A Synopsis on

E-fresh : Computer vision and IOT based system for food industry

Submitted in partial fulfillment of the requirements
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in

Information Technology

by

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CERTIFICATE

This is to certify that the project Synopsis entitled ***"E-fresh : Computer vision and IOT based system forfood industry"*** Submitted by ***"Siddhesh Gaikwad (18104069), Krishita Tolia (18104021), Akshata Gawas (18104039)"*** for the partial fulfillment of the requirement for award of a degree ***Bachelor of Engineering*** in ***Information Technology*** to the University of Mumbai,is a bonafide work carried out during academic year 2021-2022

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Abstract

The food industry is expanding every day and it is crucial to maintain the required standards which impact their market value. To maintain these standards, manpower is used which is inconsistent, expensive, and time-consuming. With the help of automation of classification, we can speed up this process with less expensive resources using Computer Vision along with the Internet of Things(IoT). The evolution of the Internet of Things(IoT) has played an important role in making the devices smarter and more connected. The large amount of data collected from these devices can be used for data analysis which helps the industries to plan their future decisions. This paper proposes the idea of implementing an infrastructure having a micro-controller that would accurately segregate three kinds of fruits into two categories i.e. Fresh and Rotten. The classification will be done with the help of the Deep Learning algorithm, Convolutional Neural Network(CNN) having architecture Inception V3 and by using a dataset containing images of those three fruits and also considering the input from the sensors which include sensors such as alcohol sensor, methane sensor, etc. The infrastructure proposed in the paper considers the standards of Industry 4.0.

Introduction

The fruit industry has become the third major after grain and vegetables. The rapid development of the fruit industry has brought us visible economic benefits, but also brought us a series of problems, fruit classification is one of them. Retail and supermarkets require manual labor to sort and classify fruits depending on their freshness. This includes not just labor costs, but also the time spent on these operations. Thus, to overcome this problem we need an automated system that can reduce the efforts of humans, reduce the cost of production and time of production. Many researches have been carried out which depicts the use of convolutional neural network(CNN) on various aspects [2] [3] [4] [14] [19] and many more. With the help of previous studies, we have proposed a model which will identify whether the fruit is fresh or rotten using a convolutional neural network(CNN). With the application of deep learning architecture in the field of image recognition, a convolutional neural network(CNN) known as one of the typical deep learning models, used for transfer learning has a good performance in image classification. CNN has various architectures which are developed with the evolving technologies, one of which is Inception-V3. It is a convolutional neural network architecture from the inception family that makes several improvements, considering accuracy as well as computational cost [9] [10] [11]. Thus, Inception-V3 is suitable for the fresh and rotten fruits dataset. Classification will take place based on color, shape, edge detection, ethanol emission, methane emission, and texture. The Fourth Industrial Revolution known as Industry 4.0 is the digital transformation of manufacturing and related industries and value creation processes. It involves automation of traditional manufacturing and industrial practices, using modern smart technology. Considering the standards of Industry 4.0 [5] [6] this project contains a conveyor belt along with the sensors such as methane, ethanol to detect spoilage of the fruit. Additionally, data analysis will provide information about the fruits which will in turn state their impact on the production. The parameters on with the data analysis will be done include size, colour, shape, ethanol level and methane level.

