www.ijiarec.com

ISSN:2348-2079

Volume-8 Issue-4

International Journal of Intellectual Advancements and Research in Engineering Computations

IoT enabled Perishable Cold Storage System for Stock Management

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ABSTRACT

In this Modern era, Internet of Things (IoT) is the rapidly growing network of physical objects or things that are embedded with sensors, software, and other technologies for the purpose of connecting and exchanging data with other devices and systems over the Internet. In a daily basis, Perishable goods like vegetables and fruits consumed by everyone are stored in the cold storage system. Industries, retail shops and warehouses dealing with perishable products have been using cold storage facilities may facing difficulties in stock management. In the advent of smart technology, IoT enabled cold storage system interacts with the items stored with in, collects the information about them and processed the relevant data. In proposed method, smart cold storage system using Raspberry Pi-3 model B+ and python programming for efficient stock management. This system is more accurate and is capable of notifying the details about the contents of the storage and their weights to the user and the product supplier, when the contents are running out of stock. Temperature inside the storage system will also be indicated in the specified app through the user's android application. Thus, the details of the stock in the storage can be easily tracked and refilling of the items can be done by the user.

Index Terms: Raspberry Pi-3 B+, Arduino, HX711 IC driver, LM35 IC Temperature sensor

INTRODUCTION

In today's world, management of perishable stocks 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 enabled cold storage system has been proposed. This prototype has the ability to connect to the internet through Wi-Fi to provide special features. It is a smart way of dealing with the stock or items present in the cold storage. It includes web camera to detect the presence of the objects.LM35 IC Temperature sensor is used to monitor the Temperature of the storage system Load cell with HX711 IC driver is used to calculate the Weight of the objects. ARDUINO is used as weight scale controller and Raspberry Pi3 as a home server. The controller will collect all information about the quantity of the items and send them to Raspberry Pi-3.Using python programming the weight of the object when placed the storage box is identified. It will provide notifications to the user and the dealer or shopkeeper, when the contents are running out of stock. This prototype will reduce the use of manual labour increasing speed and shipping accuracy, and

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offer retailers an opportunity to obtain unparalleled visibility into inventory and supply chains.

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. 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. The smart kitchen management is made by Guruler et al. which countered problems in the purchase of kitchen items which are left in refrigerator or kitchen. The smart refrigerator proposed by Nasir et al. consisted of sensing module, control module, and transmission module. The contents inside the refrigerator are determined by this system and the notification sends through thing and speak. 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 in 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.

PROPOSED METHOD

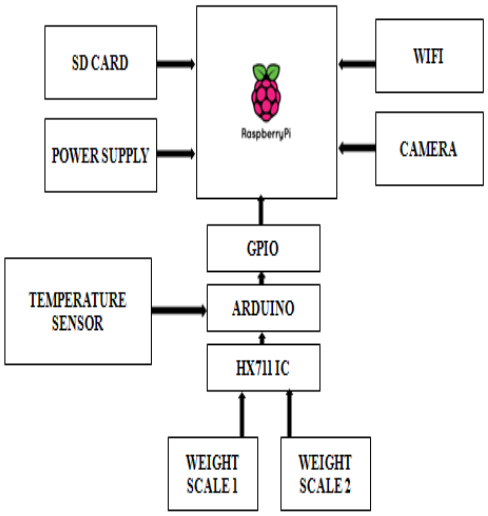

Fig.1.Block diagram of IoT enabled cold storage system

Process of stock management

The above Fig.1 shows the Block diagram of IoT enabled cold storage system. Whenever a product is kept in the storage box, the image of it is captured using webcam. The captured image is detected using python programming. Then weight of the product on each scale is converted into electrical output using wheat stone bridge circuit. The electrical output given to Arduino, Arduino is programmed so that the data of temperature and weight is given to raspberry pi. Using python programming the raspberry pi analyses the data. An app is created to notify the user and shopkeeper. The app consists of data base of product images of products present in the storage box, weight present on each weight scale and temperature inside the storage box. Raspberry is programmed to have a threshold value of each weight scale. Whenever the weight of the products reduce beyond the threshold value the user and shopkeeper are notified using mobile application. This app displays weight of each object along with its image so as to make user have knowledge regarding presence of the products and weight of it if present. The app is updated automatically with details of temperature and products to make it easy for the user.

