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NBA Accredited

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A Project Report on

E-Fresh: Computer Vision and IoT Based Framework for Fruit Freshness Detection

Submitted in partial fulfillment of the degree of

INFORMATION TECHNOLOGY

By

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1.Project Conception and Initiation

1.1 Abstract

Detection of defected fruits and the classification of fresh and rotten fruits represent one of the major challenges in the agricultural fields. Rotten fruits may cause damage to the other fresh fruits if not classified properly. Traditionally this classification is done by men, which is labour-intensive, time taking, and not efficient procedure. Thus, factories need human intervention for segregation of fruits

Hence, we need an automated system which can reduce the efforts of humans and time of production. Our system will automatically do that with help of CNN classification Algorithm. The proposed idea will create a segregation model which would need no human intervention for classifying and segregating fruits.

1.2 Objectives

- Classification of fruit into fresh and rotten.
- To achieve industry 4.0 standards by integrating machine learning and sensors.
- To perform data visualization on classification of fruits on tableau and blynk.

1.3 Literature Review

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]

1.4 Problem Definition

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 project 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

1.5 Scope

- Can be applied in domestic use.
- Can be useful in food industry .

1.6 Technology stack

Hardware Requirements:

- NodeMCU ESP8266
- ESP32 Camera Module
- Motor/ Rotator(for conveyor belt)
- Wi-Fi module
- Flaps
- Servo-motor
- Alcohol Sensor(MQ3), Methane Sensor(MQ4)

Software Requirements:

- Google Colab
- Tensorflow, Keras, Pandas, Numpy, Matplotlib.
- Tableau

1.7 Benefits for environment & Society

- Processing of fruits and vegetables alone generates a significant waste, which amounts to 25–30% of the total product. We need a system which helps us to reduce wastage so that we could increase the yield
- We need a system which is technology driven rather than human driven to increase accuracy and efficiency whereas reduce human labour.

