Automated Sorting of Tomatoes Using Deep Learning Algorithm

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Abstract

Tomato is an important fruit in our day-to-day lives. Therefore, it is necessary to sort a tomato based on that colour for the export market. The crucial characteristics of our fruits and vegetables are appearance. In this paper, our goal is to provide better quality tomatoes to the market standards and differentiate the tomatoes like green and ripe tomatoes unripe tomatoes based on their colour. Deep learning is getting a lot of attention these days, and achieving unprecedented levels of accuracy. The machine learning techniques have a great scope to provide an intelligence system to provide automation. CNN and RNN algorithms are used to improve the accuracy of the tomato sorting. Framework is used to realize the feature extraction of tomatoes. Its increases the accuracy and timing speed by using python programming.

Keywords: Convolution neural network (CNN), Deep learning algorithm (DLA), Recurrent neural network (RNN), Artificial Intelligence (AI) and Sorting.

I. Introduction

In the agriculture sector, tomatoes are regarded as a well-recognized fruit as millions of people consume it every day. With a growing world population, the demand for tomatoes is found to be higher than its production. Therefore, sorting strategies must be focused in order to increase production. However, labor cost is one of the limiting factors in the tomato industry as well as various agricultural industries. Computer vision based intelligent systems are fetching a major part of agricultural product maintenance and it is increasingly used to improvement yield and efficiency. Stages of tomato maturity are

classified as mature green, yellow or pink color appearance and red color (Yamaguchi, 1983). Sorting of tomatoes is accomplished based on appearance, texture, shape and sizes. Also, neural network-based computer color vision is good inspection systems for tomatoes (De Grano and Pabico, 2007). Shibata et. al. (1996) developed a method for evaluating tomato ripeness, utilizing its surface color using a machine vision system with color image processing capability and a multi layered neural network-based software system. Iraji and Tosinia (2011) proposed an efficient and accurate method for tomatoes sorting. They extracted features from tomato images. Adaptive fuzzy neural network method was used for accurate and appropriate decision on classification tomatoes. The results showed that the proposed system had less error and the system worked more accurate and appropriative than prior methods. Ukirade (2014) designed a system to perform classification of tomato maturity based on color. Image processing techniques including image acquisition, image enhancement and feature extraction were implemented in the system. The collected images were converted to color space format (HSV) to improve image quality. A Backpropagation neural network used Matlab software and its image processing toolbox used in the analysis.

Although many researchers have used machine vision technologies, there is still a significant need to develop a more accurate, reliable and automated sorting machines software like Artificial Intelligence, deep learning algorithm, convolution neural network, Recurrent neural network. Here we have used python program in the CNN algorithm and RNN algorithm to check the quality of tomatoes. The tomatoes where checked with colour to differentiate green, ripe tomatoes, unripe tomatoes.

A convolution neural network is a type of artificial neural network used in image identification and processing that is specifically designed to process the image data. To collect the data set image to given for testing and training by using keras library in python. In RNN it is one of the deep learning algorithm it is also used the image identification it maintain the accuracy. It also used same process to test and train the dataset images.

II. Convolution Neural Network

The machine learning is a rapid and consistent technique, which has expanded into the food industry. Themachine learning algorithms are used for grading of fruits, to detect the defects and has increased during the recent years. In this, there are two types of algorithms; they are supervised and unsupervised algorithms. In supervised algorithm convolution neural network (CNN) has been used. CNN is used to train the input RGB image, CNN involves the convolution layer which can extract low level features such as edges and colors. Tomato sorting using convolution neural network (CNN) to provide the better quality products and differentiate the green, ripe tomatoes, unripe tomatoes. The classification was based on maturity level, for each of the three classes.