Process of output stock notification

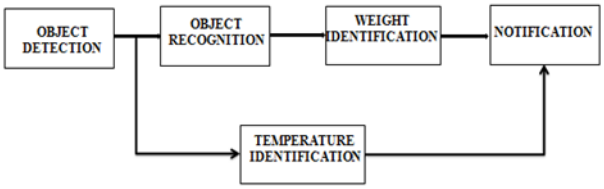

Fig.2. Output block diagram of stock notification

Object detection

The goal of object detection is to detect all the instances from the known samples. It mainly focuses on the object detection and tracking based on its colour, i.e., the input to the proto type will be an image, which is captured by a webcam. A webcam will detect he object and tracks it continuously. Each sample that is specified in the python script is detected when placed in the storage area using webcam. The visual data captured by the webcam is processed with Raspberry Pi and the object is detected based on the colour or shape. Eachdetection is reported with information like name or ID of the object.

Object recognition

Object Recognition It is the process of recognizing the product. As mentioned above in the process of training the webcam is programmed to capture 50 samples and stores them in database. Stored images are specified according their identity. After completion of object detection with the help python script, the webcam recognizes the product placed in the storage box. It compares the detected image with the stored samples in the database as samples are saved along with the number. The Raspberry Pi identifies the number of the sample matched with the detected image. The numbering of each samples is linked to specifications the product. Specifications consist of name of the product. Using these parameters and the detection of the object the product placed is recognized along with its identity i.e. Name.

Weight identification

Weight identification involves identifying the weight of the object which is recognized in the process of object recognition. Each sample saved is specified with number, name and threshold value. These parameters are used in the weight identification. To identify the weight of the product 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 scales, the resistance of strain gauge changes and produces proportional

electrical output. The output pins of the load cell is connected to HX711 IC. This IC acts as a driver for storing the output of weight scales.

Notification

After the identification of the data regarding the weight of the products and temperature inside the storage box the user is notified through an app. An app named all things maker is created and linked to the program using its ID. Using this mobile application, the image of the product identified and the weight of it is updated in the app. Whenever the weight of any product is reduced beyond its threshold value the user and shopkeeper notified through an alert notification. The information regarding the presence of the product, weight of it and temperature inside the storage box are updated automatically in the android application. The Fig.2.shows the output block diagram of stock notification.

HARDWARE DESCRIPTION

Raspberry Pi 3 Model B+

The Raspberry Pi 3 Model B+ shown in Fig.3 has a processer which is 10 times faster than 1st generation. It has onboard WIFI/ Bluetooth support and a 64bit improved Processor used for many applications. It runs based GNU/Linux operating system. To provide enough connectivity, it uses 4 built-in USB ports which can output up to 1.2A. Pi will begin to boot as soon as power is applied, to turn it off simply discard the power. The Raspberry Pi camera is a CMOS camera used to take HD quality video, as well as still photographs. The module has a 5 megapixel fixed-focus camera that supports 1080p30, 720p60.

Fig.3.Raspberry pi 3 model B+

Load cell HX711 IC

HX711 is an Analog to digital weight Pressure Sensor Load Cell Amplifier with two Channels. When it is interfaced with the microcontroller we can read the changes in the resistance of the load cell. The HX711 weighing Sensor uses a Clock and Data interface for communication. It has an on chip power supply regulator to provide to power the Sensor and A/D Convertor. Clock input can be from an external clock source, a crystal, or the on-chip oscillator. Digital interface initialization is simplified by On-chip power. All controls to the HX711 are through the pins .The basic diagram of HX711 I C based on Semiconductor's patented technology is shown in Fig.4.Table I shows the specifications of HX711 IC Driver.

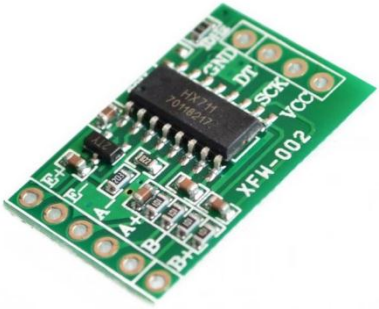

Fig.4.Load cell HX711 IC driver

Table I. Specification of HX711 IC Driver

No of channels	02
Supply voltage	5V
Differential input voltage	±40mV
Precision	24 bit
Operating voltage	2.7V to 5V DC
Operating current	<10Ma
Refresh frequency	10/80Hz
Size	24x16mm

Storage Box

The storage box shown in Fig.5used in the proposed proto type is an energy efficient and Eco-friendly Semiconductor refrigeration system. It is Portable, Auto Mini Travel ABS Multi-Function Fridge with a capacity of 12V 7.5L. It works on electronic (semiconductor) cooling principle. It serves for both cooling and warming. Set 650 C to warm up or choose 5 0 C to cool. Table II shows the Specifications of storage box.