2. Project Design

2.1 Proposed System

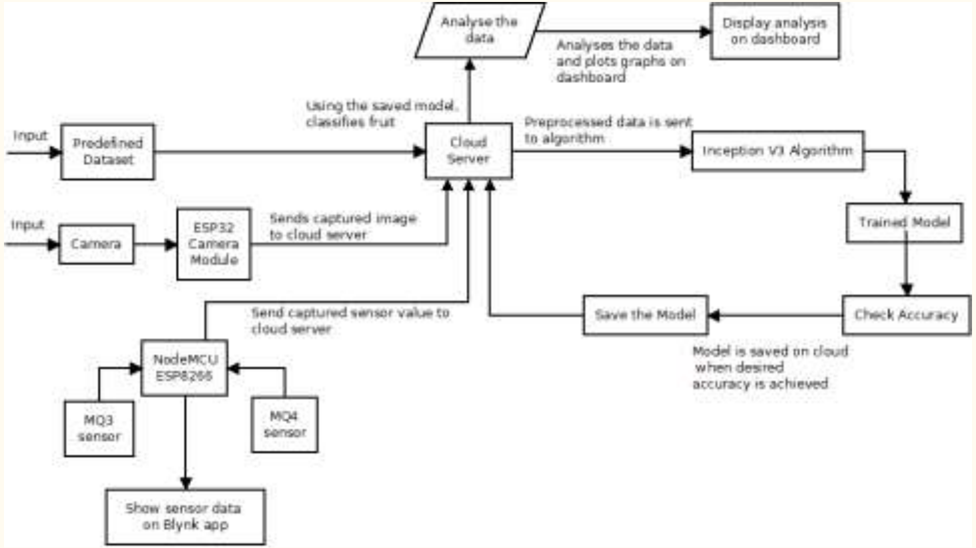


Fig 1: System Architecture

2.2 Design(Flow Of Modules)

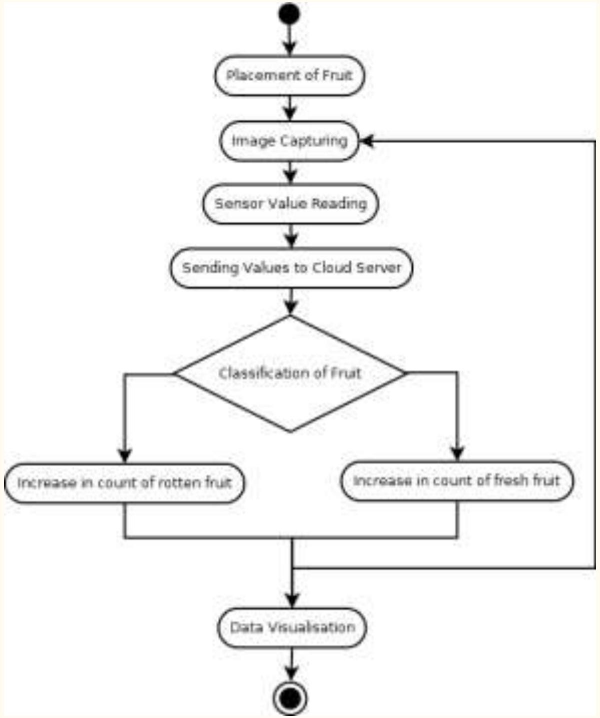


Fig 2: Flow of Modules

2.3 Description Of Use Case

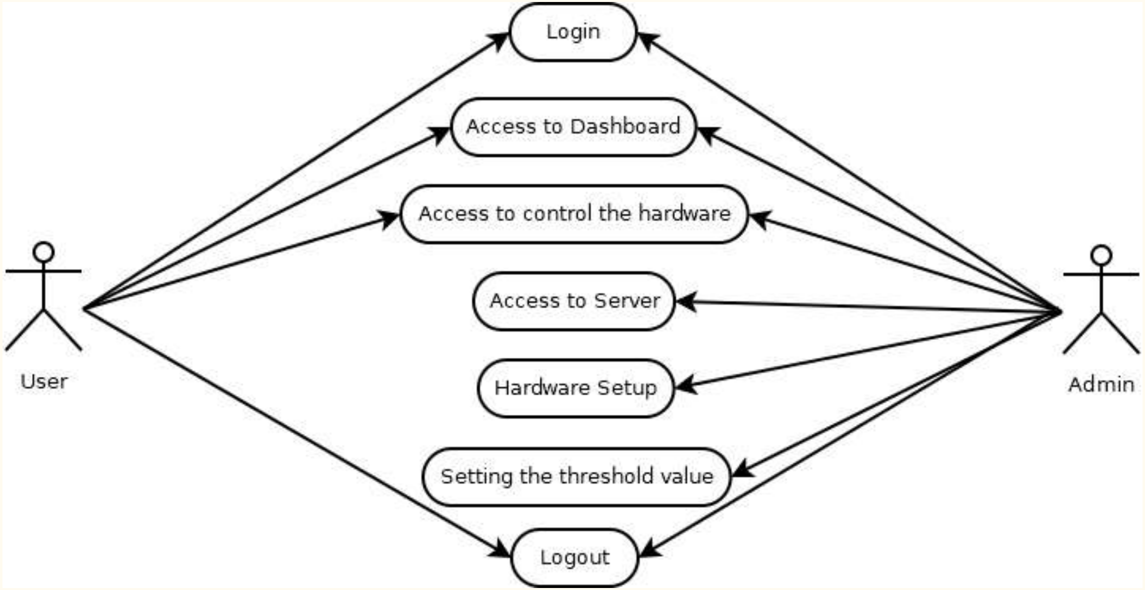


Fig 3: Use Case

2.4 Sequence Diagram

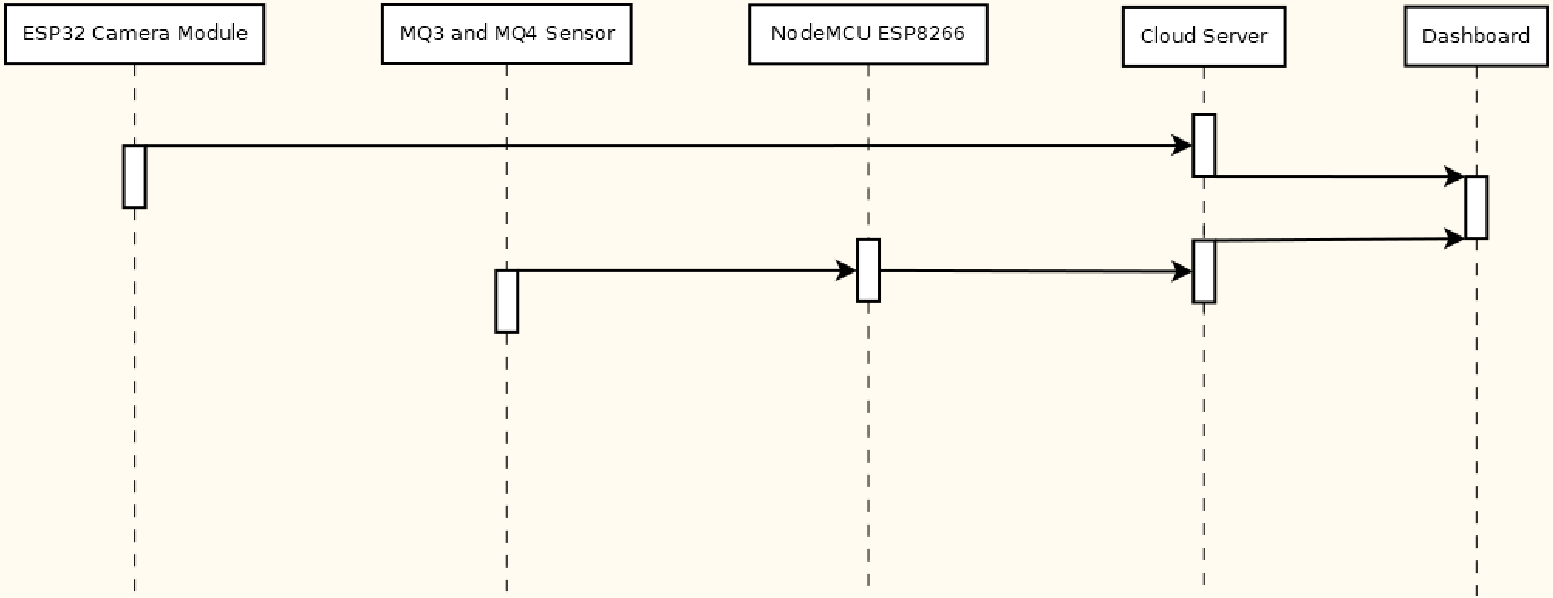


Fig 5: Sequence Diagram

3. Implementation

```
callbacks = myCallback()
history = model.fit(
    train_generator,
    steps_per_epoch=(train_len/32),
    epochs=3,
    verbose=1,
    validation_data=validation_generator,
    validation_steps=(val_len/32),
    callbacks=[callbacks],
)
```

Fig 6: Model Training

```python
model = Model(pre_trained_model.input, x)

model.compile(optimizer='adam',
              loss='categorical_crossentropy',
              metrics=['accuracy'])
```

Fig 7: Model Compilation

```python
from tensorflow.keras.optimizers import RMSprop
from tensorflow.keras.applications import InceptionV3
from tensorflow.keras import layers
from tensorflow.keras import Model

pre_trained_model = InceptionV3(input_shape=(150,150,3),
                                include_top=False)

for layer in pre_trained_model.layers:
    layer.trainable = False

x = layers.Flatten()(pre_trained_model.output)
x = layers.Dense(1024, activation='relu')(x)
x = layers.Dropout(0.2)(x)
x = layers.Dense(6, activation='softmax')(x)
```