Year	Author	Problem Description	Dataset used	Algorithm	Learning Type	Accuracy	Limitations	Ref
2020	Sai Sudha Sonali Palakodati, Venkata RamiReddy Chirra	Fresh and Rotten Fruits Classification Using CNN and Transfer Learning	3 fruits: apples, bananas and oranges	CNN	Transfer Learning	97.82%	Small dataset with small number of convolution layers.	[14]
2015	Karen Simonyan, Andrew Zisserman	Very Deep Convolutional Networks for Large-Scale Image Recognition	ILSVRC-2012 dataset	CNN-VGG	Supervised Learning	top-5 test error: 6.8%	A fixed kernel size of 3x3 was used.	[15]
2020	Deepika Srinivasan, Mahmoud Yousef	Apple Fruit Detection and Maturity Status Classification	Kaggle's Fresh and Rotten fruits Image dataset	CNN-ResNet50	Supervised Learning	97.92%	Locally based system with small dataset.	[8]
2019	Mengying Shu	Deep learning for image classification on very small datasets using transfer learning	6000 images of dogs and cats.	CNN: VGGNet, GoogleNet, InceptionResNet	Transfer Learning	InceptionResNet: 96%, Inception V3: 95%	Problem of underfitting was observed.	[16]
2020	Yuhang Fu	Fruit Freshness Grading Using Deep Learning	6 fruits: apple, dragon fruit, kiwi, pear, banana, orange.	YOLO for detection and classification, CNN for freshness level regression	Supervised and Transfer Learning	91.49%	YOLOv3 localize objects through rectangular bounding boxes that results in background noises.	[17]
2019	Nguyen Truong Thinh, Nguyen Duc Thong	Mango Classification System Based on Machine Vision and Artificial Intelligence	Images of mangoes.	ANN	Unsupervised Learning	90%	ANN are more suitable for textual data rather images.	[1]
2013	Jagadeesh Devdas Pujari, Rajesh Yakkundimath	Grading and Classification of Anthracnose Fungal Disease of Fruits based on Statistical Texture Features	Images of fruits of type normal and affected by anthracnose	BPNN	Supervised Learning	Normal: 85.65%, Affected: 76.6%	Small dataset and BPNN is very sensitive to noisy data.	[18]
2018	Ling Zhu, Zhenbo Li, Chen Li, Jing Wu, Jun Yue	High performance vegetable classification from images based on AlexNet deep learning model	ImageNet	AlexNet	Transfer Learning	92.1%	Overfitting was observed as image dataset was small.	[19]
2019	Ranjit K N, Raghunandan K S, Naveen C	Deep Features Based Approach for Fruit Disease Detection and Classification	Quadtree segmentation RGB images	CNN	Supervised Learning	93%	A fixed kernel size of 3x3 was used.	[20]

Objectives

- To create a model to classify fresh and rotten fruits.
- To pre-process images before sending them to the model.
- To achieve efficient model considering the cost.
- To train a model with high accuracy.
- To develop a hardware system considering the Industry 4.0 standards.
- To program NodeMCU for collecting and sending images to server.
- To program NodeMCU for segregation.
- To host data analysis dashboard on AWS cloud

Literature Review

Our literature review discusses the study of different classification algorithms used in past few years with their obtained accuracy. The among the recent ones, the study of Apple Fruit Detection and Maturity Status Classification [8] obtained the highest accuracy of 97.92% by fine-tuning the ResNet50 architecture of the CNN algorithm. But it had a limitation as the system was locally based and the model was trained on a small dataset. In another paper on the topic of Fresh and Rotten Fruits Classification using CNN and transfer learning [1], various architectures of CNN were used to check the accuracy, and a simple CNN model was deployed having a small number of convolution layers, and the model was trained on a small dataset and an accuracy of 97.82% was obtained. A study on the Classification of images having dogs and cats [16] was reviewed, various CNN architectures like VGGNet, GoogLeNet., and InceptionResNet were used, and it was observed that InceptionResNet gave an accuracy of 96% while Inception V3 gave 95% accuracy. As the dataset was very small a problem of overfitting was observed in the study. A study on Mango Classification System based on Machine Vision and Artificial Intelligence [1] was studied where they used an ANN algorithm to sort mangoes and detect blemishes by considering features such as size, density, color, etc., and got an accuracy of 90%. A paper on the topic Deep Features Based Approach for Fruit Disease Detection and Classification [20] has described the use of the CNN algorithm on Quadtree segmented RGB images for detecting the fruit disease with an accuracy of 93%. However, a fixed-size kernel was used in the algorithm. A paper on the topic of High-performance vegetable classification from images based on the AlexNet deep learning model [19] was studied, the CNN algorithm AlexNet was used on the dataset ImageNet from which broccoli, pumpkin, cauliflower, mushrooms, and cucumber images were used and it gave an accuracy of 92.1% but as a small number of images were used, it may result into overfitting. So, we reviewed various kinds of algorithms and tried to overcome the limitations observed in the reviewed studies. Our dataset has an acceptable number of images, and we wish to expand it as we deploy the architecture. The algorithm selected is Inception V3 which is considered one of the efficient CNN algorithms as it has varied kernel size, batch normalization, and Auxiliary branches which will help to conquer the problem of vanishing gradient. The software part of our proposed system will be deployed on the cloud and the data obtained from the system will be used for data analysis.