Fig.5.Storage box

Table II. Specification of storage box

Capacity	6L
Temperature	15-25
Heating mode	60
AC power supply	220-240V
Power	48-65W(Cooling) /30-55W(Heating)
Size	32.5L x 18W x 27H cm

SOFTWARE DESCRIPTION

OpenCV Python Library

OpenCV is a cross-platform library using which is used to develop real-time computer vision applications. It mainly focuses on image processing, video capture and analysis including object detection. Computer Vision can be defined as a discipline that explains how to reconstruct, interrupt, and understand a 3D scene from its 2D images, in terms of the properties of the structure present in the scene. It deals with modeling and replicating human vision using computer software and hardware.

Android Studio or IDE

Android studio or IDE stands for Integrated Development Environment, which is software or application that has all the tools that are required for the application development. They provide us with the platform to develop apps. There are many IDEs in the market. Android Studio is the official IDE for Android App Development and it is based on IntelliJ IDEA. Android studio contains all the tools which are required to build an application.

SIMULATION RESULTS

Fig.6.Prototype of IoT enabled cold storage system

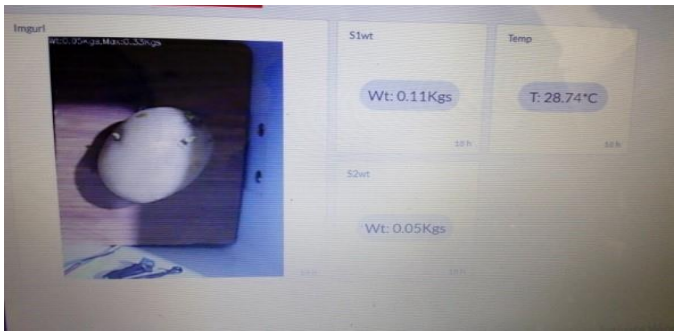

Fig.7. Display the presence of object and its weights

Fig.8. Notification send to the user regarding temperature and weights of stocks

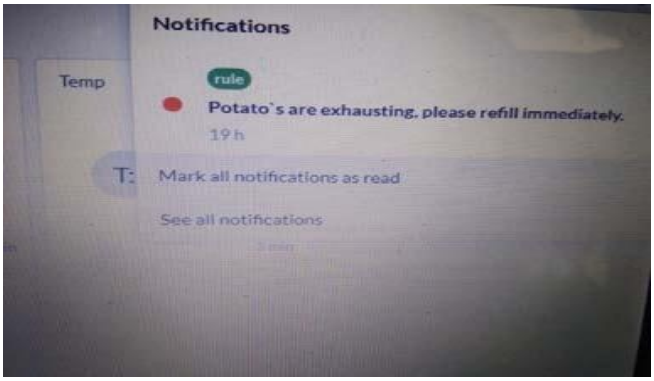

Fig.9. Alert message send to the users android application.

```
Temperature="28.74 degree celcius"
Thresholdvalue="300kg"
Potatoes="290kg"
c="Potato's are Exhausting..Refilling it Immediately"
d=Temperature
e="Notifiction:')"
f="Alert!!!"
w=Potatoes
if Potatoes<Thresholdvalue:
  print(f)
  print(c)
  print("Weight of Potato's:",w)
else :
  print(e)
  print("Weight of Potato's:",w)
  print("Temperature of Storage Box:",d)
```

```
Alert!!!
Potato's are Exhausting..Refilling it Immediately
Weight of Potato's: 290kg
```

```
Temperature="28.74 degree celcius"
Thresholdvalue="300kg"
Potatoes="301kg"
c="Potato's are Exhausting..Refilling it Immediately"
d=Temperature
e="Notification:)"
f="Alert!!!"
w=Potatoes
if Potatoes<Thresholdvalue:
  print(f)
  print(c)
  print("Weight of Potato's:",w)
else :
  print(e)
  print("Weight of Potato's:",w)
  print("Temperature of Storage Box:",d)
```

```
Notification:)
Weight of Potato's: 301kg
Temperature of Storage Box: 28.74 degree celcius
```

Fig.10. Execution of code

CONCLUSION

In this proposed method, the prototype of an efficient, cost effective and accurate Iot enabled cold storage system using Raspberry Pi-3 model B+ is developed. This smart cold storage system is more accurate and is capable of notifying the details about the contents of the storage and their weights to the user and the product supplier, when the contents are running out of stock. Temperature inside the storage system will also be indicated in the specified app through the user's android application. Thus, the details of the stock in the storage can be easily tracked and refilling of the items can be done by the user.

FUTURE WORK

Even though the smart cold storage system is more efficient, the camera captures images at limited angles and distance. So the camera capturing range has to be increased which acquire images from multiple view points. By using more advanced algorithms for detection and recognition, irrespective of the position of the products as well as product misplacement should be able to detect and recognize them accurately.

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