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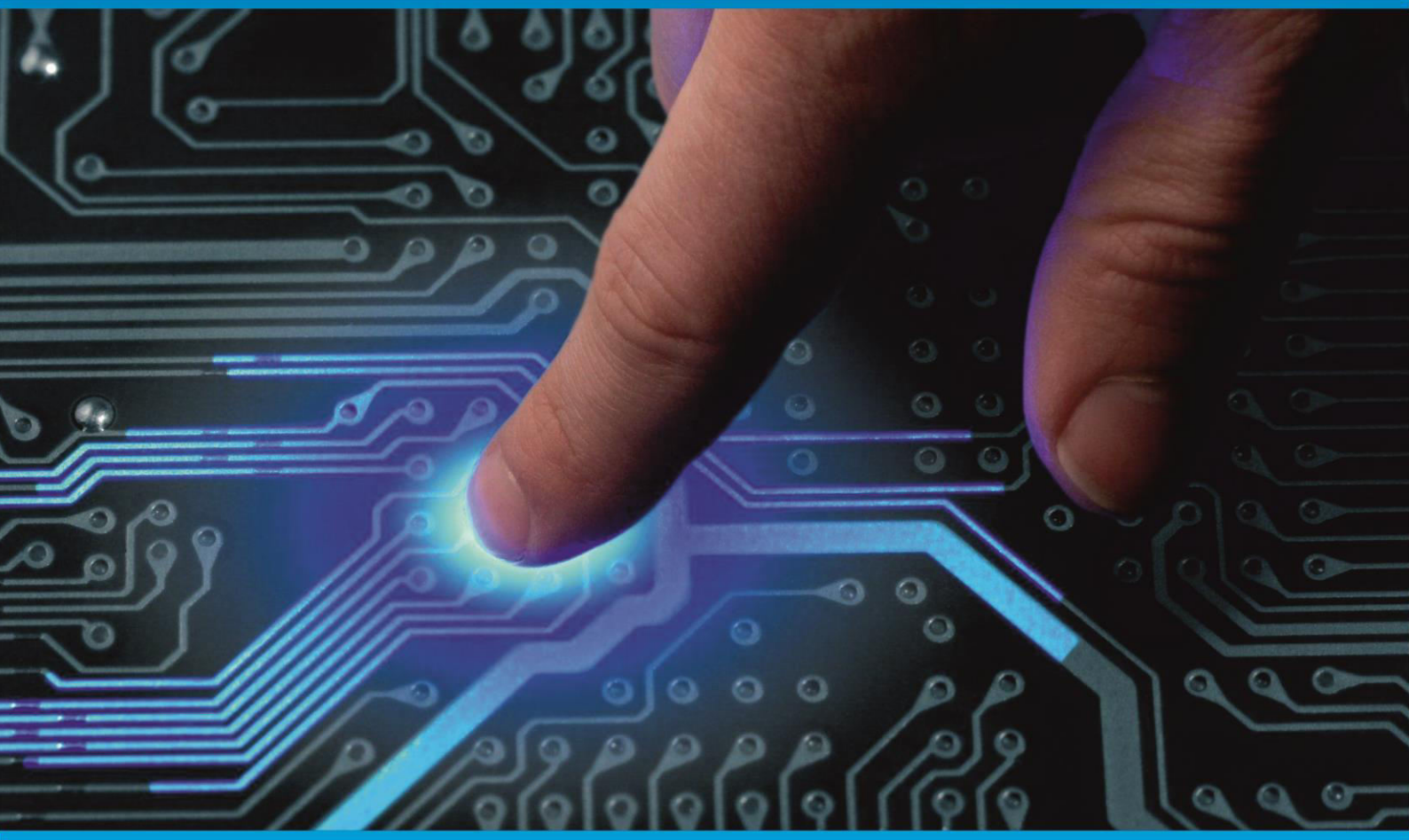

