Towards Developing an Automated Freshness and Defection Detector

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Abstract

One of the biggest problems in the food industry is that it faces food spoilage and these spoilt items are going undetected and onto the hands of the consumer. The process of checking of quality of items is done manually depending on human eye which in most of the cases fails to give an accurate result. The general process of detecting defection of fruits and vegetables is inefficient and high time consuming for industrial uses. This automated defect detection project intends to create an automated system to identify raw and stale elements and separate them from the fresh ones. Index terms- Fruit freshness detector, fruit defection detector, fruit separator, image processing.
Keywords: Fruit detector, image processing, automated system.

1 Introduction

In our country almost in every aspect of food marketing food is judged on site based on human evaluation. Each time a customer buys fruits he has to evaluate each fruit to make sure he is getting fresh fruits. Again an important sector of agriculture business is the production and supply of the fresh fruits and vegetables to the vendors and markets. The growing demand for effective food production and quick and safe supply to the market has led to the development and use of various innovative technologies in this industry [4]. On the other hand, industries or factories that are working with fruits are also judging fruits depending on the evaluation of workers and the process of separation is done by hand. Whereas for regular customer evaluating food isn't a very big deal but at an industry level it is highly inefficient and time-consuming. So instead of hand picking fresh fruits, industries can incorporate an automated system using conveyor belt, camera for detecting food and mechanical separator to separate fruits. And using image processing and deep learning models [1]-[3] the system will be capable of detecting food and separate and automatically, which is more correct value than of hand picking system and overall efficient and time saving.

2 Literature Review

Main challenge of this system is the implementation of an algorithm that will be able to detect fruit efficiently. Deep learning is one of the latest trends in Machine Learning and Artificial Intelligence research [5]. Many significant breakthroughs have been made in this field throughout the world. In the field of agriculture, deep learning was applied to classify the maturity of oil palm fruit [6] which is then developed to automate the palm fruit picking machine that can harvest palm fruit according to its level of maturity. Other studies showed that deep learning can be used as an automatic system for plant counting [7-8]. Deep learning is also useful for various domains, for instance, in medical diagnostic imaging, it can reduce delays in diagnosis and provide a better level of accuracy than other analytical techniques, classify videos on knowledge management systems in an organization, for batik pattern recognition [9], remote sensing, and even for protein modeling. This superior performance of deep learning is obtained from its capability to automate feature discovery, which differs from the classical image processing that needs handcrafted features [10- 11]. However, this excellent performance comes at a cost of requiring a huge amount of data to train the model. In deep learning, Convolutional Neural Network is a class on deep neural networks that is most commonly applied to analyze visual images. It is used to perform image recognition, image classification, object detection, and face recognition. CNN consists of neurons that have weights and biases that can be learned. Each neuron can receive several inputs, by producing a point as a product and optionally following it with non- linearity. The whole network still expresses a single score function that can be distinguished from raw image pixels at one point to class scores at the other end.

In the algorithm, CNN is a deep learning model that can take pictures as input, by determining the value of weights and biases that can be learned from various aspects/objects in the image and can distinguish one from another. Pre-processing required by CNN is far more economical compared to other classification algorithms. While in the previous method the filter was manually engineered, while CNN with sufficient training, was able to learn the filters/characteristics of an object. CNN has the advantage of computational efficiency which uses convolution operations, spatial integration, and uses parameter sharing. Thus, it allows CNN models to run on any device including mobile devices. Inthe history of the development of the first CNN is LeNet then followed by AlexNet, GoogLeNet, VGGNet, Inception-V3, Inception-V4, ResNet-50, MobileNet,

MnasNet, and many more. Main challenge of this system is the implementation of an algorithm that will be able to detect fruit efficiently. Deep learning is one of the latest trends in Machine Learning and Artificial Intelligence research [5]. Many significant breakthroughs have been made in this field throughout the world. In the field of agriculture, deep learning was applied to classify the maturity of oil palm fruit [6] which is then developed to automate the palm fruit picking machine that can harvest palm fruit according to its level of maturity. Other studies showed that deep learning can be used as an automatic system for plant counting [7-8]. Deep learning is also useful for various domains, for instance, in medical diagnostic imaging, it can reduce delays in diagnosis and provide a better level of accuracy than other analytical techniques, classify videos on knowledge management systems in an organization, for batik pattern recognition [9], remote sensing, and even for protein modeling. This superior performance of deep learning is obtained from its capability to automate feature discovery, which differs from the classical image processing that needs handcrafted features [10- 11]. However, this excellent performance comes at a cost of requiring a huge amount of data to train the model. In deep learning, Convolutional Neural Network is a class on deep neural networks that is most commonly applied to analyze visual images. It is used to perform image recognition, image classification, object detection, and face recognition. CNN consists of neurons that have weights and biases that can be learned. Each neuron can receive several inputs, by producing a point as a product and optionally following it with non- linearity. The whole network still expresses a single score function that can be distinguished from raw image pixels at one point to class scores at the other end.

