Fruits Classification using Convolutional Neural Network

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Abstract

Automation of fruit classification is an interesting application of computer vision. Traditional fruit classification methods have often relied on manual operations based on visual ability and such methods are tedious, time consuming and inconsistent. External shape appearance is the main source for fruit classification. In recent years, computer machine vision and image processing techniques have been found increasingly useful in the fruit industry, especially for applications in quality inspection and color, size, shape sorting. Researches in this area indicate the feasibility of using machine vision systems to improve product quality while freeing people from the traditional hand sorting of fruits. This paper deals various image processing techniques used for fruit classification.
Keywords- Fruit, Feature Extraction, Neural Network, Convolution Neural Network (CNN), Fruit Classification

I. INTRODUCTION

Machine vision system for fruit classification is one among the current topic that is under research in the agriculture industry. As a part of this current research area, this fruits classification using image processing techniques was developed. This classification of fruits can be used to identify a fruit and generate its price automatically in a shop or supermarket. As an initial step in this proposed methodology classification of 7 fruits was done. Even agriculturist will be benefited if an automation machine vision exits to classify different variety of fruits and vegetables in the agriculture industry.

Fruits provide an essential role as a food in our everyday life. It provides nutrients vital for our health and maintenance of our body. Those who eat more fruits as a part of a healthy diet are likely to have reduced risk of some chronic diseases. However, not all fruits are treated equally and it is a matter of concern that not every person knows about every fruit well. With the help of Artificial Intelligence (AI) and Machine Learning (ML) this research can develop an automatic fruit classification system with an information dataset of each fruit. This system can help us to select fruit that is suitable for us and teach us about the characteristics of that particular fruit. These types of systems can help us to educate children and familiarize them with fruits. Furthermore, these systems can be used to teach a robot to find the correct fruit for its user and this becomes much important for those robots which are being used for fruit harvesting related works. Another major application of fruit detection and recognition is at smart refrigerator. Now a days smart refrigerator can detect how fresh a fruit is, how many of which kind of fruits are left, which fruits are less in amount and need to be added in the shopping list. As people have more access to health information, it is often found that recommendation of healthy food is very essential. While shopping, an automatic fruits classification system connected to information database can help the consumer to select healthier fruit along with nutrition details. Also, in recent time super shops use these kinds of systems to provide information about each type of fruit to customer, to keep track of the sold and in stock product and also to identify the most demanding fruit item. Even on-line shopping sites can use such automated system very easily. For all these functions a proper fruit detection and recognition system is a must.

