Smart Cabinet

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Abstract - *The purpose of the Smart Cabinet is to store necessary items or any household products in a much more interactive and efficient manner that is convenient to the user. There have been numerous instances where a user has run out of necessary items, unexpectedly, which makes it impossible for the user to perform various tasks on time. The main factor that makes a Smart Cabinet stand out with rest of the normal cabinets is the fact that it has got a software incorporated to it, which notifies the user about the quantity or amount of products that are prevailing in the Smart Cabinet after each use and helps the user to stock the products with more flexibility so that the user will not run out of any necessary items in the future while performing any sorts of task (mainly cooking). Basically, it is like a convenient, user friendly kitchen cabinet that is modified according to one's convenience and also alerts or reminds the user before the necessary products gets fully utilized.*

1. INTRODUCTION

The growth of technology is remarkable. All innovations are done to make a bright impact on people's lives. One among those advanced technologies in the present day is the Internet of Things (IoT), which can automatically discover, track, track and control things. Rapid advances in information technology (IT) have propelled a hyper-connected society in which things are connected to and interact with each other through mobile devices and the Internet. Many IoT-based devices, such as smart cabinets, are designed to meet the human needs. All of these successful applications are contributed to a high quality of life and comfortable environment.

Smart home is one of the foremost areas of smart devices. The kitchen is one of the places where such smart items are being used. At the same time it has become a habit for all of us to consume junk food, vegetables or fruits that are very old in our daily life because of the busy lifestyle we live. On the other hand, there maybe situations in which people are unable to identify the items stored in the refrigerator or a cabinet or anywhere. This mainly comes in case if he/she is a foreigner. Foreigners may not be familiar with the traditional or local vegetables/fruits/spices available in our country or locality. There are also cases where we do not remember that vegetables/fruits/spices have not been used/eaten for a long time. This can also lead to malnutrition or some dangerous diseases or may affect the immune system of each of us. Why not join in an effort to have a machine to

show what we have (food/vegetables/fruits) or how old it is. Of course it may not be practicable for us to calculate or find the accurate age of the product, for it must be calculated from the day it grows, but nevertheless we can find one little effort to find how old it is derived from the date it was collected from the seller or from the expiration date mentioned and determines the remaining amount.

The fundamental Engineering principle that has been employed in the manufacturing of Smart Cabinet is to make the lives and circumstances of the users to be much more predictable and flexible. Creative ideologies are the centre of attraction of various engineering aspects and engineers make use of their informative knowledge to develop and establish different promises and to clear and difficulties that may come into being.

2. BACKGROUND

Over the recent years, the sudden development and growing web service of smart home automation and wireless connected module technologies, has accelerated the sudden growth of the smart homes. However, the internet is growing quickly since the turn of the 21st century, which evidently helped in the growth of China's e-commerce during these years. Compared to many foreign markets, China faces many problems, such as high business costs, high investment risks, strong competition and market imperfections, and therefore, the e-commerce e-commerce e-commerce is growing rapidly and growing, leading to more and more traditional retailers, Wal-Mart, Paul Long warehouse and profits of other major retailers have declined sharply and market share has declined sharply over the past few years. A very successful management firm in both domestic and foreign domain, Bain released a report based on their recent analysis on retail industry. According to the report, the growth of China's online retail sales continues at an alarming rate each year. Therefore, it is very important to find a new business model to transform. At the same time, eventhough majority of the products can be bought online now, e-shopping of a new food may not be easy, as these new foods are not easy to keep and your storage time is short. But currently, the lifestyle of people is growing rapidly than ever, so much so most of the people do not have time to buy them form the stores, in this case, the fulfillment of online shopping for unpreserved food can make their lives easier. So producing a smart refrigerator

having this functionality is close, there is a great working value and this will make it much easier for people to survive.