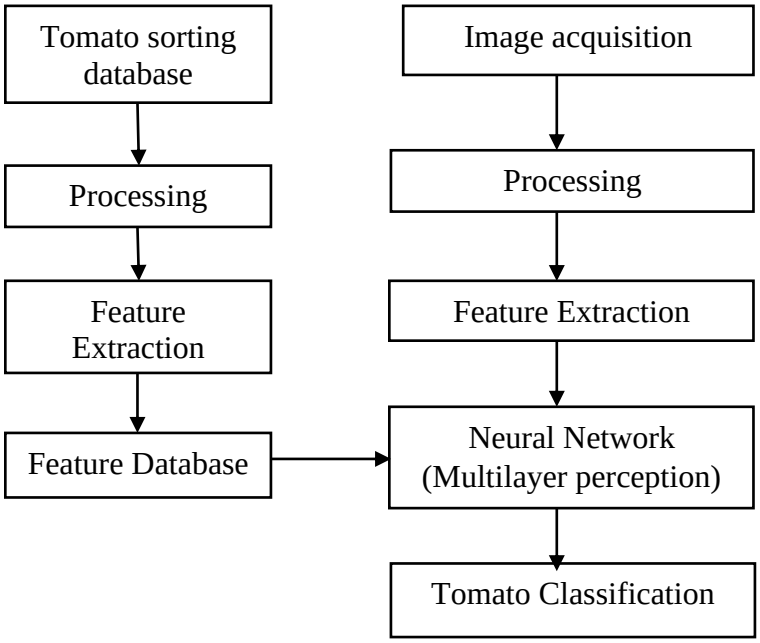


Figure.1 Block diagram

The image of the tomato is taken and preprocessing is done to enhance the image data. The segmentation is required, which separates a digital image into distinct area as shown in figure 1. The major function is to separate the background during feature extraction. The features are provided to CNN model.

CNN is a deep learning approach that is widely used for solving complex problem, which overcomes the limitations of traditional machine learning algorithms. It is a feed-forward neural network architecture. that is generally used to analyze visual images by processing data with grid-like topology. It's also known as a ConvNet. A CNN model is considerably used to detect and classify objects in an image when compared to other model due to the following reasons. First the key interest for applying CNN is that the weight sharing due to which number of parameters needed for training is reduced. Secondly the implementation of this model is used in various domain.

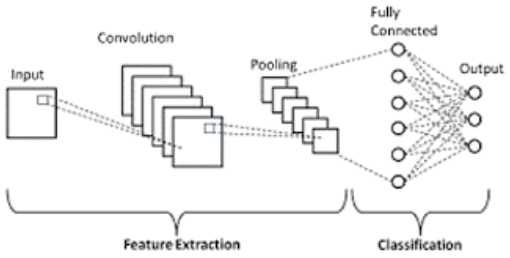
Basic CNN model

The typical model of ANN has single input and output layer along with multiple hidden layers. A particular neuron takes input vector X and produces output Y by performing some function F on it, represented by general equation (1) given by

$$f(x, w) = y \quad \text{--------(1)}$$

where, W denotes the weight vector, CNN is a model has multiple hidden layers that is achieving attention because of its classification capability based on contextual information. A general model of CNN as shown in figure 2, consists of four components namely (a) convolution layer, (b) pooling layer, (c) activation function, and (d) fully connected layer. Functionality of each component has been illustrated below.

Figure.2 Basic CNN model Convolution Layer



Numerous filters work together to accomplish the convolution action in a convolution layer. Each and every image is viewed as a 3x3 matrix of pixel values. To obtain the convolved feature matrix, slide the filter matrix over the image and compute the dot product. From the input image, this method extracts N number of characteristics.

Pooling Layer

To distinguish distinct portions of the image, such as edges, corners, bodies, feathers, eyes, and beak, the pooling layer employs a range of filters. Flattening is the procedure's following phase. The generated 2-Dimensional arrays from pooled feature maps are all flattened into a single, lengthy continuous linear vector. A window is chosen to do the pooling operation, and the input items found there are then fed through a pooling function, which creates a new output vector. There are only a few pooling methods, such as average pooling and max-pooling; max-pooling is the most used method and considerably reduces map size.