II. METHODOLOGY

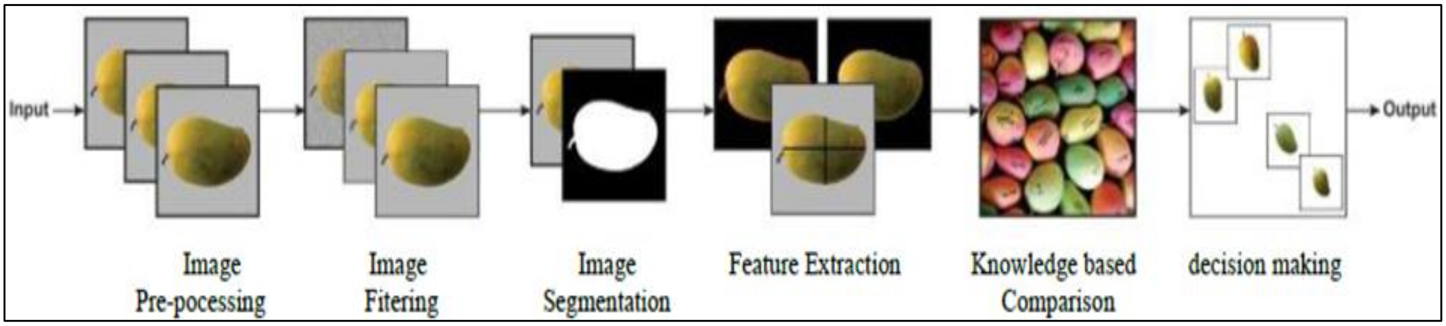

Fig. 1: Flow of fruit classification process

A. Samples used

For experimentation a total of 1260 images were taken for training and 140 images was taken for testing. Out of these 1260 training images, 180 apple images [red variety], 180 banana images [yellow variety], 180 mango images [green variety] , 180 orange images , 180 pear images , 180 pineapple images and 180 strawberry images were taken and out of 140 test images 20 apple images [red variety] , 20 banana images [yellow variety], 2 mango images [green variety], 20 orange images, 20 pear images , 20 pineapple images and 20 strawberry images were taken.

B. Image Pre-processing & Filtering

This sections removes noise, sharp, smoothen the image also perform resizing of images. RGB images are converted to the grey images also contrast of image is increased at certain level. Such preprocessing operations are also named filtration.

C. Image Segmentation

Segmentation is used for partitioning an image into various parts. The goal of image segmentation is to simplify and / or change the representation of an image, which is more meaningful and easier to analyze. Image segmentation methods are categorized on the basis of two properties of discontinuity and similarity. Methods based on discontinuities are called boundary-based methods, and methods based on similarity are called region-based methods.

D. Feature Extraction

Next step in fruit classification process after segmentation is feature extraction. Main and important visual external features for fruit are its color, size, shape and texture. Feature descriptor is a representation of an image or part of it, which extract useful information and discards unnecessary information. It is mainly used for image recognition and object detection.

E. Knowledge-based Comparison and Decision Making

The comparison of the extracted features from the image takes place with the predetermined classification and sorting criteria or the rules. The features are compared on the basis of the extracted features and classification is made are given to the fruits. The knowledge-based comparison and decision-making have been made using Convolutional neural network algorithms. This algorithm is explained in section 4. This is the final step of the classification system.

III. DATASET

For training and testing, all the pictures were chosen from the fruits 360 dataset, which is publicly available on Kaggle. The dataset contains 1400 different fruits pictures of 7classes.Each class represents one type of fruit. The chosen classes are apple, banana, orange, pear, mango, pineapple and strawberry. These classes are chosen because some fruits have similar appearances and are frequently bought in retail markets. Limitations to the data set has been done in order to not make the paper to extensive. These limitations are that all types of a fruit reside under the same class. This means all types of apples reside under the apple class and similar for each fruit. Images for the data set are collected from Image Net. Each class consists of approximately 200 images. After removing the background, all the fruits were resized to 100×100 pixels of standard RGB pictures. From the fruits- 360 dataset, has been selected 1400images from 7 different categories. Here has been used 1260 images (85%) to create the training set and the rest 140 images (15%) for testing the model. Table-1 shows the 7 categories of fruits we used for analysis.

A. Dataset Properties

1. Training set size: 1260 images
2. Validation set size: 140 images
3. Number of classes: 7
4. Image size: 100*100 Pixels

Table 1: Fruits in the Dataset

Name of fruits	Number of Training Fruits	Number of Testing Fruits
Apple	180	20
Banana	180	20
Mango	180	20
Orange	180	20
Pear	180	20
Pineapple	180	20
Strawberry	180	20

