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Color and Contour Based Identification of Stem of Coconut Bunch

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Abstract: Vision is the key component of Artificial Intelligence and Automated Robotics. Sensors or Cameras are the sight organs for a robot. Only through this, they are able to locate themselves or identify the shape of a regular or an irregular object. This paper presents the method of Identification of an object based on color and contour recognition using a camera through digital image processing techniques for robotic applications. In order to identify the contour, shape matching technique is used, which takes the input data from the database provided, and uses it to identify the contour by checking for shape match. The shape match is based on the idea of iterating through each contour of the threshold image. The color is identified on HSV Scale, by approximating the desired range of values from the database. HSV data along with iteration is used for identifying a quadrilateral, which is our required contour. This algorithm could also be used in a non-deterministic plane, which only uses HSV values exclusively.

Keywords:Contour, HSV Scale, Threshold image

1. INTRODUCTION

India, one of the largest number of coconut tree growers in the world is facing acute shortage of manual laborers to climb and pluck the coconuts. This indirectly affects the livelihood of many families whose income depends on the coconuts from few coconut trees they own. Coconut industry also faces problems of coconuts processing being delay which affects the cost. Consumers see steep rise in price. This issue is not an isolated on in which only coconut tree growers of India are facing this but it is an international issue. As there are several advancements in the field of agricultural robotics, robotics is one good option to solve this problem. If an automated robot is developed and has to climb the coconut trees and harvest the coconuts, then computer vision is strictly need.

Color based estimation and identification of contour, is one of the major aspects of Image Processing. Various cameras or sensors are used in the process of identification and recognition using shape matching. Contour Recognition and Shape matching based on color, could be achieved by a stereo vision camera. The desired part is identified and assumed to be a contour, shape matching is done according to the proposed algorithm. Unlike the monocular camera, the stereo vision camera has a broader view and two cameras of vision for the same object which makes the identification of contour simpler. Identification using a Stereo Vision Camera is

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complex yet has a very good yield. The process can also be implemented using a Monocular Camera, but the accuracy is greatly decreased when compared to Stereo Vision Camera. There are few methods for shape matching, of which, the two widely used methods are the Iterated Closest Point (ICP) method and Variational Shape Registration via Level Sets method. The algorithm used is similar to Iterated Closest Point (ICP) method. The paper is segmented as follows: Problem Statement discusses the problem we are addressing. System Architecture and Implementation sections explain how the algorithm is used in Contour Identification based on color and shape matching, and how is it carried out efficiently. The Experimentation and Results section clearly explains the results obtained by the algorithm implemented. It also depicts the efficiency of the algorithm used. Future Works include the developments further on the identification to make it more accurate. Illumination effects the accuracy.

2. PROBLEM STATEMENT

It is time for robotics and automation as a solution to the existing problem of coconut plucking as the entire world is facing acute shortage of manual coconut tree climbers. As there are lucrative job options available, no one want to take up this job of coconut tree climbing as it pays less compared to other jobs and risk factor falling and accidents is high. In India coconut tree climbing is traditionally carried out by the people from the lower spectrum of economy. Due high literacy rate and various job opportunities available, most of the younger generation from this category are not taking up the job of coconut tree climbing. So strong and sustainable alternatives are required to tackle this issue. Robotics and automation could prove to be one of the best solutions. There are mechanical coconut tree climbers which are used by people in which the user has to get into the setup and climb to the top of the tree with some kind of mechanical padding. But these are not user friendly and still risk of accidents is involved. With robotics and automation along with computer vision can provide an effective system which can climb the coconut tree, see and identify the coconut bunches and cut the stem of the coconut bunches. In this context we base our research work for the color and contour identification of the coconut bunch stem. The coconut bunch stem even though looks green, sometimes it is yellowish green or even orange green. Also the shape of the stem is not same in all bunches. Some of the stems are not easy to identify as they are hidden with the dry coverings and hidden under the leaves.

