Journal of Electronics, Computer Networking and Applied Mathematics
ISSN: 2799-1156
Vol: 03, No. 01, Dec 2022-Jan 2023
http://journal.hmjournals.com/index.php/JECNAM
DOI: https://doi.org/10.55529/jecnam.31.27.40

Design and Implementation of Intelligent Refrigerator

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Received: 30 September 2022 **Accepted:** 14 December 2022 **Published:** 18 January 2023

Abstract: ***A system for home and grocery refrigerators has been developed and proposed for an intelligent refrigerator, although it has not yet been implemented. An intelligent refrigerator system's basic architectural and electrical design as well as its software simulation, operation, and analysis as well as its hardware implementation are shown in this prototype. In order to collect data on the physical environment and properties of the system both inside (within the fridge) and outside, several sensors including weight sensors, pH sensors, contact sensors, and temperature sensors have been used in this system (compressor unit). The fridge keeps track of stock levels and freshness levels by analysing that data. For remote control, stock and freshness information, and alarming of any hazard (overheating compressor unit, open door etc.), the proposed Intelligent Refrigerator control unit includes numerous sensors and arrays. You can utilize an LCD screen to show notifications and alarms. An optional IP camera has been installed inside the fridge for continuous monitoring. For the benefit of users, an android app has been created (owner, store manager etc). For command and notification reasons, Bengali language voice recognition has been incorporated into the system. Additionally, an Android software has been developed that uses the mobile phone's GPS technology to locate nearby supermarket and superstores (such as Kacha Bazar, Aagora, and Swapno).***

Keywords: Intelligent Refrigerator, Sensor, Android App, User Interface, GSM Module, Real Time Monitoring.

1. INTRODUCTION

The actual development of smart appliances is critical to the realization of a smart home. With a wide range of smart appliances designed to improve the lives of families, the kitchen is a

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crucial part of the home. The smart refrigerator is the subject of our investigation. It is a common goal in industry and research to develop smart fridges. It is becoming increasingly common to find refrigerators that not only store food, but also include television, radio, computer, and Internet connectivity. Apps for smart refrigerators, for example, can be developed using these computer-like qualities [1].
Smart refrigerators with an eye on better nutrition and well-being are the focus of this Endeavor. The product stack (beef, vegetables) will be monitored with minimal or no human intervention, which is the primary goal of this research. as well as to monitor the freshness of food, beverages, and other products. The nutritional values (calories, fat, vitamins, etc.) of consumed items will also be tracked in order to determine the daily or monthly eating patterns of individuals. We'd like to learn more about macronutrients like carbs, protein, and fat in order to make healthier food choices. Numerous functions that could be made better or more convenient as a result of this investigation are among the many potential advantages. The following is a partial list of the potential advantages of this project [1, 2].
It is possible to view what is in the fridge at all times through the use of an IP camera. This feature will notify us via SMS when it's time to replace or update our inventory, and it will also recommend nearby stores using a GPS-enabled smart phone. A long-term goal of ours is to be able to track the amount of fat and protein that a user consumes.
An alert can be issued to the user if a door is left open for an extended period of time. If our refrigerator overheats or catches fire, the fire or overheat notification will sound [3].

Circuit Block Diagram
The proposed prototype of an intelligent refrigerator has a refrigerator unit with three separate compartments for meat, veggies, and fish. The following is an explanation of the PH sensor, force sensor, and colour sensor circuit block diagrams:

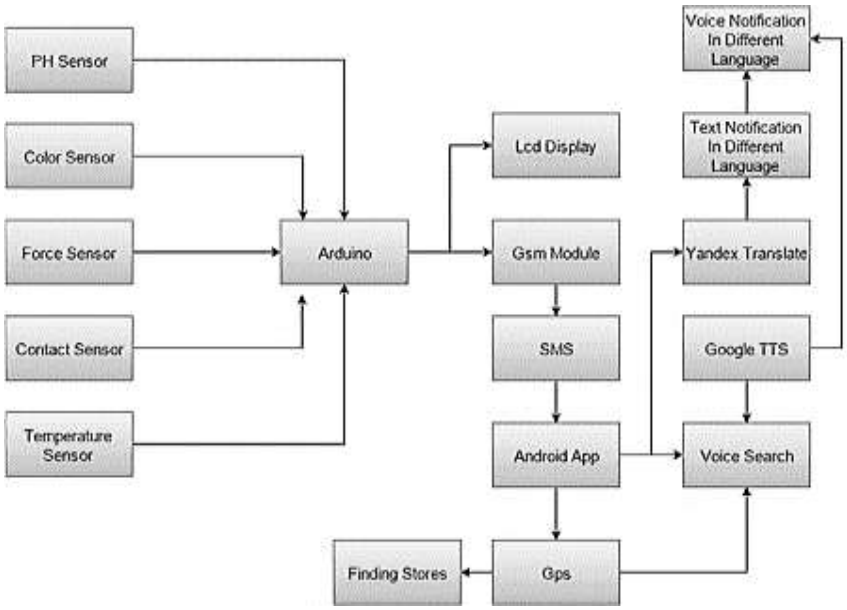

Fig.1 Project Block Diagram

- pH sensors are used to determine whether or not a product is rotting in a monitoring solution.

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- Detection of colour change is detected by a colour sensor, which compares it to the stored colour and delivers an alert.
- Force is measured in Newton when a weight is added to the force-sensitive resistor sensor mounted on the Arduino. The user will be alerted if the weight falls below a predetermined threshold.
- A temperature sensor near the compressor unit has found that there is a risk of fire or overheating in the refrigeration unit.
- A contact sensor is also put on the door to make sure it is closed.

The user should be alerted when a product's freshness or stock status changes. The GSM modem receives a signal from the Arduino if stock is low or not fresh. Messages like "your meat/fish is not fresh" or "your supply is low" will be sent to the user's cell phone through GSM modem. If we don't have a smartphone, this is a great alternative for us. Sending a control message to a GSM modem results in an SMS to the user's cell phone. Android users will receive both a text and voice notification if our companion application is installed. If the user selects, for example, Bangla as their preferred language, the subsequent message will be in Bangla. The user has the option of receiving video feeds on both their mobile device and computer. The customer is on the lookout for a nearby retailer [3].

Refrigerator Prototype Design

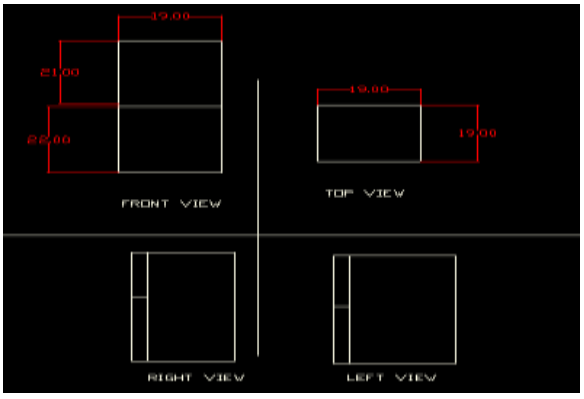

Fig.2 Prototype design of Refrigerator

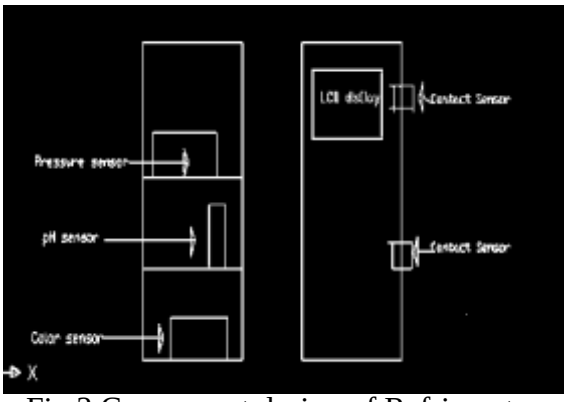

Fig.3 Component design of Refrigerator

Our project's architectural concept was unveiled in this section. It was decided to use force sensors for weighing food, and a pH sensor to determine the acidity or alkalinity of the liquid in the middle compartment. Using color sensors, the freshness of food may be determined in the lower chamber. We installed an LCD display on the outside of the door to show the sensor's entire output measurement. We utilized a contact sensor in the door to alert the user if the door is left open for an extended period of time[7,10].