Fig 8: Importing Inception V3 Model

```
[3] import os
    import matplotlib.pyplot as plt
    import numpy as np
    import tensorflow as tf
    from tensorflow.keras.optimizers import RMSprop
    from tensorflow.keras import layers
    from tensorflow.keras import Model
    from tensorflow.keras.preprocessing.image import ImageDataGenerator
    from tensorflow.keras.utils import plot_model
    from tensorflow.keras import backend as K
    import matplotlib.pyplot as plt
    import shutil
    from tensorflow.keras.preprocessing import  image
    from tensorflow.keras.applications.inception_v3 import preprocess_input
```

Fig 9: Importing Libraries

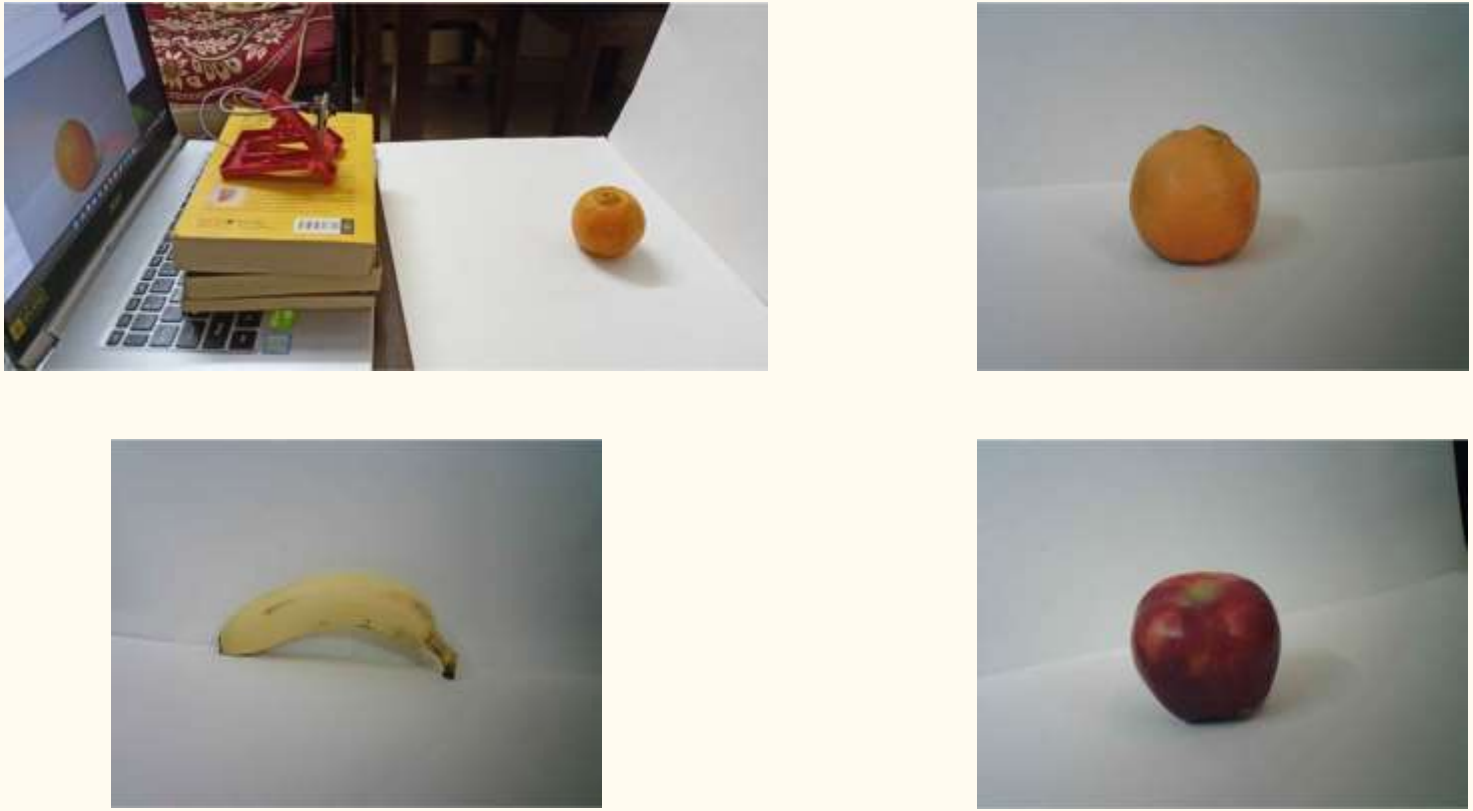
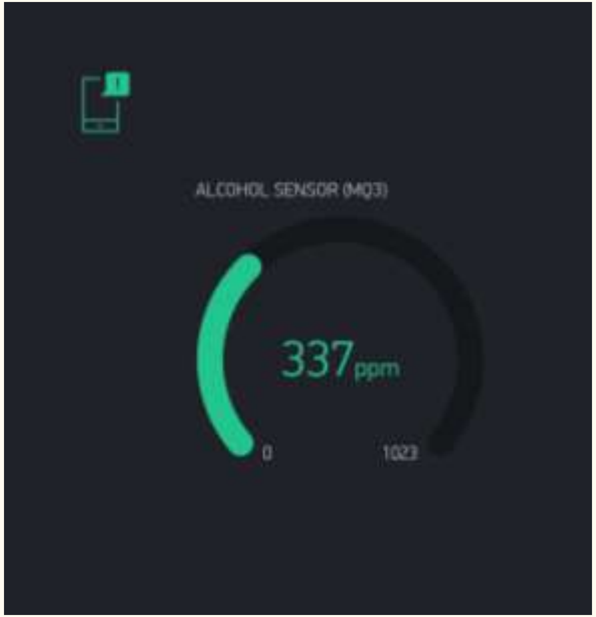