Problem Definition

Detecting the rotten fruits has become significant in the agricultural industry. Retail and many supermarkets require manual labor to sort and classify fruits depending on their freshness. So, e-fresh is a device which will identify whether the fruit is fresh or rotten and it will also segregate it accordingly using CNN.

Proposed System Architecture/Working

The architecture consists of software as well as hardware. The spotlight of our project is to classify and segregate fruits according to their freshness. The paper proposes the implementation of Inception-V3 an advanced architecture of Convolutional Neural Network (CNN) using transfer learning [14] [16] [21] for image recognition and softmax function is used for image classification. For classification we need a supervised learning model which will brief us on whether the fruit is fresh or rotten so, Fig no. 2 shows the whole process to be accomplished. Firstly a predefined dataset stored in the database will be passed for preprocessing that mainly includes resizing, noise reduction, etc. and it is an important step to be performed before passing it for training. After that, the images will be passed to the model for training, and after accomplishing it, the trained model will be saved in the database having the desired accuracy. For calculating accuracy, we pass the test set for prediction and check whether the predicted values match the original value.

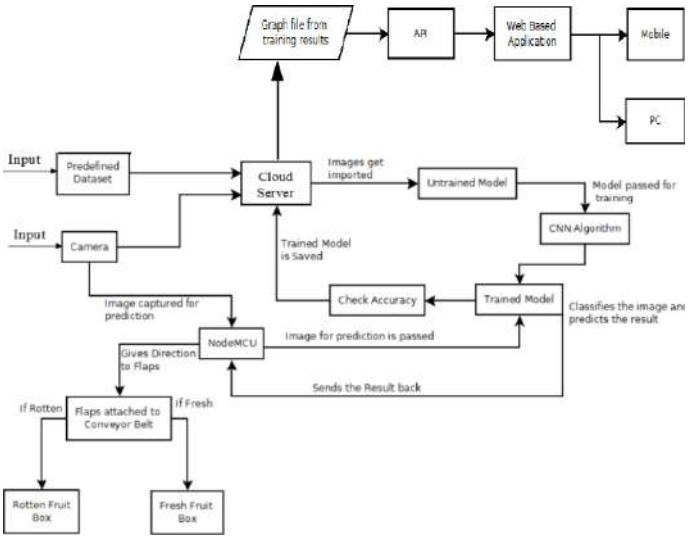

Figure 1: Demonstration of proposed architecture

Now we shall have a look over the hardware section (Segregation section) i.e. Fig no.1. The hardware comprises of one conveyor belt. The conveyor belt is built considering the Industry 4.0 standards. Sensors, nodeMCU8266, camera modules, servo motors are incorporated in the conveyor belt. MQ3 and MQ4 sensors are used to detect the concentration of ethanol [23] and methane gas emitted by the fruits, three camera modules are placed at suitable positions to capture images of the fruits that are kept on the conveyor belt to classify and segregate according to their freshness, nodeMCU8266 is used to pass images to the trained model which is stored on the cloud, the servo motor is used to push the rotten fruits into a separate basket. In nutshell, the fruits will be carried forward through the conveyor belt, recognition and classification will be done using the trained model, Google Colab, Keras, TensorFlow, NumPy, etc then the fresh fruit will fall in the fresh fruit basket and rotten fruits will be pushed into a separate basket. After the whole process analytical graphs will be presented for future use on the web portal. Colour, size, ethanol level, methane level, texture, and edge detection are the parameters which

