Design of Smart System to Detect Ripeness of Tomato and Chili with New Approach in Data Acquisition

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Abstract. Manual laxity of fruit ripeness classification is highly influenced by operator subjectivity, thus there is inconsistency for some periods in the classification process. Information Technology development allows fruit identification based on color characteristic by computer aids. A developed system was designed to work on a mobile device with the ability to detect four levels of ripeness of tomato and chili fruits. The acquisition of training data is done with a new approach. Training data came from objective observation of the same fruit of tomato and chili, captured since one month before harvesting until harvesting period. Image segmentation uses K-Means Clustering Method while ripeness detection uses fuzzy logic. The system output consists of types and level of ripeness grouped into four categories: unripe 1, unripe 2, medium, and ripe. This article explains preliminary results of the testing system in static and partial condition using a personal computer before being applied into a mobile-based integrated system. The results showed the level of success for fruit segmentation was 80% for tomato and 100% for chili. The fault is due to the similarity of fruit sample size. The level of success for detecting fruit ripeness is 80% for tomato and 90% for chili. By 10 training data of each, it is shown that the good result with an overall accuracy level of average ripeness detection is 85%.

1. Introduction

The problem countered in fruits marketing is their availability in the market with inappropriate ripeness, sometimes they are over ripe and become rotten, sometimes they are unripe. This becomes a problem in particular for fruits/vegetables sent to far place or to be exported. This problem often occurs due to improper harvesting time; the condition of fruits ripeness is not enough or even overripe when harvested.

Fruit ripeness is usually determined by some parameters, such as size, weight, the color characteristic, fruit aromatic, etc. Fruit ripeness characteristic can be identified through fruits color skin and that is one of an important factor and an easy way to identify fruit ripeness [1] [2]. There are many human laxities to make the perception of fruit ripeness by their own sight, their subjectivity and inconsistency potentially able to make one assessor assess differentially to another assessor.

Identification and detection method, a majority are still conducted manually. The manual method is conducted visually direct to the classified fruits. The laxity of manual classification is affected by operator's subjectivity, thus the assessment is inconsistent in some condition to classify the fruits [2].

Information Technology development allows fruit identification based on color characteristic by computer aids [3]. This computerized is conducted by visual observation indirectly using camera digital as an image processor of captured images (image processing) then be processed using computer software [1] [2]. Utilization of image processing technology has been widely used in determining fruit ripeness. However, the developed detection system is static, using a Personal Computer (PC), not portable that cause impossible to detect fruit color when the fruit is still on the tree directly. Fruit ripeness detection system supported by mobile technology is relatively more useful than a static system using a PC, moreover if the system is able to detect the ripeness of several types of fruit and their harvest predictions.

In order to predict the harvest period with several levels of ripeness, a new approach is needed in the acquisition of training data. Train data are acquired from the same object of observation continuously. For example, the tomato captured since 1 month before harvesting until harvesting period. This paper will explain the preliminary results of developing a ripeness detection system which capable to detect 4 levels of ripeness of big tomatoes and chilies. These preliminary results are partially conducted between each stage and processed by PC.

2. Related Works
Some research to develop fruit ripeness identification system has conducted by utilizing the color features contained in the fruit [4] [5] [6] [7] [8] [9]. Sigit and Feri [7] examined ripeness classification level in Papaya California using HSB (Hue Saturation Brightness) color room and algorithm of K-Nearest Neighbors (KNN). Examination with total K-neighbor is 3 and a total number of image testing data is 12, it showed accuracy level KKN algorithm is 75% with inappropriate output data is 3 and appropriate data is 9 data [7].

H. Yin et al [9] made a vision robot to recognize and localize the ripe tomatoes in a greenhouse. The system will recognize fruit ripeness from the color feature and fruit shape. Image captured by a camera, formerly segmented using K-Means Clustering method in L*a*b color room. Recognizing the ripe tomatoes use morphological operation to resolve an overlapping figure. Accurately fruit detection obtained by combining the shape feature and color feature. The detecting result showed a success rate of 94% [9].

Meanwhile, the more complicated technique such as Backpropagation Artificial Neural Network and Fuzzy Logic has been widely used [1] [10] [11]. Several studies using the Fuzzy Logic Approach were performed by Febry Yuni in a research entitled Guava (Psidium guava) Ripeness Classification Using Fuzzy Method [11], and Meenu Dadwal in a research entitled Estimate Ripeness Level of fruits Using RGB Color Space and Fuzzy Logic Technique [12].

