A Novel Method of Billing System Using Deep Learning

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Abstract. In order to make the billing process of goods easier and quicker for the customers as well as the shopkeepers, the RFID tags and the bar-codes are used in most of the products. But for the edible products like fruits and vegetables, these tags cannot be used as each item has to be stuck with the tag and its weight must be measured individually. To overcome this, a system is designed in which the weighing and billing of the fruits and vegetables are automated. The proposed billing system consists of Raspberry pi, a microprocessor with a camera module and a load cell. Using Raspberry pi 3 camera module, images of fruits and vegetables are captured and are recognized by using the deep learning technique, ImageNet which is built on Convolutional Neural Network (CNN) architecture and a machine learning technique, K-means clustering is used for classifying the products into corresponding groups. The camera module captures the images of the fruits and vegetables placed on the tray under which the load cell is placed for the weighing purpose. The price of various items per kg is given as an input to the microprocessor. As a result, the Raspberry pi computes the total cost of the items and displays it on the monitor. The general-purpose high-level programming language, Python is used for developing the efficient deep learning algorithm.

Keywords - Raspberry Pi, Load Cell, K-means, CNN

1. INTRODUCTION

With the advancement of technologies, works have become more and more easier and quicker, therefore making our life cozier compared with the ancient times. Many new technologies have evolved in the recent times such as artificial intelligence, blockchain, cloud computing, internet of things, data mining, augmented reality and virtual reality, etc. In this project, a deep learning technique CNN and machine learning technique, K-means clustering has been used to automate the process of object recognition without any manual intervention. Deep Learning (DL) is a part of Machine Learning (ML), which is a part of Artificial Intelligence (AI). The word “deep” in the deep learning refers to the number of layers the data had undergone to get transformed. Deep Neural networks are a list of algorithms that imitates the operations of a human brain to recognize the relationships between the different sets of data. Neural networks play a very important role in the text classification, information extraction, decision making, speech recognition, etc. Its contribution towards the development of world is remarkable, from Google’s assistant to apple’s Siri, in financial services, from estimating and marketing research to fraud detection and risk judgement.
The aim of this project is to design a system which makes the billing process easier by using the deep learning algorithm efficiently for identifying the different types of edible fruits & vegetables on the billing desk and to automate the weight measurement using load cell to estimate the cost of the procured items and produce the bill.

2. LITERATURE SURVEY

The primary aim of this novel low-cost intelligent shopping cart is to deliver people with a technology related, cheap, user friendly and effective system to aid in shopping by implementing an embedded system into it. This system also decreases the time required for purchasing. This system mainly consists of 4 parts namely Location Detection unit, server communication unit, user interface and display unit, automatic billing and checklist management unit. [1]
This system is mainly dealt with the wireless communication technologies for efficient, cost effective RFID (Radio-Frequency Identification) based smart shopping since shopping consumes a lot of time especially during weekends and holidays at malls in cities. Its main components are RFID tag and RFID reader. [2]
This system is proposed to provide an intelligent shopping cart system which helps in tracking of purchased products and online money transfer with the help of RFID and Zigbee. In this, every product is provided with RFID tag and cart is provided with RFID reader and Zigbee. In addition to that, this system also assists people by giving suggestions based on purchase history from a consolidated system. It also consists of RFID reader at the exit gate for anti-theft. [3]
An IoT based smart shopping system is constructed in which RFID tag and RFID reader plays a major role. RFID tag is attached to each product and RFID reader is fixed to the cart. When the customer buys a product, the RFID tag in the product will be scanned using an RFID reader.[7]

3. BLOCK DIAGRAM

The major components used in the design of automated billing system for fruits and vegetables is shown in Fig. 1. The image of the fruits and vegetables placed on the tray under which the load cell is placed is captured by the camera module. Using deep learning algorithm, the fruits and vegetables are recognized and clustered. By using the load cell, the items present on the tray are weighed.

The recognized fruits and vegetables are recorded on the billing page along with the weight measured by the load cell. The cost of various items per kg is already fed as an input to the microprocessor for calculating the total price of the items procured. As a result, the Raspberry pi computes the total cost of the items and displays in the monitor.

![Figure 1. This shows an entire block diagram of the automated billing system for fruits and vegetables.](image-url)
4. COMPONENT DESCRIPTIONS

4.1 Raspberry Pi 3 Model B

Raspberry pi is a 40-pin single board computer that runs Linux. It also consists of a set of GPIO (General Purpose Input/output) pins through which power supply, monitor, keyboard and mouse can be connected and used. Memory card is inserted in the pi to store the data. There are so many different types of models in Raspberry Pi. Most of the models contain 40 pins. It uses languages like python, C, C++, scratch, java and ruby. Raspbian software is a special version of Linux built specifically for the Raspberry pi. This software is packed with all the basic operation of a computer. Raspberry pi serves as a low-cost but high-performance computer which is mainly used for the studying purposes.

4.2 Raspberry Pi 3 Model B Camera Module

The Raspberry Pi Camera module is a high quality 5-megapixel Sony IMX219 image sensor designed for Raspberry pi and it has a fixed focus lens. The board is very small at around 25mm x 20mm x 9mm and weights just 3 grams. It is supports 1080p30, 720p60 and 640 x 480p60/90 video and still images. In terms of still images, the camera module can take 2592 x 1944-pixel static images. To interface this in Raspberry pi, the ribbon cable of the camera module is connected to the CSI (Camera Serial Interface) port on the raspberry pi. This module is perfect for applications where size and weight are mainly considered such as mobile phones.