Smart Home being a product of the sudden development of the high advancement of the technology, can fully meet the needs of modern people involved in health care, so that people living fast-paced lives will temporarily slow down and become smarter. A home where you can enjoy your daily life. In addition, you can manage your daily life in many ways including remote control, wireless remote control etc. The main purpose of the smart homes is for intelligent system to create a series of control systems to manage daily family life, make life more efficient, making life management more intelligent and make health management more efficient and effective. Now people are gradually paying attention to environmental protection, energy saving, and smoke reduction. Smart homes efficiently meet these needs, intelligently meets human needs using small electronic chips, intelligent humidity control and temperature, and can detect excess formaldehyde and other harmful gases in the room. Even if they are excessive, so life will be healthier. It will become more and more environmental friendly and the living environment will be more reliable and trustful. In the environment of a smart homes, the emergence of smart cabinet is an unavoidable result, and smart cabinets are the product of the wave of smart homes, it is an important part of the smart home, and their emergence. It will definitely make people's daily life easier.

3. RELATED WORKS

There are a great deal of smart home projects available. L. Xie et.al [1] developed "iFridge: An Intelligent Fridge for Food Management based on RFID Technology" which gives details on how recipe recommendations can be done based on the items left over in the fridge. Another research done by Prapulla SB et.al [2] involves the development of a smart refrigerator using internet of things. The items inside the refrigerator is monitored in real time and a notification is pushed to the user when the quantity goes below a particular level. This project uses Light Dependant Resistor (LDR) and pressure resistors. The pressure sensor pushes a notification to the user when the applied pressure us below 0.5 kg. LDR sensor sensor triggers a notification to user as soon as the applied pressure is below 0.5 kg. The container in which liquid is sensed are monitored by the LD sensor. The user is notified about the stock by means of SMS or email

Work done by Deepti Singh and Preet Jain [3] categorized smart refrigerator by implementing means to sense the quantity as well as the quantity of the food items kept inside it. It also constantly checks the expiry of the food items and the consuming condition of edible foods.

The system uses load cell sensor, STM32F103x8 Microcontroller, ESP8226 Wi-Fi module and Android application. The whole system is controlled by the STM32F103x8 cortex M3 ARM Microcontroller where the input of Microcontroller is given by the load cell and Wi-Fi transmits all the information to the Android phone by using IoT. Another work done by S.Luo et.al [4] introduced "A smart fridge with an ability to enhance health and enable better nutrition,".It is simply a smart fridge which provides us with nutritional values by simply looking inside the fridge. H. Nasir et.al developed an IOT based smart refrigerator [5] which forewarns the user about various aspects of edibles present in it via and SMS or an email.This primitive smart refrigerator system consists of three main parts: sensing, transmission and control modules. Load cells and odour cells are present in the sensing module. The Arduino UNO, power supply are present in the control module. Finally, LCD module and Wi-Fi module are present in the transmission module. The efficient integration of these modules helps the user to obtain information such as the commodities present inside the refrigerator, working condition, quantity of food etc. via an SMS or an email.

The Smart Fridge by M. Edward et.al [6] is capable of knowing the number of items that are stocked in the refrigerator and transmit timely notification to the user. Notifications basically comprise of the expiry date of the items present in the product, any sorts of temperature variations and its corresponding crucial error messages. In addition to this, it is also integrated with an Android application that will enable the users to get an idea about the contents or the commodities present inside the fridge, order the necessary food items, store the necessary history of transaction and accordingly perform the necessary configurations.

4. THE PROPOSED SYSTEM

This chapter mainly describes about the methodologies that have been undertaken for obtaining the required solution. Initial selection of components, server requirements, specification of components are all explained in detail. Various processes and its corresponding results have been mentioned along with the steps taken to correct the errors and to come up with a modified, efficient solution which aids in dealing with day-to-day activities in a much more flexible manner. Integration and optimization of both hardware and software provides an integral path to enhance the product's utility and correspondingly establish a secure method and pathway for communication which enables the product to exchange various information. Optimum integration of both hardware and software are the main goals for any product- level commodity to enable the solving of tasks in a much more efficient manner and to solve other co- related problems.