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IOT Based Smart Cold Storage Monitoring and Fruits Maturity Prediction Using Convolutional Neural Network

R.Monisha[1] , Dr.P.Sukumar[2]

Student, Department of Electronics and Communication Engineering, Nandha Engineering College, Erode, India[1]

Professor, Department of Electronics and Communication Engineering, Nandha Engineering College, Erode, India[2]

ABSTRACT: In this Modern era, Internet of Things (IoT) is the rapidly growing network connecting real world sensor to the internet for the purpose of connecting and exchanging data with other devices and systems.The project interprets here is used to monitor smart cold storage system, which stores a ton of fruits and vegetables for few months, and preserving it such that it can be used whenever the demand rised in the market. Hence the frequent monitoring of cold storage system is needed. Here the essential parameters such as temperature and humidity are continously checked and the data is stored in a cloud. The arduino controller maintains the correct temperature and humidity by adjusting the cooling unit. The weight of the fruit and vegetable is sampled every day to find any lose in its weight. The monitored weight is also stored in the cloud. In this proposed method, an image processing technique using deep learning in which the Convolutional Neural Network (CNN) is implemented to predict the maturity stage of fruits from images i.e Apple, Orange and Banana (Found 480 images belongs to 6 classes) to tell whether the fruits is raw or riped. The accuracy of fruit maturity prediction using CNN reaches nearly 96.46%.The notification about the fruit maturity send to the cloud,which helps the user to remove the fruit earlier so it will be prevented from spreading to others.Furthermore, Arduino IDE and Google Colab is used for implementation.

KEYWORDS: Arduino UNO, DHT11 Sensor, Load cell , HX711 IC driver, NodeMCU, Deep learning,Convolutional Neural Networks(CNNs) , VGG -16 Architecture.

I. INTRODUCTION

In today's world, management of fruits stock in a cold storage system is a key issue to achieve customer satisfaction and reduce the risk of profit loss for both retailers and manufacturers.If the product is running out of stock for some contagious time customer satisfaction is reduced with potentially negative effects for both retailers and manufacturers.Significant research efforts have been devoted, so far, by academic and industrial bodies to address the out of stock problem, mainly focusing on supply chain management issues.By overcoming this issues,IoT based smart cold storage monitoring system has been proposed.Furthermore,Fruit classification is an important task in many industrial applications. A fruit classification system may be used to help a supermarket cashier identify the fruit and its maturity stage.This paper proposed an efficient framework for fruit classification using deep learning convolutional neural network(CNN) to detects and predict the maturity level of fruits from images. This technique has achieved high accuracy rate in fruit maturity prediction. The project described here is used reduce the use of manual labour increasing speed and shipping accuracy, and offer retailers an opportunity to obtain unparalleled visibility into inventory and supply chains.

II. LITERATURE REVIEW

A smart refrigerator was proposed by Edward et al. using photodiodes, temperature sensors, NodeMCU, and Raspberry Pi. The objects were identified with the help of barcode scanner. Air quality sensor, pressure sensor, humidity sensor, temperature sensor, and IR sensors were interfaced by Zhongmin et al. with STM 32 controller to make a smart refrigerator. A touch module based on android system was developed to interact with the system. In this manner, the food utilization is effectively improved. A proof-of-concept level smart refrigerator was developed using RFID sensors and Arduino by Sgarciu et al. With the help of RFID sensors, new and removed products were identified.