Fig 10: Dataset



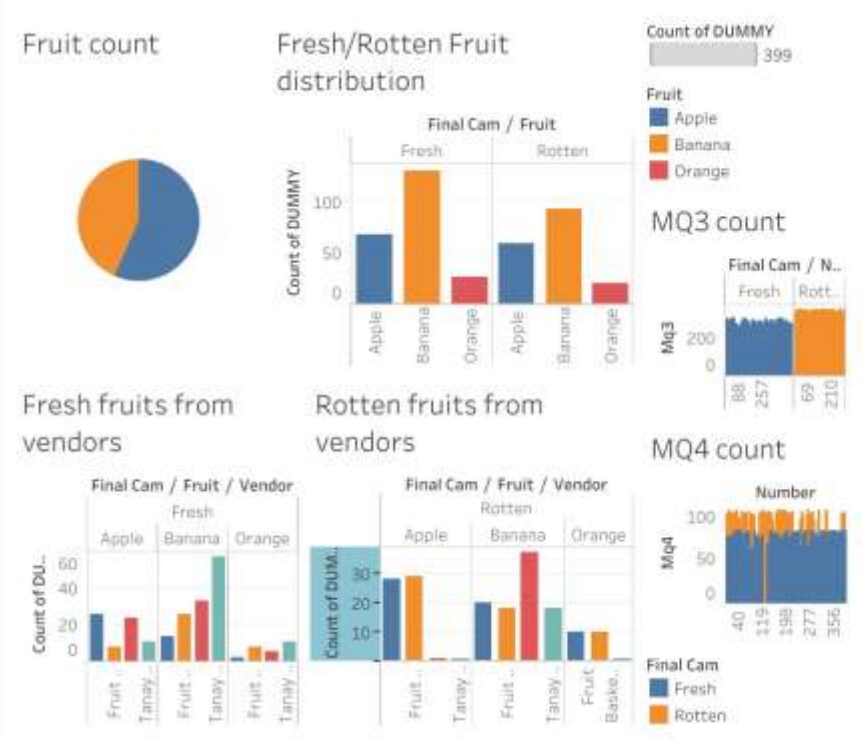


Fig 11 : Dashboard

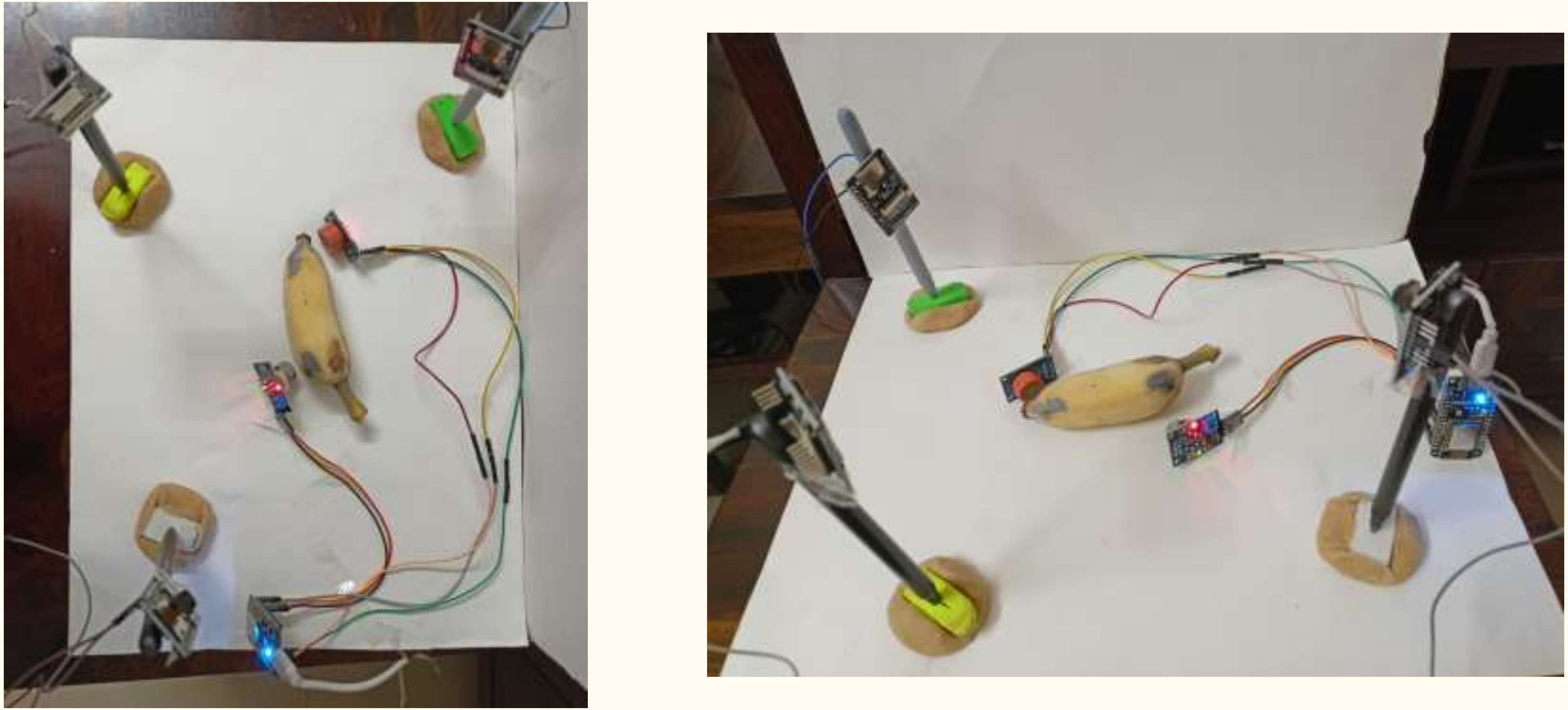


Fig 12 : Hardware Setup

4. Testing

Unit Testing

Unit Testing is a type of software testing where individual units or components of a software are tested. The purpose is to validate that each unit of the software code performs as expected. It is a very useful technique that can help you prevent obvious errors and bugs in your code. It involves testing individual units of the source code, such as functions, methods, and class to ascertain that they meet the requirements and have expected behaviour. Unit tests are usually small and don’t take much time to execute. In our case we began writing code for our machine learning algorithm and sensors in form of units. We then tested each unit separately to minimize the error. Isolating the code helps in revealing unnecessary dependencies between the code being tested and other units or data spaces in the product. These dependencies can then be eliminated.