The fundamental idea mainly emphasizes on installing the well- organized and coherent implementation of both hardware and software that are implemented and incorporated in the hardware that enables efficient storage of products and also providing the provision for alerting the users whenever and wherever necessary. The incorporated software basically alerts the user regarding the initial quantity of the product (food item) and also notifying the user when the quantity falls below a particular threshold. It also gives an account on the quantity of products that are left in the cabinet after a particular use by the user which helps in re-stocking the product in a much more efficient and orderly manner so that the user does not run out of any essential commodities while performing any sorts of activities. The image processing aspect of the product helps in automatic detection of the food item, such as spices, and helps in allocating different commodities in a much more tangible manner.

5. COMPONENTS USED

By considering different components and choices for the servers and evaluating their pros and cons, the final methodology for the implementation of the solution comprises of the following components and tools :

5.1 Load Cell

A load cell is basically a force transducer. Conversion of various types of force such as tension, pressure, torque or compression into a signal of electrical properties can be standardized and then measured. With the increase in the force applied to the load cell, there is a proportional change in the signal that is generated electrically. Strain gauges, pneumatic and hydraulic cells are the most commonly used type of load cells. Load cells that are strain gauges are basically used for industrial applications. An ideal characteristic is exhibited because of its high accuracy, cost- effectiveness, versatility. The structure of a load cell basically consists of body which is metallic in nature that are secured by strain gauges. Aluminium, alloys of steel or stainless steel are basically employed to make it considerably sturdy and also to provide a little degree of freedom i.e. with minimum elasticity. The 'spring element' is given by this elasticity term, which is referring to the body of the load cell. When a considerable force is applied on the load cell, a deformation is formed on the spring element and it gets restored to its original shape unless and until it is overloaded. With the deformation of the spring element, a change in shape is also noticed.

Very fine wires are used for the construction of a strain gauge. If not fine wires, then foil of grid pattern which is integrated to flexible backing is used. When there is an alteration in the strain gauge's shape, a variation in the electrical resistance also takes place. With the application of force in a unique direction, there will be a

linear change in the resistance value. The force of tension can cause a stretch in the strain gauge, which makes it longer and narrower, which in turn increases the resistance again as well. The opposite takes place when a compressing force is subjected to the load cell. As the strain gauge compresses it becomes even more shorter as well as thinner, which results in the decrease of resistance. An attachment is provided to a flexible backing which can be easily applied to the load cell, reflecting the small and minute changes that can be measured and taken into consideration.

The variation in resistance is brought about by a strain gauge of single unit which is considerably small, which makes it difficult to provide a reading that can accurately measure any sorts of variations. The small changes can be magnified by increasing the number of strain gauges which makes it even more measurable. An application of Wheatstone bridge is employed by the integration of 4 load cells that are strain gauges which are set in a specific circuit.

5.2 Raspberry Pi 4(4 GB RAM)

Raspberry- Pi is basically a series of SBCs i.e. small 'Single Board Computers' (SBCs) developed by the foundation of Raspberry- Pi in UK in collaboration with Broadcom. It was initially introduced in order to enhance the teaching of basic computer science in various educational institutions. The initial model or the original model became more popular and widely used than it was anticipated, and making a impactful involvement in the field of robotics. It is extensively used in various applications such as monitoring of the weather, because of its modularity, cheap cost an open design as well. With the adoption of HDMI and USB devices it is being collectively used by various electronic hobbyists.

Three series of Raspberry- Pi are actually present with the release of several generations of them as well. The SBCs of Raspberry- Pi have a system of Broadcom on a chip which is SoC with a Central Processing Unit (CPU) of ARM compatibility as well as an on chip Graphic Processing Unit (GPU) while a RP2040 system on chip is implemented in Raspberry Pi Pico.