will be used for data analysis. All the acquired data from various sensors and the prediction from classifying algorithm will help to segregate the fruits on the basis of their freshness.Various papers depicts the use of cloud computing which has resulted into increasing efficiency of the model [22]. So, our proposed framework also intends to store all the collected data on a cloud which will be used in data analysis which will help in taking better decisions considering the business point of view.

Design and Implementation

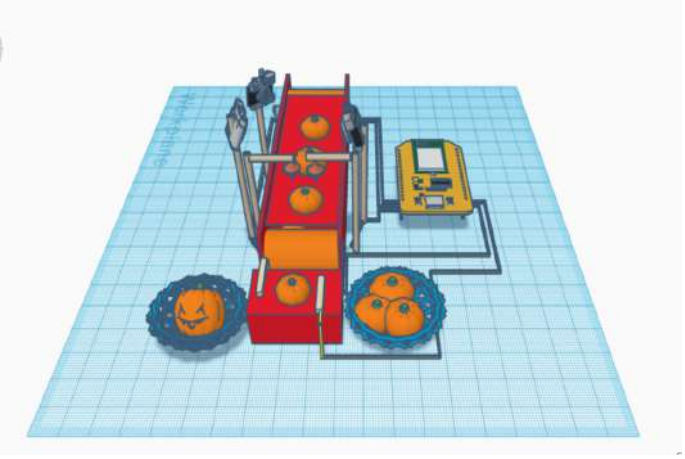

Figure 2: Demonstration Model

This is the demonstration model for better understanding of the segregation process. Here, we will be using two conveyor belts for moving the fruits through our desired path, three cameras will placed at particular positions to get the full coverage of fruits, two flaps will be placed on the second conveyor belt to seggrerate the fruit. These cameras and flaps will be connected to NodeMCU which will operate them. The fruits will be placed on the first conveyor belt which will move in forward direction as the fruits reach the certain spot cameras will capture the images and pass it to NodeMCU then NodeMCU with the help of wifi module will pass it to trained model and will get the result. According to result it will command those flaps to push the fruit in their alloted baskets. For example, if the fruit is fresh flaps with push the fruit into the fresh fruit basket and vice versa. This proces will repeat until all the fruits and classified.

Summary

The process of recognizing, classifying, and segregating fruits according to their freshness is proposed in this paper. CNN architecture i.e., Inception-V3 using transfer learning is implemented in this proposed framework. Datasets with different fruits such as apple, banana, orange are used to train and test the model. The accuracy of the trained model with epochs 100 and batch-size 16 was recorded as 99.17. A touch of the Internet of things (IoT) is given to the architecture by using sensors, camera modules and sending data over the internet to the trained model stored on a cloud. Sensors give an additional advantage along with image classification to filter fresh and rotten fruits. While designing the hardware model the standards of Industry 4.0 were kept in consideration. This proposed framework would be an aid for the food industries as a huge amount of capital and time is spent on labor-intensive and repetitive tasks. So to conquer the drawbacks, this proposed framework can be implemented. Data analysis will provide information about the fruits which will, in turn, state their impact on the production. Further, the analytical report will be prepared on the web portal.

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1 Publication

- Paper entitled **"E-fresh : Computer vision and IOT based system forfood industry"** is submitted at **"International Conference CSP-ICE 2021"** by **"Akshata Gawas, Krishita Tolia, Siddhesh Gaikwad, Kiran Deshpande, Kaushiki Upadhayaya, Sonal Jain".**

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