Image recognition based billing system for fruit shop using raspberry PI

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Abstract: This work describes a system that automatically does the billing of fruits in the retail market. Smart billing system is used for identifying and classifying the fruit types and to calculate the bill amount based on the type and quantity of fruits purchased by the consumer. Fruit identification is done using image processing technique and for weight measurement a load cell is used in the smart system. In this system an SVM classifier is used for fruit recognition. This smart billing system analyzes and classifies fruits successfully and bill calculation is performed accurately.

Keywords: fruit recognition, billing, raspberry PI, SVM classifier

1. Introduction

The demand for fruit classification has been increased in different areas such as defect finding, fruit quality evaluation, retail business etc. This paper describes identification of fruits in retail business where the identification is mostly done by the labour. The main objective of this work is to reduce the intervention of human being in bill calculation. Optimization is performed for all the features during feature selection process and linear support vector machine method is used for classification [1]. Different fruits are classified using Weighted K-Nearest Neighbours algorithm. Support Vector Machine algorithms is applied to differentiate the decayed fruits and fresh one. Colour and texture are considered for performing classification [2].

For multi class SVM classifier for different features such as colour, zone, area, centroid, size, equidiameter, perimeter and roundness are considered [3]. Three different classifications are performed to differentiate tomato from others, defected item from good tomato and type of defect in the tomato [4]. Machine Learning Techniques are used for classification of fruits and vegetables [12][14][15]. Machine learning techniques included Support Vector Machine, K-Nearest Neighbour, Decision Trees, Artificial Neural Networks and Convolutional Neural Networks are used for classification [5]. Features considered for the classification are colour, texture and shape. At first images of the fruits are captured using the camera then the preprocessing of images is done. The third stage is the image classification [6].

Fruit and Vegetable identification is done using machine learning for retail applications. A system is developed to classify fruits from the images [7]. Colour and shape features are taken to classify apple fruit varieties. Simple linear iterative clustering algorithm is applied to segment images. The colour feature extracted from blocks is used to determine candidate regions, which can filter a large proportion of non-fruit blocks and improve detection precision [8]. Automatic fruit recognition based
on DCNN is used [13]. Images were directly used as input to DCNN for training and recognition without extracting features; besides this DCNN learn optimal features from images through adaptation process [9]. Raspberry Pi used for implementing system in real time[11]

Here, SVM classifier is used to identify and classify the fruits effectively [10] Fruit classification is mainly based on their color and shape. First image is acquired by a camera and the image is converted into a gray image and the image is resized. Based on the extracted features the fruits are classified. In terms of hardware this system measures the weight of the fruits and calculates the bill accordingly. Numerous billing systems like barcode scanning mechanism based systems or tag based systems are available in the market. It is important to replace such existing system with better and robust systems. It is essential to have efficient billing management system in shopping places so that customers can avoid long queue on billing counter, save time and shop comfortably.

2. Proposed method
2.1. Hardware setup
The camera used for doing the experiment is QHM495LM PC. The camera has 25 megapixel resolution and compatible with Raspberry pi. The machine is trained for classifying different fruits. The image from the camera is given to the classifier. The classifier classifies the fruits. The system uses 10 kg load cell. The output from the load cell is in few millivolts. This electrical signal needs to be amplified. The electrical signal from the load cell is amplified using LM358 amplifier. This analog value is converted into digital by using ATMEGA8 analog to digital converter. The amount per kg is already fed to the system. The price of the fruit will be displayed accordingly in the monitor with their weights. Figure 1 shows the block diagram of the proposed smart billing system.

3. Methodology
3.1 Dataset collection
In this project 20 different fruit types were selected for training and testing. The chosen classes are apple, apricot, avocado, cherry, dates, grape, kiwi, guava, lychee, mango, mulberry, orange, papaya, peach, pineapple, plum, pomegranate, strawberry, and walnut. These fruits were chosen because some fruits have similar appearances and are frequently bought in retail markets. The dataset of all the types of fruits are placed in a single class. For example the class apple contains all type of apples such as apple golden, apple pink Lady, and apple red. There is no subclasses in the dataset. A dataset with 500 images per class has been collected from GitHub. The data set contains both GitHub images and self-collected images.
3.2 Classification algorithm
SVM classifier is supervised machine learning for classification problem. A hyperplane is used for classification. Here multi class classification is performed. In figure 2 the flow of fruit identification and billing is shown.

3.2.1 Fruit recognition:
Below are the steps explaining the flow of the fruit recognition system. The input is a dataset of 10000 images consisting of 20 categories of fruits. Cv2 module is imported to read the image and to convert it into gray style. The imread function is used to read the images. The cvt Color function which allows converting the image from a color space to another. The function receives two inputs. First input is the original image and the second input is the color space conversion code. COLOR_BGR2GRAY is the color conversion code for BGR color space to gray. To resize an image, resize () function is used. This function does not modify the user image; it instead returns another image with new dimensions (128*128). The SVM classifier using our training data and draws a line between two classes and considers a region about the line of some given width. Fit () method is used to fit a SVM classifier to the points. Scikit-learn algorithm accomplishes the training of our datasets. After being fitted, the model can be used to predict the fruits.

3.2.2 Bill calculation
Once the fruit class is predicted, the read weight functions read the weight as input and calculate the weight per kg. Go to step 3 for next fruit classification. If all the fruits are classified and weights are determined then add the all the price to calculate the bill.
4. Experimental setup
The camera is mounted on a tower in a board. The fruit to be recognized is placed on the board. The camera captures the image and sends the image to the Raspberry pi. The bill amount is displayed in LCD. The experimental setup is shown in figure 3. Raspbian language is used for programming the Raspberry Pi. SVM classifier is designed using standard libraries of Python. SVM classifier is trained using training images collected from Github and real time images. Here the testing image is classified based the training given to classifier. The load cell connected on the board is used to weigh the fruit. The inputs are taken and the bill amount is calculated. The class number and the corresponding fruit names are shown in table 1.