The 4th model of Raspberry- Pi i.e. Raspberry- Pi 4 makes use of a processor of 64- bit, 1.5 GHz quad core ARM Cortex A72 with an on- board Wi-Fi, Bluetooth version number 5, an Ethernet of full gigabit (of throughput and not limited) with a couple of USB 2.0 ports and two ports of USB 3.0 along with a RAM of 1-8 GB and also a support of dual- monitor with a pair of micro HDMI type D ports with a resolution of upto 4K. 1GB RAM version has been halted along with the reduction in the price of 2GB version. The circuit board has been revised for the 8GB version. With the help of a USB-C port the Pi 4 is powered for the downstream peripherals, when used

with the right kind of PSU. Basically the operating voltage of Raspberry- Pi is 5V and not of 9 or 12V as used for other mini- computers. A flaw in the design of Raspberry Pi 4 was noticed in which the third party electronically marked USB cables, as used in Apple MacBooks. Falsely recognised it and refused in providing power of varying degree. In revision 1.2 of the board the design flaw was rectified and was released later. Later, the Pi 4 B models made an appearance with an improvement in the structure of Broadcom BCM2711C0. This is currently used by manufacturers for the Pi 4B and Pi 400. However, a noticeable increase in the tack frequency was not determined.

Speed of the processor ranges from 700 MHz to 1.4GHz for the model of Pi 3 B+ or 1.5 GHz for the 4th version of Pi 4, and the on- board memory has a value ranging from 256MB to 8GB memory of RAM i.e. Random Access Memory with more than 1GB only for the Raspberry- Pi 4. Cards of Secure Digital (SD) in MicroSDHC form factor are used for the storage purposes of operating systems as well as the program memory.

5.3 ESP8266 (NodeMCU)

This particular small- sized module establishes a connection to a Wi-Fi network and make use of Hayes-style commands for simple TCP/ IP connections. Initially, there wasn't any documentation in English on the chip and the commands that were required to be accepted. With the presence of very few external components on the module and is of very low price, it was expressed that it would have a very inexpensive volume, which attracted many attackers/ hackers to explore the module without any authentication along with the chip and the software associated with it.

Along with it, the ESP8285 is a similar chip with an in-built flash memory of 1MB, which allows the connection via a Wi-Fi with the design of single- chip devices. However, these chips of micro controller have been succeeded by the family of devices of ESP32. The GPIO and ADC pins are categorized under the category of "Active pins" in which the external devices attached to the ESP8266 MCU is established. The space between the pins

is termed as "Pitch" on the ESP8266 module, which is an integral factor that determines the usage of the device on a breadboard. The term "Form factor" explains about the packaging of the module as "2x9 DIL", signifying 2 rows of 9 pins that are arranged "Dual in Line", which is similar to the pins of DIP ICs. Many other modules of ESP-xx make use of a small LED which is on- board and that can be blinked which in turns indicates the activity.

An option of trace antenna, is available for ESP-xx boards , with an on- board ceramic antenna, provided with

an external antenna which is ceramic in nature, along with an external connector that provides the permission for an external Wi-Fi antenna to be under attachment. Since a lot of RFI i.e. Radio Frequency Interference is generated in Wi-Fi communications, the legalised governmental bodies such as the FCC prefer shielded electronics in order to obtain minimum amount of interference with other types of devices. A metal box is also provided as it is housed with ESP-xx modules with a seal of approval of FCC imbied on it. In order to obtain a workable and noticeable development, the system makes use of extra components, including a serial TTL- to- USB adapter (sometimes referred to as bridge of USB-to-UART) along with an external voltage power supply of 3.3 V.

5.4 HX711

The HX711 is a precision 24-bit analog to digital converter that is designed for weighing scales and industrial applications to interfere directly with a bridge sensor. It is specially made for amplifying signals from cells and reporting them to another microcontroller. HX711 is an ADC that is specially designed for load cell. It consists of an on-chip low noise programmable amplifier with an optional gain of 32, 64 and 128.

5.5 Thingspeak (Server)

ThingSpeak is basically a Ruby based open- source software that establishes a communication link with devices that are enabled on the Internet. It correlates and initiates various methods of data access methods along with the logging and retrieval of data by initialising an API to devices as well as websites on the social network. As a support for IoT applications , it was initially launched for that purpose. It is also incorporated with various integrated support from software employ numerical computing such as MATLAB from MathWorks that enables ThingSpeak users in visualizing and analysing the data that has been uploaded using MATLAB without needing the purchase of a license of MATLAB from MathWorks.ThingSpeak has also been subjected to articles in a specialized "Maker" websites that incorporates displaying and processing of various digital data such as the Instructables, Codeproject and Channel 9.