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Based on this data and inventory and shopping list was made in which user can access through a web application. Guruler et al. developed a smart refrigerator using GSM module, microcontroller, LCD, and sensors.User can gain information about product quantities and temperature of the refrigerator by sending a message or making a phone call. An intelligent internet refrigerator made by Qiao et al. was developed using RFID technology. The refrigerator could intelligently manage the food items and make food records. A warning was sent to the user a week before shelf life of food.It also provided recipes for the available items in the refrigerator. The refrigerator made by Hachani et al. also used RFID sensors but a separate Android application was developed so that user could access the contents of the refrigerator through the application. The Wu et al. presented a low-cost smart refrigerator consisting of sensors, cameras, and Raspberry Pi.The cameras captured the photos and the Raspberry Pi transferred these images to the database so that user can see the contents of the refrigerator with the help of these images through an Android application. An intelligent refrigerator was proposed by Shewta, in which image processing was used to identify the count of different vegetables.It monitored the contents and count of the vegetables and the notification send to the user. The proposed system monitors the ingredients inside it and notifies the user about its quantity of items remotely through an android application. The sensor's data which is collected is processed by the control module and is sent to the cloud so that it can be retrieved in the user's android application. With quantity monitoring of items, the smart refrigerator also provides the facility of online shopping of the scarce items inside. The provision of recipe suggestion based on the vegetables present in the basket is carried out through a basic machine learning algorithm which classifies the vegetables based on the colors which in turn suggests a particular recipe.The IoT enabled perishable cold storage system for stock management can be found in [2] developed using computer vision technology.It uses web cam, LM35IC temperature sensor and load cell with HX711 IC driver.The proposed system notifies the details of the stocks present in the cold storage through android application.A smart cabinet and smart refrigerator consists of four modules such as refrigerator, cabinet, data storage and receiving module, were implemented using RaspberryPI, NodeMCU, load cells, cameras and google Firebase on a domestic refrigerator.. Inspired by LeNet-5 architecture , a convolutional network (CNN) is proposed with significant results to identify the sufficiency of eggs in the shelf. The web application running on a computer and mobile imported the data from Google Firebase to display the data to the user.

III. PROPOSED METHOD

The proposed method comprising of Smart cold storage monitoring and fruit maturity prediction using convolutional neural network (CNN).The smart cold storage monitoring system is used to determine the data regarding temperature, humidity and weight of the fruit stocks present in the cold storage .It has been implemented using the concept of IoT. Moreover, deep learning(CNN) is used to detect the fruits and determine whether the fruit is raw or riped.

A. SMART COLD STORAGE MONITORING SYSTEM

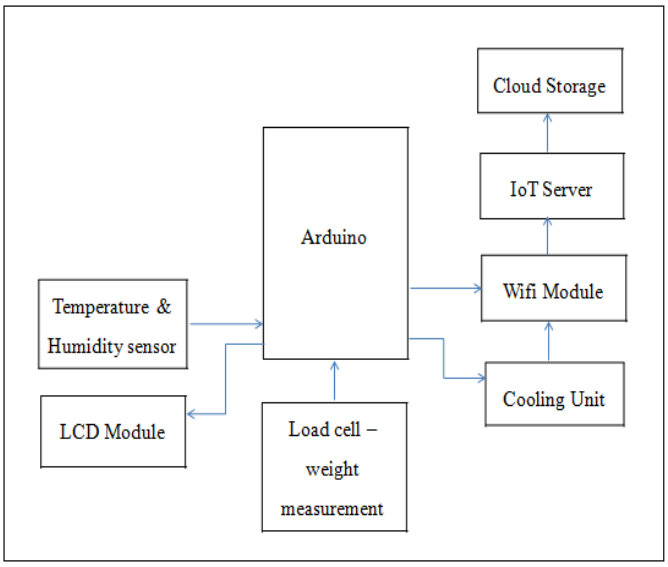

Fig.1 Block diagram of smart cold storage monitoring system

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PROCESS OF SMART COLD STORAGE MONITORING

