Design and Implementation of Fruits Classification System using Machine Learning Algorithms

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Abstract

Detecting the rotten fruits become significant in the agricultural industry. Usually, the classification of fresh and rotten fruits is carried by humans is not effectual for the fruit farmers. Human beings will become tired after doing the same task multiple times, but machines do not. Thus, the project proposes an approach to reduce human efforts, reduce the cost and time for production by identifying the defects in the fruits in the agricultural industry. If we do not detect those defects, those defected fruits may contaminate good fruits. Hence, we proposed a model to avoid the spread of rottenness. The proposed model classifies the fresh fruits and rotten fruits from the input fruit images. In this work, we have used three types of fruits, such as apple, banana, and oranges. A Convolutional Neural Network (CNN) is used for extracting the features from input fruit images, and Softmax is used to classify the images into fresh and rotten fruits. The performance of the proposed model is evaluated on a dataset that is downloaded from Kaggle and produces an accuracy of 97.82%. The results showed that the proposed CNN model can effectively classify the fresh fruits and rotten fruits. In the proposed work, we inspected the transfer learning methods in the classification of fresh and rotten fruits. The performance of the proposed CNN model outperforms the transfer learning models and the state of art methods.

Keywords: CNN, Kaggle, Fresh Fruits, Rotten Fruits.

1. Introduction

The recent approaches in computer vision, especially in the fields of machine learning and deep learning have improved the efficiency of image classification tasks. Detection of defected fruits

and the classification of fresh and rotten fruits represent one of the major challenges in the agricultural fields. Hence, we need an automated system which can reduce the efforts of humans, increase production, to reduce the cost of production and time of production. The recent approaches in computer vision, especially in the fields of machine learning and deep learning have improved the efficiency of image classification tasks. Detection of defected fruits and the classification of fresh and rotten fruits represent one of the major challenges in the agricultural fields. Hence, we need an automated system which can reduce the efforts of humans, increase production, to reduce the cost of production and time of production. Image processing can help in the classification of the defect and non-defect fruits. Then pre-processing is carried out on the images and is given to a CNN model for the task of classification. The method can meet the requirements of the detection of apple defects, especially when the defect regions are similar to the stem and calyx regions in gray characteristics and shapes. In our work, the proposed CNN model provides high accuracy in the classification task of fresh and rotten fruits. We inspected the different pre-trained models of VGG16, VGG19, MobileNet, and Xception of transfer learning. This paper introduces a powerful CNN model which has enhanced accuracy for fresh and rotten fruits classification task than transfer learning models while investigating the effect of very important hyperparameters to obtain better results and also avoid over-fitting.

2. Literature Survey
1. Xuehua Chang et al proposed "Application of Computer Vision Technology in Post-Harvest Processing of Fruits and Vegetables: Starting from Shape Recognition Algorithm" IEEE-2022

The basic principles of computer vision and the basic components of computer vision systems are briefly explained; representative examples are selected, and the domestic and foreign applications in fruit and vegetable harvesting, fruit color detection, shape and size detection, damage detection and surface defect detection, are respectively introduced, and then the use of Gabor A method for filtering and extracting Gabor features of fruits and vegetables. The two-dimensional Gabor kernel function can more accurately describe the receptive field of simple cortical cells in the human visual system. Using Gabor filtering to extract fruit and vegetable image features can better represent the basic information of fruit and vegetable images and improve the recognition rate of fruit and vegetable images.

2. R.S. Latha; G.R. Sreekanth; R. Rajadevi; S.K. Nivetha; K.Ajith Kumar; V. Akash et al proposed "Fruits and Vegetables Recognition using YOLO" IEEE-2022

Real-time live detection of fruits and vegetables is the most important task to know the availability of the current stock of fruits and vegetables that the customers looking for in the vegetable market. For this problem, a new technique based on Deep learning and IoT is required. The proposed work has applied the YOLO model for identifying different types of vegetables and fruits available in the vegetable market and hence the customer can know the updates the livestock of fruits and vegetables in that shop. The images of commonly used fruits and vegetables in India are collected from Google and also from Kaggle. The collected images are labeled using the Roboflow framework. To implement the proposed model, YOLOv4 -tiny model is chosen which is a super-fast object detector with better accuracy and is also most suitable for embedded devices. Further, this tiny model performs fast prediction in real-time video processing scenarios. The result of the proposed system is evaluated using the metric

mean Average Precision (mAP). A high-value of mAP indicates that the model performs better is in its detection. Our YOLOv4-tiny model produced an mAP value of 51% with an inference time of 18 milliseconds.

3. Jayant Meshram; Ajinkya Mondhe; Akash Nachan et al proposed "Ripeness Detector for Vegetables and Fruits"IEEE-2022

The ripening and color transition of fruit and vegetables are closely related to each other. Changes in Chlorophyll, Carotenoids, flavonoids and other important pigments decide the color of fruit and vegetables. As fruit/vegetables ripe, over time, the number of these particular pigments changes, changing the color of the fruit or vegetables. Using this relationship based on color, and by using appropriate technology one can determine the ripeness(fully developed) of the fruit and vice versa for a particular fruit or vegetable. Ithas been shown that different color spaces produce different results with spectral analysis. Also, it is shown by researchers that L*A*B* colorspace is more effective than the others when it comes to working with spectral analysis of components. Using an artificial neural network, this research describes a system that uses the RGB color space to forecast the maturity stage of a fruit or vegetable.