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3 Features

- Classification of 3 types of fruits (Apple, Banana, Orange).
- Identification of freshness and hence determining whether fruits are stale.
- Automatic separation of fresh and defected fruits according to their fruit type.
- Keeping records of daily inspected fruits using database through personal network.
- Permit owner access to the date-wise statistical data from the database using website.

4 Concept Design and Architecture

The system architecture is basically consisting of three part- Hardware, software backend and software frontend (UI). The hardware is a conveyor belt system where camera will be incorporated to detect fruits. Backend of software is basically consisting of database to store fruits images and result of detection and image processing algorithm. And lastly UI will be an interface among hardware and software.

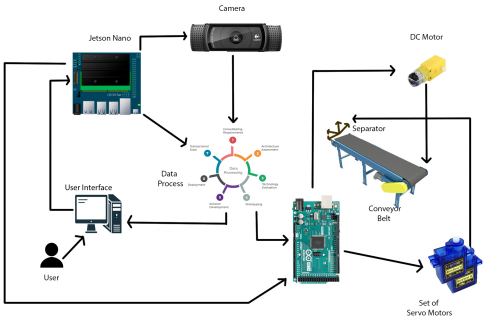

Figure 1. An overview of the system architecture

Owner/worker can start the system by navigating the web application. After starting the conveyor belt system workers will start to provide food to the conveyor belt. Then upon detection camera will send data to micro- controller (jetson nano) and it will calculate whether the fruit is fresh or stale. It it detects that the fruit is not fresh it will separate it to a bucket.

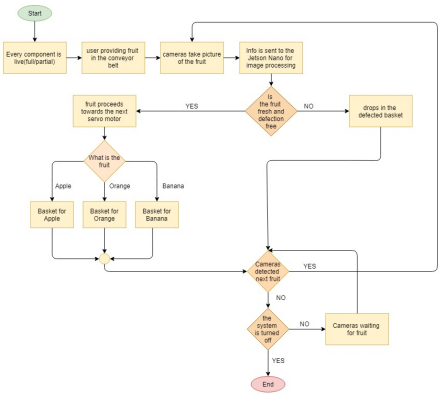

Figure 2. System workflow diagram

Upon detection fresh food the system will the separate the food based on their classification, such as we are working on three fruits (apple, banana and orange). So if the system detects

that a particular fruit is fresh then it will put it on a specific bucket of its type. And this process will continue until there is no food or the system is turned off. Apart from that owner can view the daily states of fruits from web application.

5 System Implementation

The proposed system includes both the hardware and soft- ware parts.

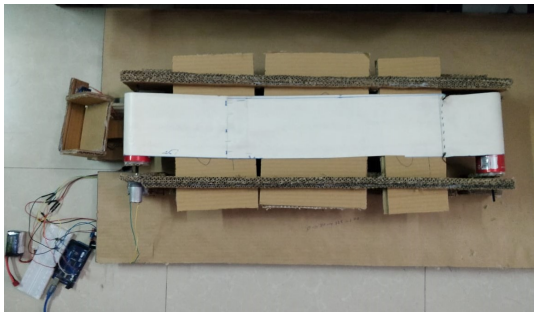

Figure 3. Prototype

5.1 Hardware Development

The hardware components for prototype are Jetson Nano B01Camera, 12v Dc Motor, L298 Motor Driver, Servo Motor, PCA9685 Servo Driver. The belt will be used to deliver the fruits and vegetables in a single column from where the cameras will be able to take readings for object detection and freshness detection. A servo motor will also be used with the alignment of conveyor belt to separate the fruits and put them their bucket according to the result of freshness or defection of the fruits.