Table 1. List of fruits taken for classification

| Class  | Class name | Class  | Class name |
|--------|------------|--------|------------|
| Class1 | Apple      | Class11| Mango      |
| Class2 | Apricot    | Class12| Mulberry   |
| Class3 | Avacado    | Class13| Orange     |
| Class4 | Cherry     | Class14| Papaya     |
| Class5 | Dates      | Class15| Peach      |
| Class6 | Grape      | Class16| Pineapple  |
| Class7 | Kiwi       | Class17| Plum       |
| Class8 | Guava      | Class18| Pomegranate|
| Class9 | Lime       | Class19| Strawberry |
| Class10| Lychee     | Class20| Walnut     |

Figure 3. Hardware setup
5. Results
Billing of different fruits is experimented and accurate result is obtained. Classification has been done and its efficiency is calculated by doing experiments with twenty fruits. The system is trained with 500 images for each fruit. To evaluate the system 100 images were used as a testing image. Table 2 shows fruit recognition accuracy in percentage using SVM classifier. Cherry, Dates, Mango and orange are classified with 100% accuracy. Avocado, Grape, Kiwi and Walnut are classified 99% accurately.

Table 3 shows the confusion matrix of classification process. Strawberry has similar color or shape with other 8 fruits. Apple and Apricot has similar features.

| S.No. | Fruits   | Training Number | Testing Number | Correct Recognition Number | Recognition Rate |
|-------|----------|-----------------|----------------|----------------------------|------------------|
| 1     | Apple    | 500             | 100            | 46                         | 46%              |
| 2     | Apricot  | 500             | 100            | 72                         | 72%              |
| 3     | Avocado  | 500             | 100            | 99                         | 99%              |
| 4     | Cherry   | 500             | 100            | 100                        | 100%             |
| 5     | Dates    | 500             | 100            | 100                        | 100%             |
| 6     | Grape    | 500             | 100            | 99                         | 99%              |
| 7     | Kiwi     | 500             | 100            | 99                         | 99%              |
| 8     | Guava    | 500             | 100            | 95                         | 95%              |
| 9     | Lime     | 500             | 100            | 98                         | 98%              |
| 10    | Lychee   | 500             | 100            | 90                         | 90%              |
| 11    | Mango    | 500             | 100            | 100                        | 100%             |
| 12    | Mulberry | 500             | 100            | 65                         | 65%              |
| 13    | Orange   | 500             | 100            | 100                        | 100%             |
| 14    | Papaya   | 500             | 100            | 89                         | 89%              |
| 15    | Peach    | 500             | 100            | 72                         | 72%              |
| 16    | Pineapple| 500             | 100            | 97                         | 97%              |
| 17    | Plum     | 500             | 100            | 98                         | 98%              |
| 18    | Pomegranate| 500         | 100            | 81                         | 81%              |
| 19    | Strawberry| 500            | 100            | 69                         | 69%              |
| 20    | Walnut   | 500             | 100            | 99                         | 99%              |

This paper presented a system that uses an image recognition technique to identify the type of fruit and based on the result the bill amount is calculated for all purchased fruits. Manual intervention for identification and wrong billing is reduced by using the proposed system. By incorporating more training images that differ from the working environment could probably increase the percentage of accuracy. Classes can be subdivided into subclasses and grading of fruits can be done effectively. For example apple class can be split into apple golden, apple pink Lady, and apple red which are the types of apple. This will provide more accurate result for the consumer.
Table 3. Confusion matrix

|   | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|
| 1 | 46| 29|   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |
| 2 | 1 | 72|   |   |   |   |   |   |   | 1  | 11 | 9  | 6  |    |    |    |    |    |    |    |    |
| 3 |   |   | 99|   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |
| 4 |   | 100|   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |
| 5 |   | 100|   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |
| 6 |   |   | 1 | 99|   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |
| 7 |   |   |   | 95| 5 |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |
| 8 |   |   |   |   | 1 | 1 | 98|   |   |    |    |    |    |    |    |    |    |    |    |    |
| 9 |   |   |   |   |   | 7 | 90| 1 | 2 |    |    |    |    |    |    |    |    |    |    |
| 10|   |   |   |   |   |   | 1 | 2 |   |    |    |    |    |    |    |    |    |    |    |
| 11|   |   |   |   |   |   |   | 100|   |    |    |    |    |    |    |    |    |    |    |
| 12| 1 | 1 | 7 | 6 | 11| 1 | 1 | 65| 8 |    |    |    |    |    |    |    |    |    |    |
| 13|   |   |   |   |   |   | 1 | 100|   |    |    |    |    |    |    |    |    |    |
| 14| 1 | 1 | 2 |   |   |   |   | 89| 2 | 2  |    |    |    |    |    |    |    |    |    |
| 15| 11| 1 | 1 | 1 |   | 3 | 72| 3 | 8 |    |    |    |    |    |    |    |    |    |
| 16|   | 1 |   |   |   |   |   | 97| 1 | 1  |    |    |    |    |    |    |    |
| 17| 2 |   |   |   |   |   |   |   | 98|    |    |    |    |    |    |    |
| 18| 8 | 1 | 2 | 2 |   | 5 | 1 | 81| 1  |    |    |    |    |    |    |    |    |
| 19| 10|   | 2 |   | 8 | 4 | 3 | 4 | 69 |    |    |    |    |    |    |
| 20|   |   |   |   |   |   |   |   |   |    |    |    |    | 1 | 99|    |    |

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