5.6 Webcam

A webcam is typically a video camera that is fed with or streams number of images of video in real time itself via a computer network such as the Internet. They can be placed on a desk as they are small cameras that can be attached to a user's monitor or can be integrated along with the hardware as well. During a chat session that involves video, webcams are typically used which can involve a number of people, along with live audio and video streaming.

The software incorporated in a webcam allows the users to either record or stream a video on the network such as the Internet. Since it requires considerable amount of bandwidth, it requires the usage of compressed formats. Compared to most of the hand held videos the resolution is quite low, as higher resolutions of webcam may be affected during transmission i.e. it will be reduced. It makes the webcam inexpensive if it has got lower resolution when compared to most of the cameras used for video purposes, although the effect is adequate for chat sessions that require video streaming.Either CCD or CMOS can be used as image sensors, which are being predominantly used as low cost cameras, however CMOS-based cameras outperform CCD cameras in the lower price range. VGA resolution can be provided by most of the consumer webcams at a particular frame rate of 30 frames per second. Megapixel resolutions can be incorporated into video streaming platforms nowadays, and a few can run at higher frame rates such as the Playstation Eye, that is capable of producing a video of 120 frames per second at a resolution of 320x240 . The remote used in Wii consists of a sensor for image that consists of resolution of 1024 x 768 pixels. Common built- on resolution for cameras are 720p for HD purposes, and a 480p for low end laptops. It was only in the early 2010s that first known laptops with 1080p i.e. Full HD webcams were employed or integrated such as the Samsung 700G7C.

5.7 MIT App Inventor

The App Inventor of MIT is a web based application with a development environment that is integrated and is provided originally by Google, which was later then nominated by MIT i.e. Massachusetts Institute of Technology. Newcomers are given with a provision for enhancing their skills in computer programming which enables them to create various software applications i.e. apps for two operating systems which are iOS and Android. It is an open source and free software which is released under the provision of dual licensing which is a Creative Common ShareAlike 3.0 license that is Unported, and an Apache License which is basically used for source code.

It comprises and makes extensive use of a GUI i.e. Graphical User Interface which shares similar characteristics with Scratch (programming language) and the StarLogo, which provides with a provision of 'drag and drop' for the users basically varieties of visual objects in order to create certain applications that is able to run on devices based on Android, whereas the App Inventor Companion (program that enables the app for running and debugging on) that makes a foundation in various iOS devices is still under progress and development. In the process of creating various Inventors for Apps, Google drew its attention to various research analysis that were significant for various computing of educational purposes,

and for private work done by Google on various environments which is used for online environments. Constructionist theories used for learning are the basis for projects relating to the App Inventor, which signifies that programming can be used as a mode of transport for various powerful ideas that are engaging through a significant source of active learning. As it is, it is also a piece of on- going development in the field of computer and its related education. The use of cloud data is being supported by the App Inventor on the basis of an experimental Firebase#Firebase Realtime Database component.

Basically, the App Inventor is a service based on cloud which is free which enables a person to make their own app suing a programming language that makes use of various number and types of blocks. The access of the App Inventor can be made using a browser based on the web services such as Chrome, Firefox, Safari. The development environment for the App Inventor is supported for various software including the operating system Mac OS, Linux/ GNU and Windows. They app based on App Inventor can be installed with ease on any Android based phone.

6. IMPLEMENTATION OF PROPOSED SYSTEM

Fig1 shows the working methodology of the proposed Smart Cabinet. At first, the commodities i.e. in this case the spices are placed on the platform of the load cell which acts as a suitable area for the spices to be easily placed. The structure of the platform is made in such a way that its geometrical shape is suitable or precise enough to provide a uniform support for the products to be placed on and to be measured. The weight of the product placed and the load cell's rigidity are balanced out by base structure that holds the load cell and the product's weight together. The platform as well as the base of the load cell are made by 3D printing. Once the products are placed on the load cell, it will cause a bend to the load cell, the corresponding strain produced will convert it into voltage values and its corresponding weight is obtained. The weight of the objects can also be viewed on the serial monitor as well.