Fully Connected Layer

The fully connected network in traditional models is similar to the fully connected layer. The fully connected layer receives the output of the first phase, which includes repetitive convolution and pooling, and computes the dot product of the weight vector and the input vector to produce the final output.

Activation Function

The usage of the sigmoid activation function in traditional machine learning methods is extensively documented in the literature. If x0, the function activates as x, where is a tiny constant, and otherwise it activates as f(x)=x.

Thus, the three different types of tomatoes—green, ripe, and unripe—were classified using the supervised algorithms. The division was made according to maturity level. 20 tomatoes for each of the three classes. These tomatoes weren't the same as the ones that were utilised for practise and testing.

CNN Algorithm

CNN is an efficient recognition algorithm, which is widely used in pattern recognition and image processing.It has many features such as simple structure, less training parameters and adaptability.

Flow chart

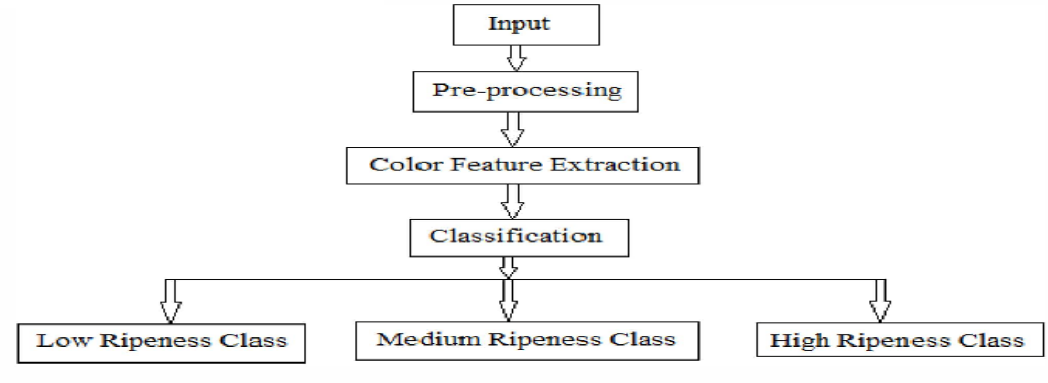


Figure.3 Flowchart of CNN model

III RNN Algorithm

RNN continuously gathers on image feature recognition. Although RNN can potentially be used for picture classification, there aren't many studies about RNN image classifier.

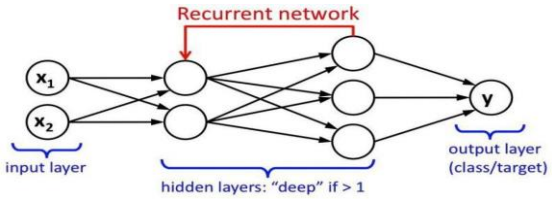


Figure.4 RNN Architecture

Figure 4 illustrates how an RNN architecture might define a special cell that could handle layered input and output. Create a hierarchical input/output RNN model. Training the model with data provided at random.

After the features are extracted using CNN, feature maps with predetermined sizes are produced for placement and classification. The RNN's enhancement involves the optimization of the ROI Pooling layer into the ROI Align layer and the addition of a hidden branch while performing the final classification and positioning so that the shapes of lesion spots on the tomato may be precisely segmented.

Flowchart

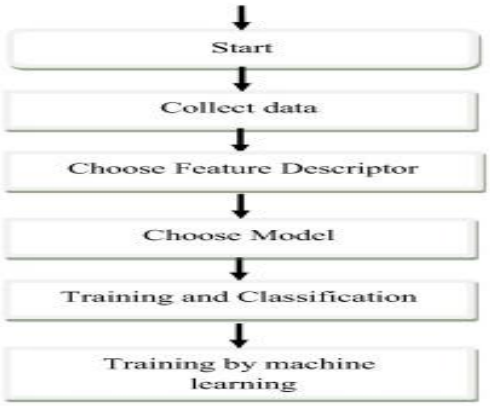


Figure.5 Flow Chart for RNN Architecture

IV Result

In proposed RNN algorithm compare to CNN algorithm, it gives high accuracy. To collect the dataset in keras and tensor flow in python.