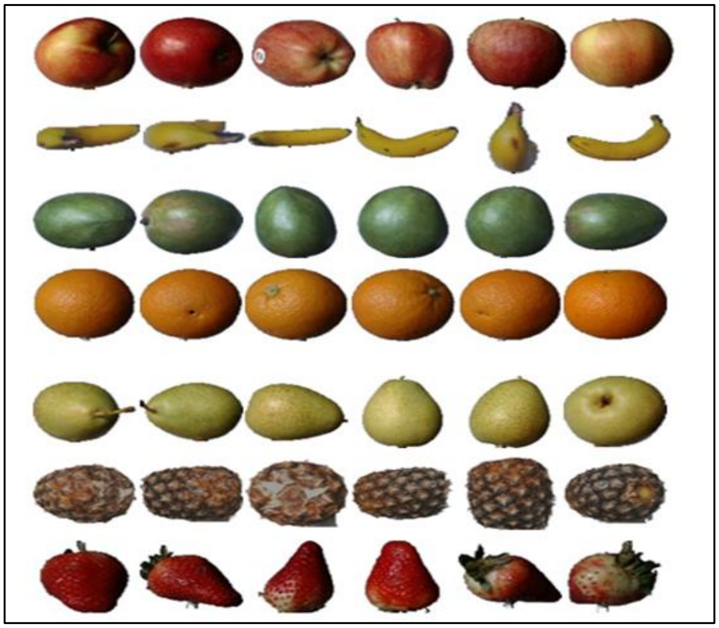

Fig. 2: Fruits Dataset

IV. CONVOLUTIONAL NEURAL NETWORK (CNN)

CNN is a multilayer, feed-forward neural networks (FFNN) which can quickly identify, classify, and recognize any features in an image. It is used mainly with visual data, such as image classification. A CNN can be prepared to do image analysis tasks including object recognition, segmentation, classification, and image processing. Large-scale image recognition has been become possible because of large public image databases such as ImageNet. CNN are networks made up of neurons similar to the human brain. Figure 3 shows an example of a CNN. These neurons consists of weights and biases that form layers and fire in a particular order to end up with a final output. The networks can be trained in order to recognize particular patterns by feeding them large amounts of data. This is very useful in the field of computer vision since it means that a computer can be trained to recognize different objects.

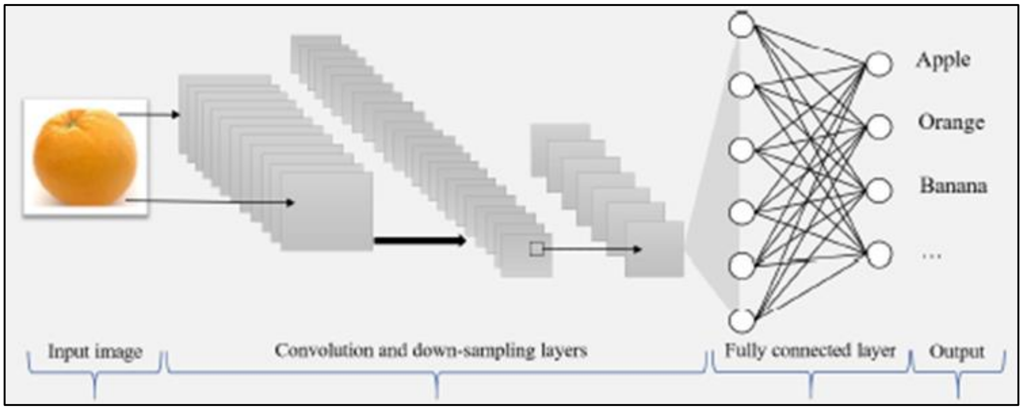

Fig. 3: A Convolutional neural network (CNN)

A. Mobile Net
In many real time mobile applications implemented with recognition tasks to identify certain objects or surroundings, light weight architectures are preferable to match the resource restrictions on the platforms. MobileNet is an architecture developed to function on mobile and embedded vision applications. MobileNet is used in Inception models and is built on depth wise separated convolutions to reduce the computation and model size. The depth wise separated convolutions splits the standard convolution method of combining and filtering in one sequence, into different layers. One layer for combining and one layer for filtering. This method reduces the computation size drastically. The architectures input layer takes an image of size $224 \times 224 \times 3$. Following the input layer is a stack of convolutional layers, one average-pooling layer and a fully connected layer. The kernel sizes of the convolutional layers vary between 3×3 and 1×1.The depth wise separated convolutions structure is clearly shown in the network. Almost 75% of the total parameters in the network are located in convolutional layers using a kernel of 1×1. This is what reduces the computation size.