Those researches conducted in one type of fruit/vegetable commodity. Only a few of the research has developed only one system to detect several different fruits, such as the research conducted by Andri and Paulus which identified ripeness using color content comparison method in chili, banana, and orange [4]. However, in previous studies, testing data and training data are not obtained continuously for the same object in ripeness growth on the tree, but on the fruit that has been harvested. Meanwhile, the observation of the fruit continuously will ensure the change of the fruit. As performed by Sutrisno, along ripeness process, the color, the taste, the texture, and fruit aroma encounter the change[13].
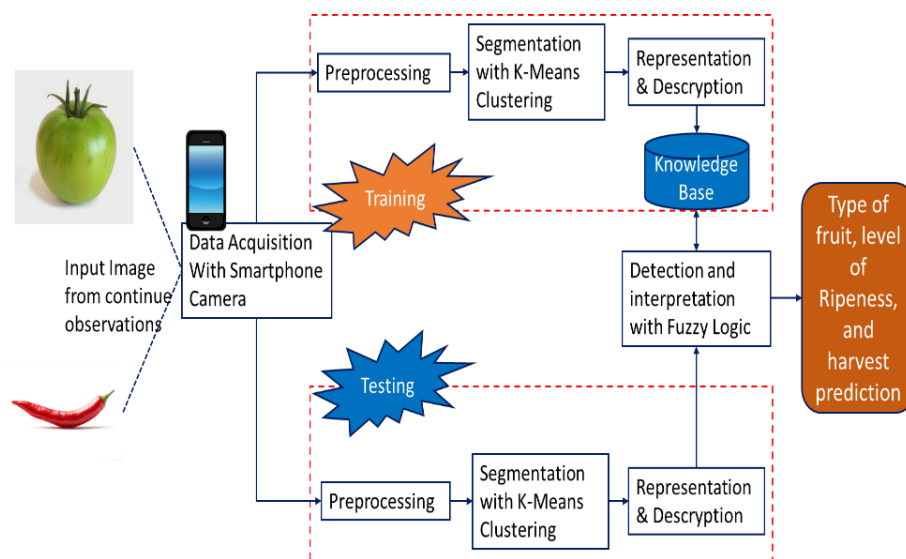
3. System Design
In this study, a prototype of ripeness detection system will be developed in 2 types of fruits, i.e. big chili and beef tomato. Tomato and chili are the fruit which easiest to detect the ripeness through its colour. On the other side, other fruits are not easiest to detect the ripeness through its colour, but also its hardness. Before detecting the ripeness, we added one segmentation step to determine the type of fruits using K-Means Clustering method because we used more than one types of fruit. Ripeness detection used fuzzy logic. Testing data used the same object continuously to see colour changing

which affect the ripeness. Along with the cultivating process to produce the fruits as an object of observation, the system training preparation was held to produce basic knowledge as the base to determine the ripeness conclusion at the testing time. Image data input for training process obtained sustainably from a farmer, it was not the harvested fruit image and collected from a market. Further, detection systems will be developed based on mobile devices.

The main process or function of the designed system consists of the function of tomato and chili information, the function of fruit detection and ripeness level including preprocessing by reducing the noise using median filter and thresholding, segmentation using K-Means clustering, and ripeness detection by fuzzy logic. The system also has a prediction feature of the harvest period.

These functions are illustrated by the system scheme in Figure 1.

Figure 1. System Scheme

4. Preliminary Results

As preliminary results, this article presents a temporary result as a temporary system prototype which was tested with some data using a personal computer. A preliminary test was performed partially in each step.

4.1 Training Data Acquisition

Collecting data of tomato and chili were taken periodically. The data were collected at 65 days, 75 days, 83 days and 90 days of planting. Fruits photograph was captured using cellular phone camera set in HDR with minimum 5 MB resolution. Tomato and chili captured periodically until harvest period.
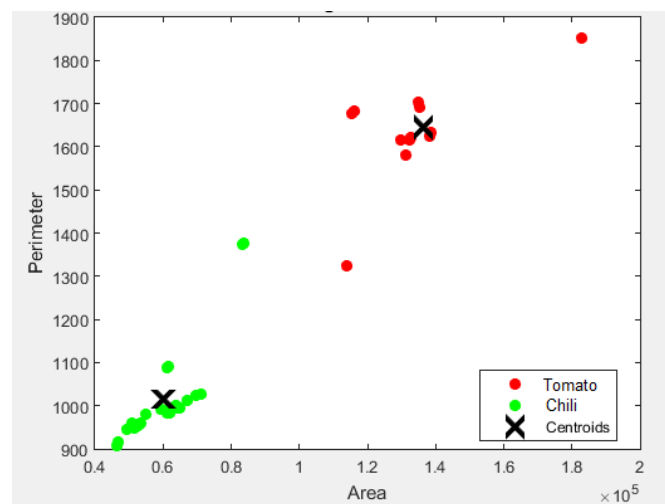
4.2 Preprocessing