The above Fig.1 shows the Block diagram of smart cold storage monitoring system.To identify the weight of the stocks placed in the storage box weight scales are used. These weight scales are constructed with load cell with a capacity of 5kgs. Whenever an object is placed on the weight scale, the weight of the product on each scale is converted into electrical output using wheat stone bridge circuit. The output pins of the load cell is connected to HX711 IC. HX711IC acts as a driver for storing analog output weight and convert into digital data.Then the output of HX711 IC is given to Arduino UNO.Temperature and Humidity inside the storage box is monitored by using digital sensor i.e DHT11 sensor and the digital output is given to the Arduino.The cooling unit attached with the transistor circuit is turned on,i.e if the temperature of the storage box is increased beyond the certain value. Data regarding the temperature humidity and weight are displayed in the LCD 16*2 alphanumeric display (JHD162A).The Arduino is connected to NodeMCU controller (ESP8266) which reads the digital data and scales it accordingly.This scaled data is sent to the real time Thingspeak IoT cloud storage.

B. FRUIT MATURITY PREDICTION USING CNN

A convolutional neural network shown in Fig.2 is a feed forward neural network that is generally used to analyze visual images by processing data with grid-like topology. It's also known as a ConvNet.The four important layers in CNN are :

- Convolution layer
- ReLU layer
- Pooling layer
- Fully connected layer

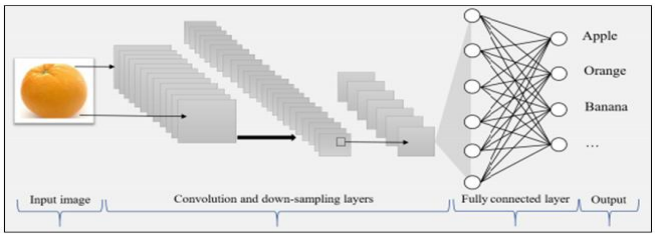

Fig.2 A Convolutional Neural Network

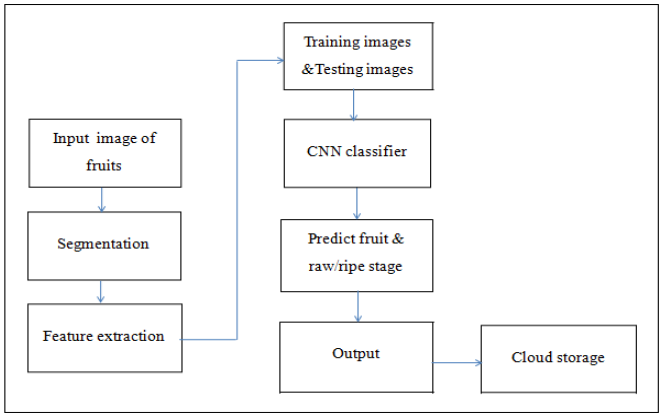

Fig.3 Block diagram of fruits maturity prediction using CNN

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VGG 16 ARCHITECTURE

In VGG16 there are thirteen convolutional layers, five Max Pooling layers and three Dense layers which sum up to 21 layers but it has only sixteen weight layers i.e learnable parameters layer.It has convolution layers of 3×3 filter with a stride 1 and always used the same padding and maxpool layer of 2×2 filter of stride 2. It follows this arrangement of convolution and max pool layers consistently throughout the whole architecture.Conv-1 Layer has 64 number of filters ,Conv-2 has 128 filters,Conv-3 has 256 filters,Conv 4 and Conv 5 has 512 filters.Three Fully-Connected (FC) layers follow a stack of convolutional layers: the first two have 4096 channels each, the third performs 1000-way ILSVRC classification and thus contains 1000 channels (one for each class). The final layer is the soft-max layer.The input to Conv 1 layer is of fixed size 224 x 224 RGB image.