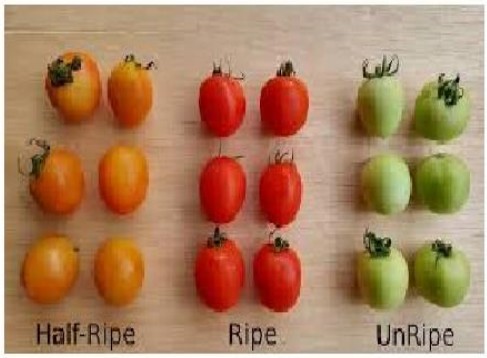


Figure.6 Collection of dataset images

The training and testing procedures for CNN's classification methods. The dataset was used to produce useful findings. This image shows the AI-based method used to categories tomatoes. Although the theoretical classification accuracy was achieved to perfection, the experimental classification accuracy for the green, ripe, and unripe was 100%, 100%, and 90%, respectively. The classification performance of the two classes was in line with the theoretical performance, although there was a 10% reduction in classification performance for the defective class. These findings suggest that for industrial sorting machines, it is recommended to continuously assess the classification's performance over an extended period of time and re-train the network accordingly, using

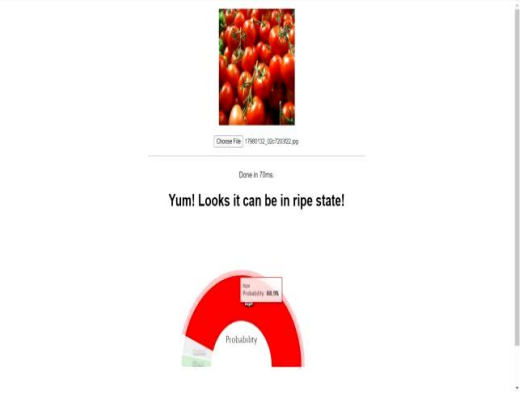


Figure.7 Ripe state & Medium Accuracy 88.9%

a new batch of samples, to ensure a continual near-optimal classification.Virtual-env is a tool to create isolated Python environments. Since Python 3.3 is used, a subset of it has been integrated into the standard library under the virtual-env module.

Table 1. Comparison between CNN and RNN Algorithm

METHOD	DATA RATIO	ACCURACY	SENSITIVITY	PRECISION
CNN	75:70	87%	95%	75%
RNN	78:73	99.98%	96%	95%

Table 1 shows the parameters like accuracy, sensitivity and precision for CNN and RNN algorithms. The RNN algorithm provides the better result. Table 2 shows the accuracy of

identification of ripe tomatoes from immature and half-ripe tomatoes. The current study simultaneously considered maturity, defects, shape, and size in one algorithm as sorting factor.

Table 2. Calculated accuracy of each sorting type

Sorting type	Expert identification		System identification		Accuracy
	Good	Bad	True	False	
Defect	68	32	90	12	90.00%
Shape	40	15	50	5	92.90%
Size	28	27	52	3	95.54%
Maturity	37	13	46	4	95.00%

V Conclusion

The effectiveness of the most well-known convolutional and deep learning neural network techniques was examined in order to raise tomato sorting algorithms' classification accuracy. For the categorization of green, ripe, and unripe classes, this study used the CNN and RNN algorithms. The CNN generated a detection accuracy rate of 100%. The green, ripe, and unripe classifications were not correctly classified by the CNN algorithm. These two categories were so categorised as difficult. The RNN network's greatest detection accuracy readings.

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