3. RELATED WORKS

Many research works on object detection or shape detection using stereo vision camera or monocular camera paved a way for the development of detection techniques. Applications are spread across different fields like robotics, face detection, object tracking, transport systems, intelligence systems, applications in stereo vision using mobiles etc. In research paper [1], shape matching is done by comparing between two known shapes and object is recognized based on a reference shape. It is only based on the known shape geometry and is not applicable for every random shape. Authors in the paper [2] explain about how static images are detected using components based on human body positioning. The algorithm uses 4 distinct parts as 4 different views of the human body which increases the efficiency of the process than full-body person detector. Authors in the paper [3] discusses the Moving Object Detection in video surveillance system. It is done using edge localization mechanism and is widely applicable in many security surveillance systems. In research paper [4], Salient Object Detection is based on multilevel image segmentation. It introduces a new regional feature vector to characterize the background.

Authors in the paper [5] discusses a technique for automating the methodology of detecting and tracking objects utilizing color feature and motion.The main aim of video tracking is to relate target objects in consecutive video frames. The relationship can be especially troublesome when the objects are moving speedily with respect to the frame rate. In this paper [6], authors describe the approach to detect the object using its shape and color information which is capable of detecting object rapidly and comparatively with good detection rate. Fourier descriptor is used for the detection process. But this will not be an effective method in case of an object having non homogeneous color distribution. Authors in the paper [7], discusses the work to accurately detect and localize boundaries in natural scenes using local image measurements and respond to characteristic changes in brightness, color, and texture associated with natural boundaries.The research paper [8] discusses about how to measure the distance with the help of mobile phones and single-camera stereo vision. It uses road geometry to estimate the depth of the object. But the camera used is single forward facing camera, through which the depth estimation might not be accurate as it is a 2D analysis.In one of our earlier papers [9], we estimated the depth of the object using single camera to vehicle crash and back-over accidents.

4. SYSTEM ARCHITECTURE

The system architecture for the color and contour based identification of stem of coconut bunch system is shown in Fig.1.

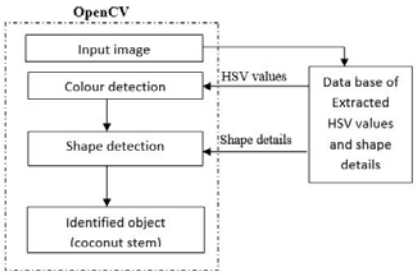

Figure 1. Color and Contour Identification System Architecture

The input image from the camera is identified on the basis of two parameters that is color and shape. Threshold values for the detection are obtained from the database. The database consists of threshold values for color and shape detection obtained from the analysis of the collected images. The first step in the two-stage process is the detection threshold for the stem color of coconut bunches i.e., HSV values of the image. The HSV obtained by performing the training algorithm on the previously collected images in the database. For the precise identification of the coconut stem, the color detection is not the optimal method. Therefore shape detection of the stem is introduced in the second stage. Shape detection is done via contour identification method. In this stage, the contour of the threshold image will be obtained by running the contour detection algorithm on the input image. The contour must be a quadrilateral if it has four vertices hence it should be a coconut stem. By identifying the coconut stem from another part of the coconut, the coconut climbing robot can easily cut the coconut bunch in the stem. This makes the system completely automated and accurate. When the coconut height is more than 10 meter, the visibility of the coconut stem by the person in the ground station is very poor. Therefore the color and contour based identification of stem decision making are superior and accurate than the manual instruction to the robot.

Object detection is a difficult task in the image processing and computer vision. Different parameters are used for the detection of objects. In this paper, we are using color and shape as the two parameters to identify the object from the image. The object which we want to identify

only the stem of the coconut bunch and have to remove all other parts. Two parameters are used for object detection is color and shape. The HSV values of the coconut stem are identified by evaluation of directly set values using track bar. These HSV values are the threshold for the selection. Noise in the threshold image is removed by morphological opening and closing. The morphological opening is done for removing small objects from the foreground and morphological closing fill small holes in the foreground. This procedure makes the threshold image noise free. In order to confirm the object, second parameter shape identification is introduced and contours of the threshold image is detected. Performing the quadrilateral check in each contour of the threshold image by iterations. If there we can find four vertices contour in the threshold image, it should be quadrilateral and that is the identified object and the required portion. The proposed method is very simple accurate one for the coconut climbing robot in order to make it real time and automated.