4. Mia Cisneros-Santisteban; Rodrigo Ríos-Yáñez et al proposed "Lean Production Model for the reduction of losses in the packaging process in MSEs that distribute fruits and vegetables: A empirical research in Peru"IEEE-2022

The importance of the fruit and vegetable sector in the economy is fundamental since this sector, by constantly growing, reduces poverty in each country. According to the above, it is necessary to maintain a stable set of activities to carry out the processing of fruits and vegetables and the

distribution process to the final consumer. Considering these considerations, we will seek to reduce the percentage of losses in a Peruvian trading company that generates 2.3% more than traders in the same sector. For the implementation of pilot plans, as a solution to the

aforementioned problem, a Lean Manufacturing standardization model was used, managing to reduce the generation of waste in this company from 17% to 14%. Likewise, through a data simulation with the Arena software, the same results were obtained, which reaffirmed that the application of this methodology is ideal for the reduction of wastage in food marketing companies.

5. D.M. Charuni M.K. Dasanayake; M. Anusha Wijewardane et al proposed "Estimation of embedded energy of some selected vegetables in the vegetable value chain, Sri Lanka" IEEE-2022

Vegetable value chain is an energy intensive process. Embedded energy of the vegetables from farm to the retailer market has a significant impact on the market prices of the vegetables. However, the market price of the vegetable does not directly depend on the embedded energy cost of a particular vegetable as the availability of vegetables in the market varies depending on the different harvesting seasons in the calendar year. Sri Lanka is an agricultural country which is self-sustain for its total vegetable requirement. This study explains the estimation of embedded energy of some selected vegetables in the vegetable value chain of Sri Lanka.

3. Proposed System

The CNN model may be designed to learn from both the image data and the other relevant information such as the date of harvest and storage conditions. Testing the model: Testing the accuracy and effectiveness of the model using a test dataset, and adjusting the parameters of the

model accordingly. The model may be used to provide recommendations on the freshness of fruits and vegetables, or to automate quality control processes in food processing and distribution industries. The proposed system may also involve using advanced techniques such as transfer learning, data augmentation, and ensembling to improve the accuracy and generalization of the model. Transfer learning involves using pre-trained models as a starting point for training a new model on a specific task, while data augmentation involves generating new images from existing ones to increase the size of the dataset.
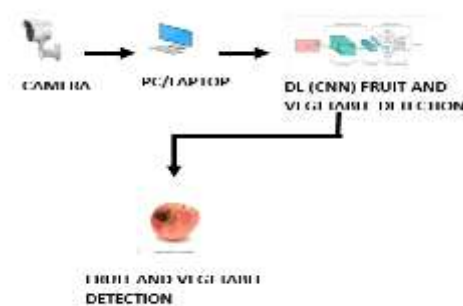

Figure.1. Process Diagram

4. Module Description

4.1. Image Dataset Collection

For this project, we must gather every image that makes a car appear to be Hand gesture. This is the project's most crucial step. Therefore, all of the visuals that we see come from real-time or recorded CCTV footage. The following procedures can be taken after we get the data.

4.2. Image Preprocessing

After gathering all the images, pre-processing is required. Thus not all images can convey information clearly. So that we may prepare the images by renaming, resizing, and labelling them. Once the procedure is complete, we can use the photos to train our deep learning model.

4.3. Importing Modules

Following that, we must import all of the required library files. Library files are collections of

functions and small execution codes. This library files will assist us in performing all of the

necessary steps of object detection and image processing. We use important library files such

as Tensor Flow, opencv, keras, and others in this project. These libraries will aid in making our

deep learning model more efficient and adaptable for processing real-time images or videos.

4.4. Camera Interfacing

One of the most important steps in image processing is computer vision. As a result, we must

connect the camera to our deep learning model. Because the computer will see all real-world

objects through the camera. This procedure will be carried out with the assistance of the opencv

module. To perform computer vision tasks, opencv is a well-known library. So, in this project,

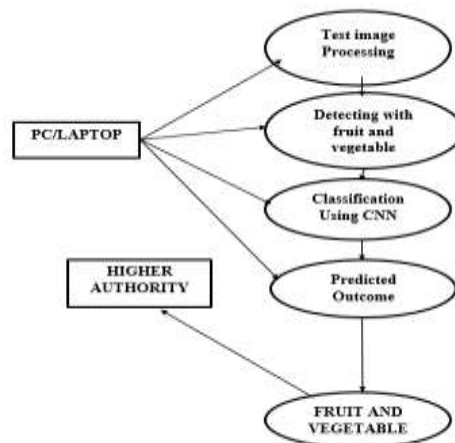we can use the opencv library to detect the hand gesture.