B. Inception v3
Inception-v3 is the 2015 repetition of Googl's Inception structural design and a broadly used image identification network model that has been presented to obtain more than 78.1% accurateness on the ImageNet dataset. Inception is a remarkable structural design and it is the outcome of numerous cycles of test and error. It is a module of GoogleLeNet designed to function under strict constraints on memory and on a computational budget. In the ImageNet Challenge 2014, GoogleLeNet with the Inception v3 module, had the least error rate comparing to other architectures. With an average error rate of 6.66%, the network defeated all the other competitors. The Inception v3 module is 42 layers deep and uses BN in both the convolution layers and in the fully connected layers. At the start of Inception v3, is a sequence of three convolutional layers which takes an input image of $299 \times 299 \times 3$. The most unique part of the Inception network constitutes of the Inception modules.

C. ImageNet
ImageNet7 is a large scale image database. In 2009 ImageNet had over 3.2 million of images of over 5000 categories and has only expanded since. ImageNet is a popular database for collections of data sets to train neural networks and has since 2010 held the annual Large Scale Visual Recognition Challenge8 which has participants from more than 50 institutions. The variety of images makes the database a great source to train a neural network. ImageNet is a common data set to have as a foundation when applying training techniques on a CNN because of variety of categories the database provides.

D. TensorFlow
Tensorflow is an open source software for numerical computation. It was originally created to conduct machine learning and deep neural networks research. Tensorflow provides neural network architectures and scripts to retrain the networks for users who wants to apply them in different contexts.

E. Keras
Keras is an open-sourceneural-network library written in Python, which is used for the preprocessing, modeling, evaluating, and optimization. It is capable of running on top of TensorFlow. It is used for high-level API as it handled by backend. It is designed for making a model with loss and optimizer function, and training process with fit function. For backend, it designed for convolution and low-level computation under tensors or TensorFlow. Importing the python libraries are used for preprocessing, modelling, optimization, testing and display emotion which having a maximum percentage.

V. EXPERIMENTAL RESULT

In this paper, has been applied MobileNet on Fruit Dataset to discover the better classification performance of the network. From Fruits dataset, here taken 1260 images from 7 different categories: 85 % of the images from these are used for training, and 15 % are used for testing the model.

The network is trained for 10 epochs with a batch size of 14. The accuracy of the proposed model was 98.74 %. The comparison of the proposed model with the conventional models shows that the results of this model are exceptionally good and promising to use in real-world applications. This sort of higher accuracy and precision will work to boost the machine's general efficiency in fruit recognition more appropriately. As a prototype, a program was developed in Python with PyQt library in a Visual Studio environment. The appearance of the program is shown in Figure 4.

The dataset is created by the author. It contains 7 class of fruits. The neural network model which have been used for dataset. For the proposed recognition model evolution this paper organized this recognition model using its training and test images. For this test, the training image for each fruit was 1260 and test images were created from detection set of using this fruit classification approach.