5.IMPLEMENTATION

Nowadays different methods are used for the object recognition such as appearance based methods, feature extraction methods, and CAD object models methods. In this paper we are using the appearance-based methodology, such as the input is given by the camera. The algorithm used for this system is applicable in a nondeterministic plane. The prior data required only for the HSV values algorithm and for the shape of the coconut bunch. Data can be obtained from the database of collected image. The flowchart of the algorithm used is shown in Fig. 2.

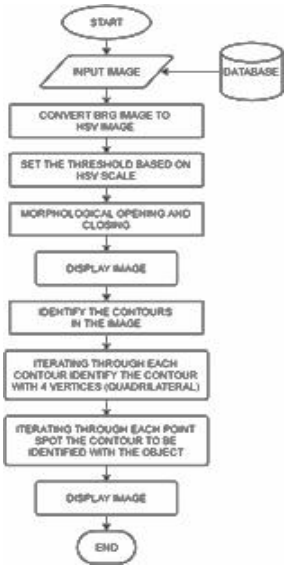

Fig. 2 Algorithm for Coconut Stem Recognition

In this system, it is possible to provide the threshold values directly so, in that case, no need for the database. Once the coconut climbing robot gets trained for the algorithm no need to train it again as the whole coconut stem have a unique color. It is possible to check the variations by adjusting the HSV values using taskbar.The significant part in the artificial intelligence of an automated system is the vision i.e. that identifies the object with the help of the camera. The camera images are the source of information, extract data from the image using image processing. Using these data identifies the object and reach the decision.This work is done in

Linux and open source computer vision libraries which are used for the image processing. OpenCV receives images in BGR format. It includes matrices of blue, green and red the values in the matrices ranging from 0 to 255. Conversion of the BGR image into HSV format is appropriate for this system as HSV color space is most suitable for the color-based classification. BGR is same as that of the RGB format but in BGR red occupies the least significant area. OpenCV supports BGR format.

HSV is the cylindrical coordinate representation of color. There is a specific range of values for each color so by setting values to the HSV can identify the color. The degree of specificity of HSV values determines the accuracy of the algorithm i.e. they are linearly dependent. The specific values can be obtained from the database or analysis of the collected images.For the coconut stem, in most of the cases, color is yellowish green. So HSV values are sets for yellowish green. To get accurate and precise HSV values the optimal number of the images analyzed by the algorithm should be 10.

Coherent and non-coherent noise are present in the threshold image. The noise removal is done by morphological opening and closing. The threshold image is a binary image (after the color detection). Morphological operations are done on binary images. Dilation, erosion, opening, closing, hit and miss transform, thinning, thickening, skeletonization/medial axis transform are different methods in the morphological operations. In this paper, we are using dilation and erosion for noise removal. By Dilation grew the image region and erosion is used to shrink the image region. The morphological opening is used to remove small objects from the foreground and morphological closing is to fill small holes in the foreground. Here morphological opening includes gray level erosion followed by gray level dilation. Morphological closing is just a reversal of the opening, in that dilation followed by the erosion is takes place. All these operations are taking place in the binary image (grayscale image). A grayscale image is a single channel image so the processing is simple and accurate. In multichannel images, edge detection and noise removal are comparatively difficult and not that much accurate.

Recognition using color is a powerful and simple method, in this match the color of image or color-related parameters for the detection. But it has some drawback that when the illumination changes that badly affects the accuracy. That drawback can be avoided by shape detection. Vertex detection and contour detection are mainly adopted for the geometric shape detection, in this paper, we are using contour-based identification. After the contour identification, reach the decision after iterating through each contour. By this the number of vertices identified, if there are 4 vertices in the contour it should be a quadrilateral. So by this color and shape detection, we identified the coconut stem.