To send the data to Raspberry Pi we make use of NodeMCU. NodeMCU is an open source platform based on ESP8266 which can connect objects and let data transfer using the Wi-Fi protocol. In addition, by providing some of the most important features of microcontrollers such as GPIO, PWM, ADC, and etc, it can solve many of the project's needs alone. ESP8266 has very low cost and high features which makes it an ideal module for Internet Of Things (IoT). It can be used in any application that require it to connect a device to local network or internet. NodeMCU Development Board/kit v1. 0 (Version2) NodeMCU is an Arduino like device. NodeMCu comes with an 80MHz of clock speed and 4MB of flash memory. Built-in TCP/IP Stack - IoT Ready: The NodeMCU contains a Wi-Fi

connection and can connect to the internet through Wi-Fi. It is best suited for IoT applications.

The data i.e. the weight of the spices is sent to the server which is set up by using ThingSpeak. ThingSpeak is an open-source software written in Ruby which allows users to communicate with internet enabled devices. It facilitates data access, retrieval and logging of data by providing an API to both the devices and social network websites. ThingSpeak was originall launched in support of IoT applications. ThingSpeak has integrated support from the numerical computing software MATLAB from MathWorks, allowing ThingSpeak users to analyze and visualize uploaded data using MATLAB without requiring the purchase of a MATLAB license from MathWorks.
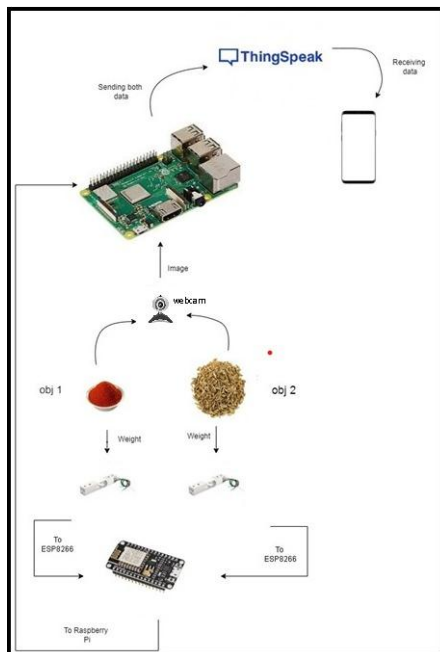
Fig -1: Detailed Flow Diagram

With the help of Raspberry Pi and the installed Webcam, the image processing takes place. A number datasets are actually collected and is trained in order to determine the kind of spices that has been placed based on its characteristics. A webcam was chosen over Pi- cam because of the large field of view that it possess. Image processing basically includes the following three steps: Importing the image via image acquisition tools; Analysing and manipulating the image; Output in which result can be altered image or report that is based on image analysis. Common image processing includes image enhancement, restoration, encoding, and compression.

So now at the server we have weights of 4 different types of spices that are being taken under consideration. These data are then sent to the receiving module which is the app developed using MIT app inventor. The result of image processing is send directly to the app as well. The first screen i.e. the front end of the app consists of the following data: weight of the spices, name of the spices being used. A provision has also been installed in the app where the user can set a favourable threshold so that the weight gets updated when it goes below the threshold value.

When the weight of a particular spice goes below the threshold value a button named 'update' will navigate the app's screen to the second screen where it consists of the name of the products whose quantity is below the threshold value. And thus, by adopting these mechanisms stocking, monitoring and re- stocking of commodities can take place in real time and that too in a much more flexible manner.
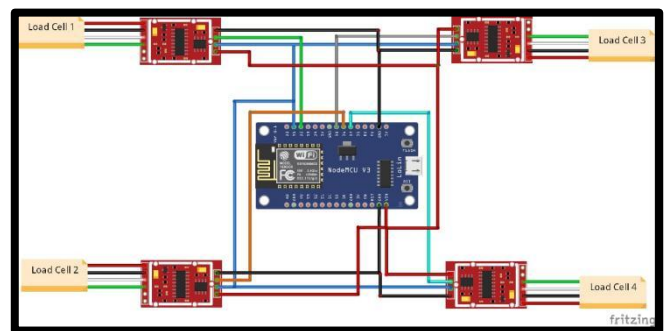

