluster.

Litchi fruits and their main fruit bearing branch are easily influenced by illumination and environmental changes, in addition to plenty of uncertain factors in vision recognition and position on litchi cluster. There are some limitations in the process of recognition of all parts of litchi image and location of picking point only with traditional and single domain knowledge. The process with multi domain knowledge amalgamation, especially method of Exploratory Analysis (EA) to assort litchi image into litchi cluster, litchi fruits and their main fruit bearing branch, statistically analyze color, illumination etc characteristics of those parts of litchi, and obtain the threshold for recognizing litchi cluster is comparatively advantageous.

EA is a method of systematic analysis proposed by RAND Corporation, which is mostly used for analyzing and decision-making on uncertain problem in complicated system with preferable result [15-18]. As a sort of statistical analysis method, EA has also become an advanced mean for dealing with the uncertain problems for exploring data and simulation analysis. On the basis of statistical analysis, the automated baling robot for automated locating and discriminatingly harvesting crop was studied by Blas, using vision system on image texture and shape [19]. After