5.2 Software Development

The main purpose of front-end development is to make the whole system easily accessible and usable for all the industrial personnel.The UI of our system is built on web-based platform. In this case, we have used HTML, CSS, Javascript in front-end php in the back-end to connect the web with database Python OpenCV for image processing. The database is created in localhost using MySQL. HTML and CSS are used for developing the skeleton of the website and for designing Bootstrap is used. JavaScript is used to go ahead with more complex designs and make the website more responsive and look attractive. It is also used for implementing the functionalities of the website, building a connection with the MySql, and store and retrieve data from MySQL Continuous feedback from end-users are taken to develop the system and made it the most user-friendly UI. The developed website is universal and easy to use for any industry to adopt for saving a lot of time and work for them. For image processing convolutional neural network (a class of deep neural network, most commonly applied to analyze visual imagery) is used. Using this we have been successful to detect a fruits freshness.

6 Results

We trained the model using Convolutional Neural Network (CNN) classified the fruits into 6 categories. -Fresh Apple, Fresh Banana, Fresh Orange, Defected Apple, Defected Banana, Defected Orange The accuracy we obtained from the trained model is 98.4 percent. We created a detector of freshness and defection for grading fruits to establish an efficient automated process with an increase the accuracy of spoilt fruits detection at industrial level.

7 Experimental Study

The experimental study was conducted by using the agile process to measure the functionality and usability of the proposed system. For each primary functionalities of the system, a test case scenario was prepared and then conducted five times. The percentage of the success rate and the average task completion time in seconds are shown in Table 1. The three tasks that our automated system had to perform are at first passing fruit through conveyor belt, after this detecting specific fruit as well as freshness defection of the specific fruit finally separating fresh fruit from defected fruit put into the bucket specifically for its type. Our system performed these tasks successfully.

Table 1: Results of the evaluation study (functional accuracy test)

Task NO.	Task Name	Average Task Completion Time	Result of Task %Success
Task 1	Passing fruit through conveyor belt.	9s	100%
Task 2	Task 02: Detecting specific fruit as well as freshness & defection of the specific fruit.	6s	80%
Task 3	Separating fresh fruit from defected fruit & put it into the bucket specifically for its type.	3s	90%

The evaluation tasks were done by five people. The participants are somehow related to business or industrial field. As this is an automated system one of the purpose of this system is to reduce required manual manpower and human dependency at industrial level, so only three tasks are designed for the user to perform. During the experimental study, firstly a consent form is handed to each participant where a brief presentation about the objective of this study the tasks was written. The proposed system was demonstrated to them and the opportunity to use the system was given to them from their respective point of view for roughly 5-10minutes. After this, the participants performed a set of tasks with the system. Finally, they were asked to provide their opinion about the usability and effectiveness of the proposed system. The tasks were Controlling system components, Logging into user account Checking for record of the fruits of any particular day. All participants were able to perform the tasks successfully without any help. A summary of the recorded data is presented in Table 2.

Table 2: Results of the evaluation study (system usability)

Task NO.	Task Name	Average Task Completion Time	Average Success/Fail	Average No. of Click Requires Vs Expected	Average No. of Attempts	Average No. of Asking Help
Task 1	Controlling system components.	1.6s	Success	Required: 1 Expected: 1	1	0
Task 2	Logging into user account.	9s	Success	Required: 1 Expected: 1	1	0
Task 3	Checking for record of the fruits of any particular day.	10.8s	Success	Required: 1 Expected: 1	1	0

8 Limitations

Our collected dataset from Kaggle contains only three types of fruits, so our system can now detect separate these fruits only. From experimental study we found out that the speed of conveyor belt detection of fruits are 9s 6s. These need to be improved for industrial purpose for better time management.

9 Discussions and Conclusions

The whole system will work on identifying the raw and stale elements and separate them from the fresh ones. Fruit freshness grading via computer vision technology exploits on the fruit texture, color and shape for visual feature evaluation. This project will work using some specific fruit(Apple, Banana, Orange). All system information will be maintained in a database. The system is designed to use as few people as possible get higher production rate and product quality.

Automation of food processing in the industry is needed for increasing production and lowering human labor cost and the industry is eager to welcome a homemade low costing solution. Instead of hand picking fresh fruits, industries can incorporate an automated system using conveyor belt, camera for detecting food and mechanical separator to separate fruits. And using image processing deep learning models the system will be capable of detecting food and separate and automatically, which gives more correct value than of hand picking system.

10 Future Work

New features such as auto-packaging of fresh fruits can be developed in future. The system can be improved for detecting separating more fruits other food products such as vegetables and stored foods (e.g. canned food). Improved image processing and machine learning methods can be implemented to grade food items according to their freshness.

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