Fig -2: Schematic of the proposed solution

7. RESULTS

The four load cells measure the weight of each individual commodity using their corresponding HX711 and this data is received to NodeMCU through the DAT pin from HX711 to the Digital pin in NodeMCU. The Digital pins D2, D5, D6 & D7 are used to receive the individual weight data from each HX711-load cell. We synchronize the data setting of SCK pin (clock) to a common Digital pin D1 so that all the datas are read together in a sync.

Fig -3: Hardware set- up (base of the cabinet) along with four load cells
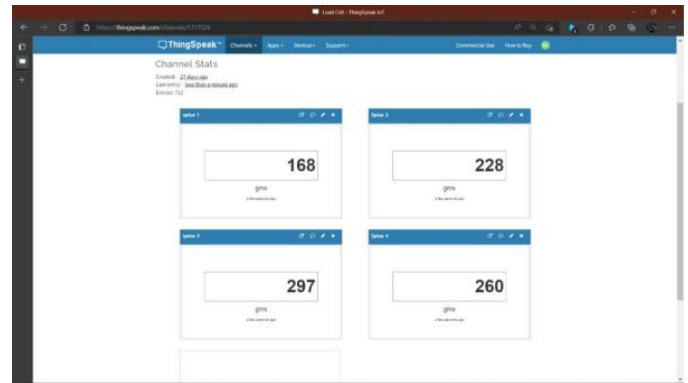
The synchronized data reading from NodeMCU is viewed in the serial monitor of Arduino IDE for verification. The weight data from NodeMCU is sent to the Thingspeak server via write APIs. Data from each loadcell is assigned to a specified field, for example field 1 data from loadcell 1 and like wise for the remaining load cell weights.

In the image processing side, there is a sectoring based on the view from the camera's position. First sector covers the area of object 1, whichever object is placed on this sector will be identified and object 1, likewise for rest of sectors covering for object 2,3&4 . Now the Raspberry pi detects these objects using image processing in order of the sectors and generates a sequence.

Now the server has the weight of each commodity from NodeMCU, and identified object sequence generated from Raspberry Pi. These data is send to mobile application via read API. The application processes the data and updates in the UI . The name of commodity and its corresponding weight is now available in the application. User can now set a threshold for each commodity. If the set threshold goes below the defined threshold value, then that commodity will be added to the shopping list.
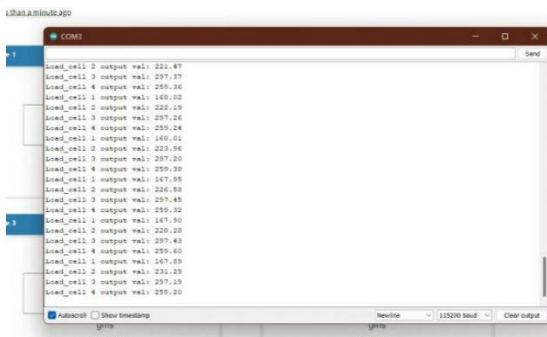

Fig -4: Data obtained-weights from 4 load cells of different spices in serial monitor of Arduino IDE

Fig -5: Output of all 4 load cell data in Thingspeak server

Fig -6: Raspberry Pi image processing setup

Fig -7: Application UI

The commodities which went below the threshold will be added here in shopping cart UI so that when the user is about to go shopping, they can check what all commodities need a refill.

Fig -8: Shopping cart UI

8. CONCLUSION

A Smart cabinet system has been proposed for analysing the item which is placed in the cabinet and provides us with a restocking alert in time. Predicting the needs in the nearby future as well as the large extent of manual usage, efforts and difficulties can be saved or made prominent use with the help of such system. Advantages such as ease, ergonomic features and flexibility that are provided by the product makes it more promising to satisfy household needs without any difficulty and saving one's time.

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