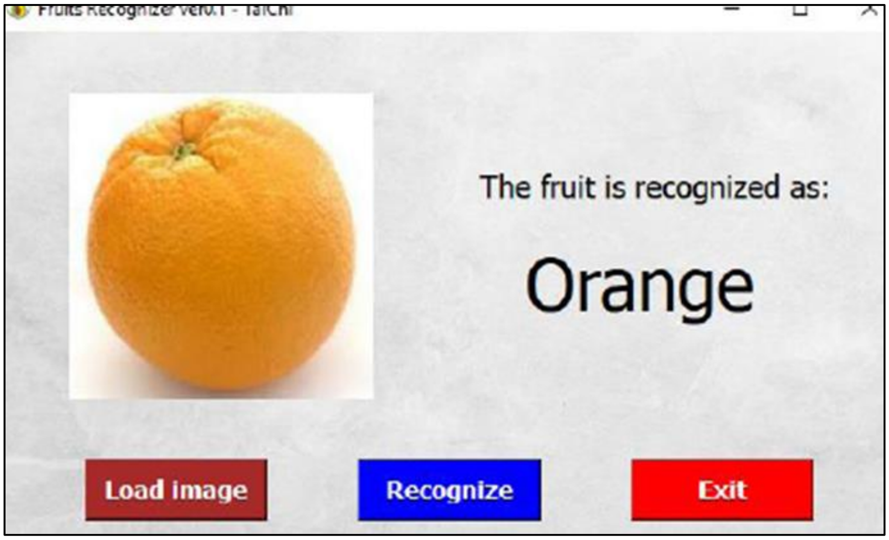

Fig. 4: Main window of the program

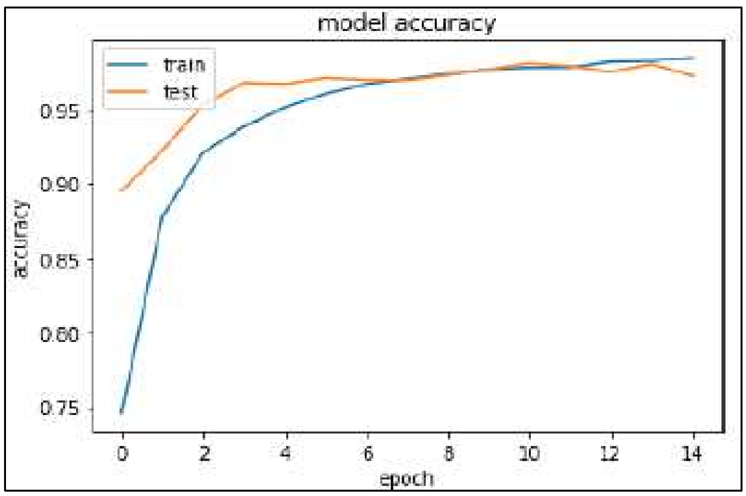

Fig. 5: convolution neural network accuracy

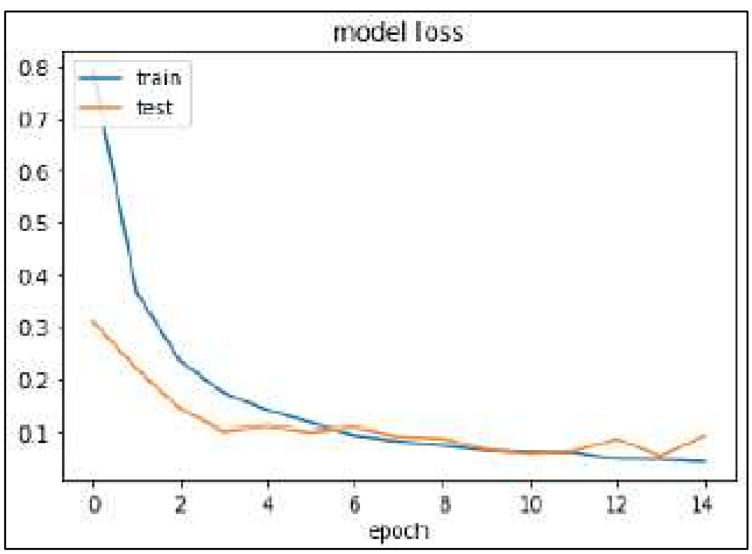

Fig. 6: convolution neural network loss

This figure clearly shows that, the model makes a good fit as here the testing error is lower than the training error. Running so many test cases, using dropout at a favorable label, checking early stopping at the end of an epoch give me a good model for classification.

VI. CONCLUSION

A new method for classifying fruits using convolutional neural network algorithm is proposed in this paper. The above listed results were obtained using 7 test samples taken out from the actual number of 180 and 20 images used for training and testing. The above algorithm was coded and tested using anaconda software. Different fruits varieties that had different backgrounds were taken for training and testing. The proposed algorithm gave 98% accuracy rate. This paper explores a fruits classification based on CNN algorithm. The accuracy and loss curves were generated by using various combinations of hidden layers for five cases using fruits-360 dataset. This paper deals various methods and algorithms used for fruit recognition and classification based on computer vision approach. CNN better performance to attain better fruit classification.

VII. FUTURE WORK

Hopefully, in the future, can be extended the work with a larger dataset having more categories fruits & vegetables.. Have the plan to implement some other CNN based models to compare the accuracy on the same dataset. Can be also work on some more features for grading and classification, which can identify types of disease and/or texture structure of fruits. All these are future direction.

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