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Integration Testing

Integration testing is defined as a type of testing where software modules are integrated logically and tested as a group. A typical software project consists of multiple software modules, coded by different programmers. The purpose of this level of testing is to expose defects in the interaction between these software modules when they are integrated. Similarly we divided our code into single unit. After each unit has been thoroughly tested, it is combined with other units to form modules. This testing facilitates smooth integration of software and hardware, if any error is encountered it will be resolved for that specific unit

5. Result

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 aid the food industries as a considerable 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. CNN architecture, i.e., Inception-V3 using transfer learning, is implemented in this proposed framework.

```
loss, acc = model.evaluate(test_generator,steps = (nb_samples), verbose=1)
print('accuracy test: ',acc)
```

```
Found 2705 images belonging to 6 classes.
2705/2705 [==============================] - 198s 73ms/step - loss: 0.1347 - accuracy: 0.9523
accuracy test:  0.9523105621337891
```

Fig 11: Accuracy

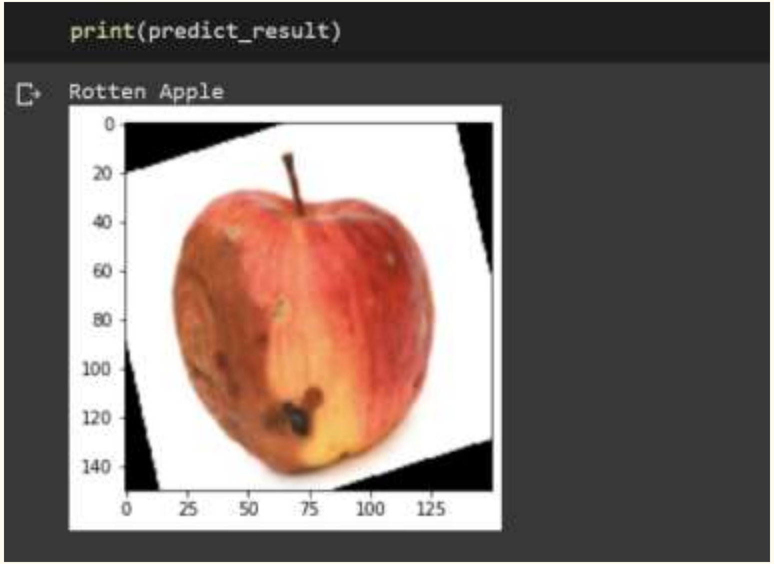

Fig 12: Predicted Value

6. Conclusion and Future Scope

- Our main aim is to create a automated segregation tool for fruit industry which can be used in place of human labour. The tool will also provide important insight using the data captured during segregation
- By giving large number of relevant data will increase the accuracy of the system.
- Camera with advance specifications will increase the accuracy as compared to the current system.
- We can further include more varieties of fruits for classification.

References

- Deepika Srinivasan, Mahmoud Yousef, ”Apple Fruit Detection and Maturity Status Classification”, International Journal of Recent Technology and Engineering (IJRTE) ISSN:2277-3878, Volume-9 Issue-2, July 2020
- Nguyen Truong Thinh, Nguyen Duc Thong, and Huynh Thanh Cong, “Mango Classification System Based on Machine Vision and Artificial Intelligence,” Ho Chi Minh City University of Technology, VNU HCMC, 2019 IEEE 7th International Conference on Control
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Paper Publication

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Thank You