4.3 Load Cell

The transducer, load cell converts force such as tension, pressure, compression, or torque acting on it into an electrical signal which can be measured. There are many types of load cells – Resistive load cells work on the principle of piezo-electricity and the capacitive load cells work on the principle of change in the capacitance.

In resistive load cells, several strain gauges are attached to the load cell by using an elastic member. The load cell used in this project has four strain gauges attached above and below the load cell. When a force is applied on the load cell, the elastic member deflects, and the strain is created at the locations where the force is applied. As a result, two of the strain gauges are in compression, whereas the other two strain gauges are in tension. Wheatstone bridge is used to convert the change in resistance in the load cell into its corresponding equivalent voltage.

4.4 Algorithms Used

The Deep learning technique is used for the feature selection because of the following reasons. Despite taking plots from the original image, deep learning reduces the dimensions of the images by passing the original image through a neural network. The Neural network also suggests selective plots. By adding the additional deep learning algorithm, this network gives prediction as close to the original bounding box and ensures more tighter and finer bounding box predictions.

By using deep learning technology, single deep neural network can be used to solve all the problems by itself, despite training different neural networks for solving each problem. The benefit of doing this, is that each part of the neural networks helps in enhancing the other parts of that network, this will support in jointly training the entire deep model. Hence, it gives best output performance compared to all other
approaches. There are two approaches in deep learning viz., developing algorithm from scratch and transfer learning.

Convolutional Neural Network (CNN) is a commonly used algorithm in Neural network. Convolutional Neural Network (CNN) can be used for all type of classification problems. There are three important layers which are named as convolutional layer, Pooling layer and fully connected layer.

**Figure 2.** The process of Convolutional Neural Network.

- **Input layer:**
  The input is typically an RGB image (Width*height*depth). The role of CNN is to reduce the image in a form which is easier to process without losing important features for getting a good prediction.

- **Convolution layer:**
  The data will iteratively expand and compress. So different patterns will occur. Based on the different types of filters we use; we will get different types of patterns.

- **Pooling layer:**
  Typically, pooling is used to reduce the amount of data. Once we done the convolution, we will end up with the large number of data so compress the data using pooling function. There are two types of pooling: Max pooling and average pooling. Convolution followed by pooling is repeated process to obtain important features from an input image.

- **Fully connected layer:**
  The output of the pooling is giving into the fully connected layer. We must feed the input data one by one. We typically flatten the data in fully connected layer as a vector input.

- **SoftMax layer:**
  Output of fully connected layer is given to SoftMax layer. Output neuron passes through SoftMax, so the output of each neuron shows the probability between 0 and 1. The data values which are close to 1 is the output of actual class for the given input image.

\[
S(y_l) = \frac{e^{y_l}}{\sum_j e^{y_j}}
\]

In this project, the second approach viz. transfer learning is used. Transfer learning is a method where existing model is used as base for the design. Here, ImageNet model is used for transfer learning where the image information such as RGB, texture, shape and features of images are taken as attributes. ImageNet is built using Convolution Neural Network Architecture (CNN). By using K-means clustering algorithm, the fruits and vegetables are classified into their corresponding groups.
5. RESULT AND DISCUSSION

The circuit diagram for connecting the load cell and the pi camera with Raspberry Pi is shown in the Figure 3. The deep learning technique, ImageNet to detect fruits and vegetables is tested initially with images of fruits and vegetables and the output is shown in Figure 4. Vegetables and fruits are placed on the tray under which load cell is connected. Load cell measures the weight of the fruits/vegetables and records it in the billing page on the monitor connected to the Raspberry Pi. Weight per kg of individual item is mapped with its corresponding labels of the fruits and vegetables in the developed algorithm K-means clustering. The cost is calculated based on the preloaded item value per kg and is displayed on the monitor.

Figure 3. This shows the connection of Pi camera and load cell through HX711 with the Raspberry Pi

Figure 4. Fruits classification and labeling using deep learning model by feeding an input of mixed fruits image to the Raspberry Pi

The cost of the fruits/vegetables is updated at regular intervals whenever there is a change in the market rate. The results obtained for the Automated Billing using Deep learning is shown in Table 1.

| Item      | Per Kg Cost | Measured Weight | Cost of the item (Rs) |
|-----------|-------------|-----------------|-----------------------|
| Potato    | 20          | 1kg             | 20                    |
| Tomato    | 10          | 2kg             | 10                    |
| Onion     | 100         | 500g            | 50                    |
|           |             |                 | **Total Cost**        | **80**                 |
6. CONCLUSION

In this project, a system is designed which can detect over 100 varieties of fruits and vegetables. The accuracy of the system detecting fruits and vegetables is 95%. The proposed system is mainly developed to make the billing process of edible products like fruits and vegetables easier and quicker. By implementing this system, the time is saved for the buyers as well as the sellers. And it also reduces the manpower. The overall cost of this system is very low, and its accuracy is very high.

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