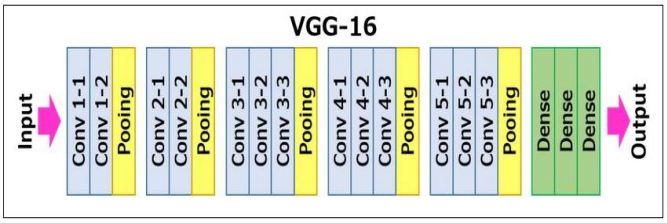

Fig.4 VGG 16 Architecture

FRUITS DATASET

Table.1 Information of the fruits dataset

S.NO	CLASS	NUMBER OF SAMPLES
1	Raw Apple	80
2	Raw Orange	80
3	Raw Banana	80
4	Ripe Apple	80
5	Ripe Orange	80
6	Ripe Banana	80
7	Total	480

METHODOLOGY

The Fig.3 shows the Block diagram of fruit maturity prediction using CNN.The information of the fruits dataset shown in Table.1 consists of three fruit image i.e Apple, Orange and Banana (found 480 images belonging to 6 classes) is provided as input. The VGG16 architecture shown in Fig.4 is used to train the model for fruit classification and fruit ripening detection. The input image is fed to the Convolutional neural network.Feature Extraction provided by CNN to automatically extract all the necessary features through the pool of Network. Based on the Feature Extraction, training is done.The testing data is passed for classification and the feature will be extracted based on shapes. The output stage predicts the fruits and determines whether fruit is ripe or damaged.The predicted data executed from the code is sent to Thingspeak IoT platform.

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IV. SIMULATION RESULTS

Fig.5 Experimental setup of smart cold storage monitoring system

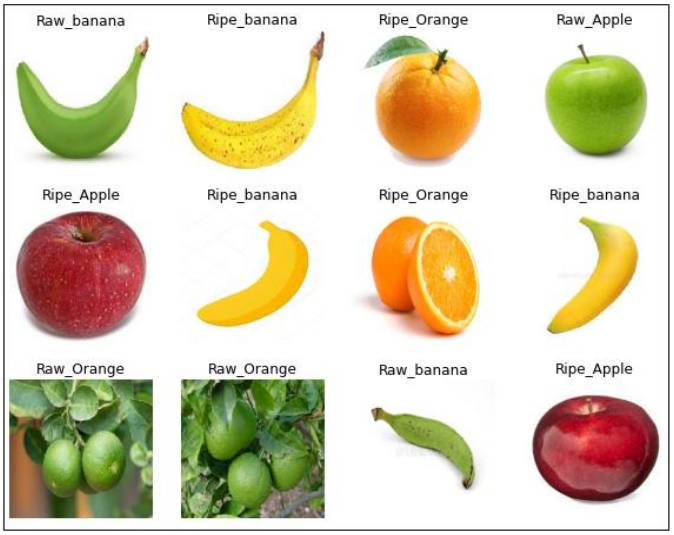

Fig.6 Display sample images

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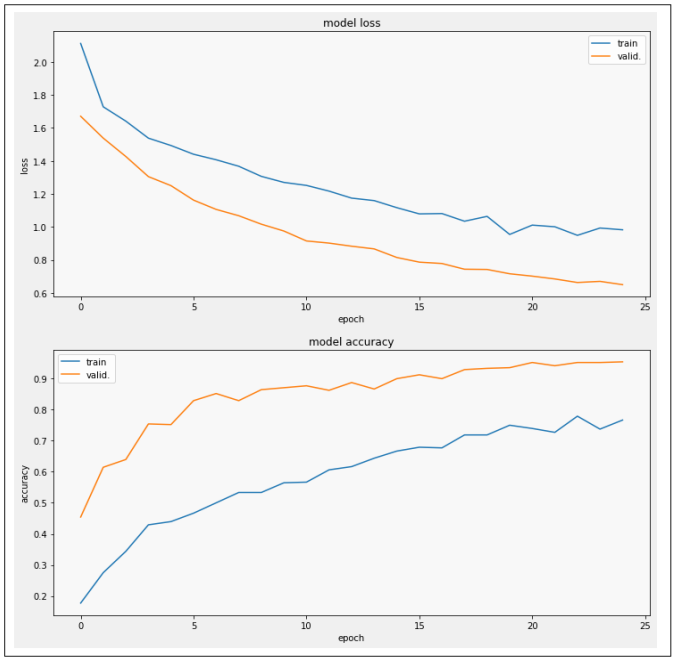