The main step in pre-processing is reducing noise. The process of reducing noise eliminates noise such as the sharp spikes intensity spread in a whole side of an image. Noise reduction used the median filter.

4.3 Image Segmentation by K-Means Clustering

Segmentation using K-Means Clustering algorithm was applied to distinguish tomato and chili fruits. The segmentation used 2 parameters i.e. circumference and wide of fruit image.

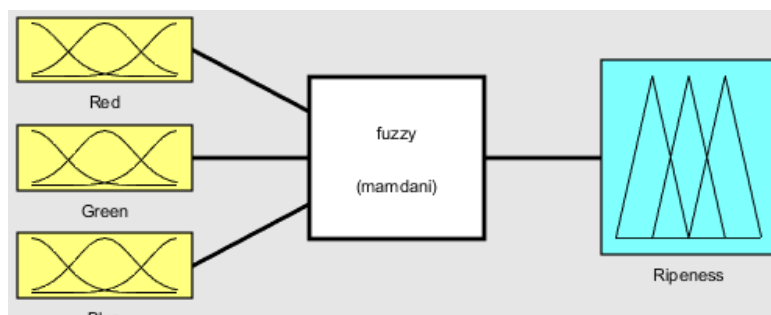Figures 5 showed tomato and chili clustering from each 10 samples.

Figure 2. Tomato and Chilli Clustering with K-Means

Visually, based on the object shape, the image divided into 2 groups i.e. tomato group and chili group. Each 10 data sample showed the accuracy in clustering process by 90% for tomato and 100% for chili. The incorrect segmentation is caused by the size of leaf circumference and leaf area look similar with a singular noun.

4.4 Image Recognizing and Interpretation
As explained in the method, the initial step for this detection system is image filtering to tomato and chili fruit images.

Before applying fuzzy process, it is prepared the concept of the control system. Following tables is the concept of the control system used in image recognizing by inputting Red (R), Green (G), and Blue (B) values, as depicted in Figure 3 below.

Figure 3. Fuzzy logic

The concept of control systems for input values is set forth in Table 1.

Table 1. Control System

Categories	Colour Value		
	Red	Green	Blue
Unripe 1	0 – 50	175 – 255	0 – 75
Unripe 2	51 - 150	100 – 199	25 – 150
Medium	100 - 199	51- 150	75 – 200
Ripe	175 - 255	0 – 50	135 – 255

The output rule is set as Table 2.

Tabel 2. Rules

No	Input			Output
	Red	Green	Blue	
1	Unripe 1	Unripe 1	Unripe 1	Unripe 1
2	Unripe 1	Unripe 2	Unripe 1	Unripe 1
3	Unripe 1	Unripe 2	Unripe 1	Unripe 1
4	Unripe 2	Unripe 1	Unripe 2	Unripe 2
5	Unripe 2	Unripe 2	Unripe 2	Unripe 2
6	Unripe 2	Unripe 2	Unripe 2	Unripe 2
7	Medium	Unripe 2	Unripe 2	Medium
8	Medium	Medium	Medium	Medium
9	Medium	Unripe 1	Medium	Medium
10	Ripe	Unripe 1	Unripe 1	Medium
11	Ripe	Unripe 1	Unripe 2	Medium
12	Ripe	Unripe 2	Unripe 1	Medium
13	Ripe	Ripe	Medium	Ripe

From 10 testing data of tomato, there are 2 data showed an incorrect detection, and it means the success level by 80%. Meanwhile, from 10 testing data of chili, there is 1 data showed the incorrect detection, and it means the success level by 90%. Total accuracy from both is 85%.

5. Future Works
The future works for this research are (1) Increasing testing data for each fruit samples in each ripeness level up to minimum 50 samples, (2) Implementation of smartphone-based applications, and (3) Testing of ripeness detection level and harvesting prediction mobile-based in varied ripeness level.

Acknowledgments

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