6. Experimentation and Results

As the process of segmentation of the required part of coconut bunch should be least dependent on various factors like shadows, lighting conditions, etc., the acquired image is processed in HSV rather than in BGR format. A collection of pre-acquired images are studied to get a range of HSV values for thresholding and is made into a database.Image acquisition is done using an onboard camera attached near the end effector of the arm. Color training is done using various HSV parameters using a pool of assorted polka dots on a white background. A track bar is used to vary the HSV parameters to get the optimum dot detection with the least noise and error. The experiments were done in lighting conditions that are comparable to natural lighting conditions.

Once the image is set to threshold on basis of color, it is further processed with morphological operations. Morphological opening and closing are two operations that are done on the

threshold image to acquire the desired part of the bunch. Morphological opening and closing are given by
Equation (1) and Equation (2) respectively.

$$I_T(x,y) \circ S_e(x,y) = \{[I_T(x,y) \ominus S_e(x,y)] \oplus S_e(x,y)\} \quad (1)$$

$$I_T(x,y) \bullet S_e(x,y) = \{ [I_T(x,y) \oplus S_e(x,y)] \ominus S_e(x,y)\} \quad (2)$$

where the $I_T(x,y)$is the threshold image and $S_e(x,y)$ is the structuring element; $\oplus$ denotes morphological dilation operation and $\ominus$ denotes morphological erosion operation.

Experimentation with various structuring element sizes(kernel size) are done with many sample images until only the desired part of the bunch remains in the image canvas.Figure 3 shows the results at various intermediate steps.Fig. 3 (a) is the threshold image with noise and few unwanted details. This image is then processed with Equation (1) and Equation (2). Fig. 3 (b) to Fig. 3 (f) are the output images for these process with kernel size of 1x1,3x3,6x6 ,12x12 and 18x18 respectively.Fig.4 shows the output image. The minimum kernel size required in order to get a single connected segment is 12.It can be inferred from Fig. 5 that a kernel size of nearly 18x18 for a 640x480 image is apt.

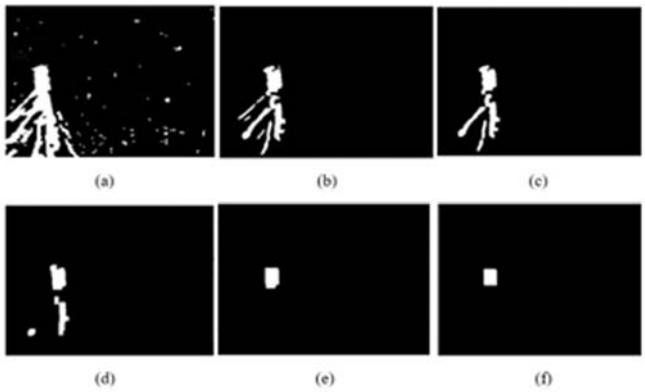

Fig. 3 (a) Thresholded image with noise. (b) Output image with Kernel size 1x1. (c) Output image with Kernel size 3x3. (d) Output image with Kernel size 6x6. (e) Output image with Kernel size 12x12. (f) Output image with Kernel size 18x18.

Figure 4. Output image

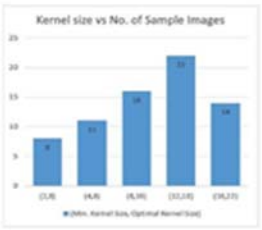

Figure 5. Variations in the choicest kernel size for various sample images.

7. FUTURE WORKS

The process discussed in this paper deals with a simple but a viable method for automating the robotic arm for coconut harvesting. As the structure of our 'Object of Interest' is never unique, a more complex algorithm - Content-based image retrieval (CBIR), is to be implemented using a large dictionary of coconut bunches. To achieve the ultimate objective of automated cutting of coconut bunches, it is necessary to calculate the position of the detected bunch in x,y,z-axis. For this method discussed in [8] seem to be practical. However, as the processing is to be done on an onboard Single Board Computers, memory and computational constraints are to be studied and dealt with.

8. CONCLUSION

By implementing 'color and contour based identification of stem of coconut bunch' identification coconut cutting robot can completely be automated. The algorithm used for identification is simple and effective. The accuracy of this method depends on the luminance in the image and the position of camera. With several iterations, and proper robot to support the climbing of the coconut tree and the cutter to cut the bunches, stem identification and cutting the stem can be entirely automated.

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