Fig.7 Model loss and accuracy vs epoch

Fig.8 Predicted raw apple

Fig.9 Predicted ripe apple

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Fig.10 Predicted raw orange

Fig.11 Predicted ripe orange

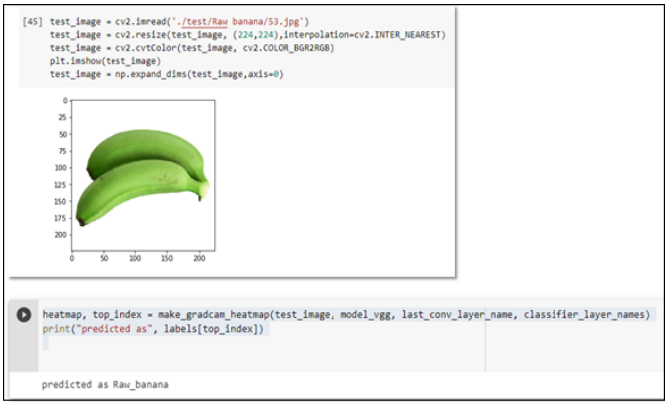

Fig.12 Predicted raw banana

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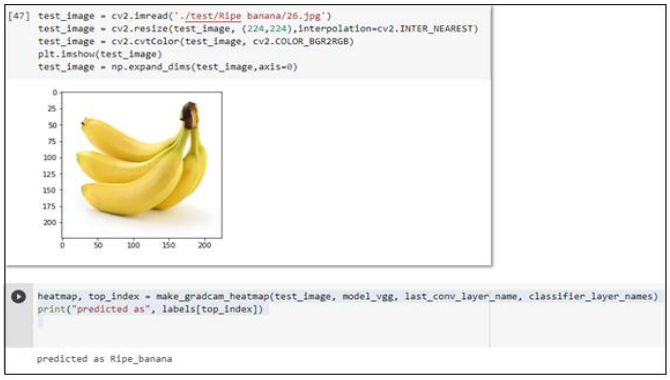

Fig.13 Predicted ripe banana

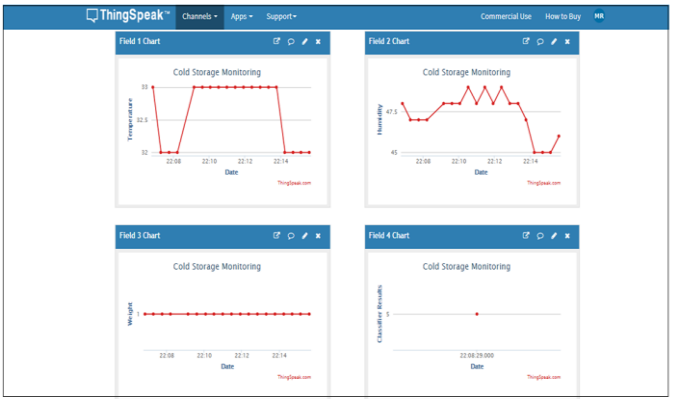

Fig.14 Channel view on Thingspeak

V. CONCLUSION

In this project ,smart cold storage monitoring system uses DHT11 sensor is used to monitor the temperature and humidity of the cold storage system. Load cell with HX711 IC driver is used to calculate the weight of the objects.By using deep learning Convolutional Neural Network (CNN) is implemented to predict the fruits and its maturity level from three fruit image i.e Apple,Orange and Banana (Found 480 images belongs to 6 classes) to tell whether the fruits is raw or riped. The accuracy of fruit maturity prediction using CNN reaches nearly 96.46%.Then the collected information is automatically updated to Thingspeak IoT platform in which the channel status can be easily accessed and viewed by the user.

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