Figure.2. Flow Chart

5. Implementation in System Models

5.1. Python Numpy

Our Python NumPy Tutorial provides the basic and advanced concepts of the NumPy. NumPy stands for numeric python which is a python package for the computation and processing of the multidimensional and single dimensional array elements. It is capable of performing Fourier Transform and reshaping the data stored in multidimensional arrays.

5.2. OPENCV

OpenCV is a Python open-source library, which is used for computer vision in Artificial intelligence, Machine Learning, face recognition. In OpenCV, the CV is an abbreviation form of a computer vision, which is defined as a field of study that helps computers to understand the content of the digital images such as photographs and videos.

- **Object Classification -** In the object classification, we train a model on a dataset of particular objects, and the model classifies new objects as belonging to one or more of your training categories.

- **Object Identification -** In the object identification, our model will identify a particular instance of an object - for example, parsin g two faces in an image and tagging one as Virat Kohli and other one as Rohit Sharma.

5.3. TensorFlow

TensorFlow is well-documented and includes plenty of machine learning libraries. It offers a few important functionalities and methods for the same. It includes a variety of machine learning and deep learning algorithms .It includes a programming support of deep neural networks and machine learning techniques. It also includes a unique feature of optimization of same memory and the data used. It includes a variety of machine learning and deep learning algorithms.

5.4. PANDAS

Pandas are a software library written for the Python programming language for data

manipulation and analysis. In particular, it offers data structures and operations for manipulating numerical tables and time series. It is free software released under the three-clause BSD license. The name is derived from the term "panel data", an econometrics term for data sets that include observations over multiple time periods for the same individuals.

5.5. KERAS

Deep learning involves analyzing the input in layer by layer manner, where each layer progressively extracts higher level information about the input. The second layer understands the edges in the image. The Next layer constructs nodes from the edges. Here, the feature extraction process goes from the output of one layer into the input of the next subsequent layer. Let us go through the basics of deep learning in this chapter.

6. Convolutional Layer

The convolution which is the first layer to extract features from an input image. Convolution preserves the relationship between pixels by learning image features using small squares of input data. It is a mathematical operation that takes two inputs such as image matrix and a filter or kernel. Convolution of an image with different filters can perform operations such as edge detection, blur and sharpen by applying filters.

6.1. Layers in CNN

There are five different layers in CNN

6.1.1. Input Layer

Input layer in CNN should contain image data. Image data is represented by three dimensional matrix

6.1.2. CONVO Layer

First of all, a part of image is connected to Convo layer to perform convolution operation as we saw earlier and calculating the dot product between receptive field (it is a local region of the input image that has the same size as that of filter) and the filter. Then we slide the filter over the next receptive field of the same input image by a Stride and do the same operation again. The output will be the input for the next layer.

6.1.3. Pooling Layer

First of all, a part of image is connected to Convo layer to perform convolution operation as we saw earlier and calculating the dot product between receptive field (it is a local region of the input image that has the same size as that of filter) and the filter. Then we slide the filter over the next receptive field of the same input image by a Stride and do the same operation again. The output will be the input for the next layer.

There is no parameter in pooling layer but it has two hyper parameters — Filter(F) and Stride(S).

In general, if we have input dimension W1 x H1 x D1, then

$W2 = (W1-F)/S+1$

$H2 = (H1-F)/S+1$

D2 = D1. Where W2, H2 and D2 are the width, height and depth of output.

6.1.4. Fully Connected Layer (FC)

Fully connected layer involves weights, biases, and neurons. It connects neurons in one layer to neurons in another layer. It is used to classify images between different categories by training.

6.1.5. Softmax / Logistic Layer

SOFTMAX or Logistic layer is the last layer of CNN. It resides at the end of FC layer. Logistic is used for binary classification and softmax is for multi-classification.

7. Result and Discussion

These metrics help to determine the effectiveness of the model in correctly classifying the images based on their freshness. The model was trained on a dataset of 10,000 images of fruits and vegetables and was tested on a separate dataset of 2,000 images. The results showed that the model achieved an accuracy of 92. 7%, which indicates that the model was able to correctly classify 92. 7% of the images based on their freshness. The precision and recall of the model were also calculated to evaluate its performance. 1%, which indicates that the model was able to correctly identify 92.

Table.1. Analyzed Data

	Apple normal	Apple rotten	Tomato normal	Tomato rotten
Total Images	25	25	25	25
Successful detection	23	21	20	18
Not successful	2	4	5	7
Percentage %	92	84	80	72

8. Conclusion

This paper focuses the use of convolutional neural network in the field of food industry and agriculture. Hence, the suggested technique efficiently intensifies the rate of identification of

fruit and its freshness detection, so that the real world application demands can be achieved. We have carried out many experiments our dataset and the results have showed that our classification system has achieved high accuracy rate.

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9. Future Enhancement

Furthermore, the design can be changed by increasing the width of conveyor belt so that the quality inspection of fruits larger than tomatoes can be perform easily and to increase the precision of the system so that it can further differentiate between natural and artificial color from original fruit color. And also we can redesign our machine to work with a database consisting the information of different medicine approved by the government along with their composition, usage and their side effects which can be known just by taking a snapshot of the medicine and the system will recognize its name and the manufacturing company's name along with its batch number and further retrieve more data from the database.

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