There are a few functionalities in the planned Android app, such as voice command, finding the nearest store, and voice notification. Below, you'll find a detailed description of their characteristics.

Android App and User Interface
User interface design (UI) of the application (app) is kept simplistic and user friendly so that most people can interact.

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Fig.4 Android app user interface

There is a text level as well as five buttons here. The first button shows a list of the stores that are located nearby. It locates the stores that are closest to the user by using Google Maps, and it uses the GPS sensor that is built into the user's smartphone to calculate their current latitude and longitude.

Voice Recognize and Command

In order to search for information on a mobile phone, users can speak into their phone's microphone and have the device do the searching for them. This is known as Google Voice Search or Search by Voice. Android's Voice Action function, which lets users issue voice commands to their phones, was first introduced as a stand-alone feature. After clicking the voice search button, the screen indicated in the figure below will appear:

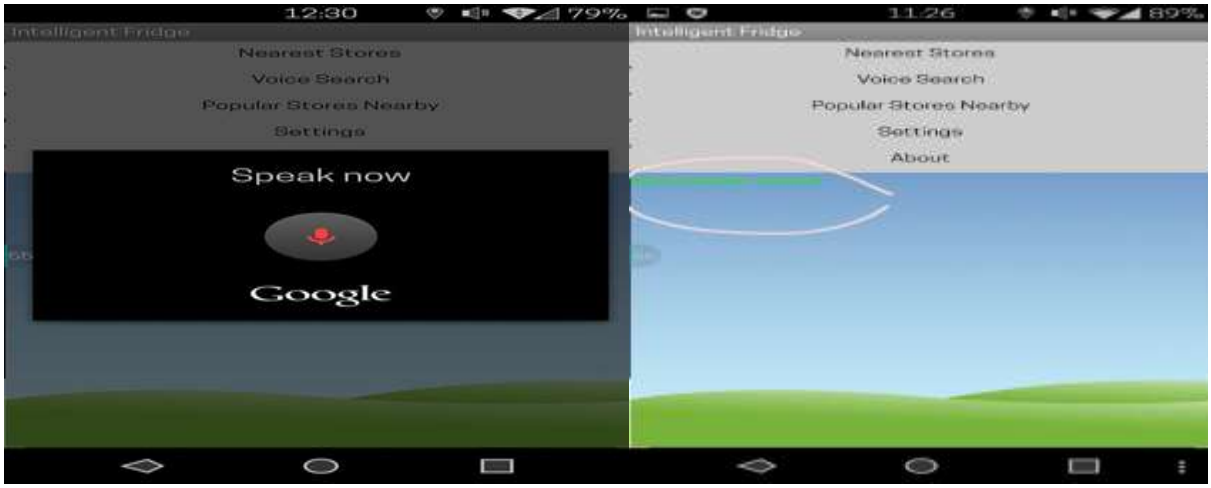

Fig. 5 Voice Command input

Fig.6 Level change with correct input

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When user speaks, whatever user spoken will be shown in the label as text. If the voice Command matches with the built-in command, text level will be in green colour.

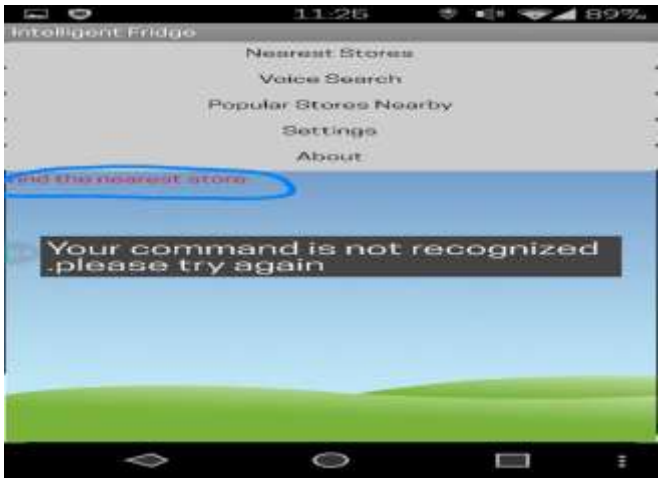

Fig.7 showing voice Command is not correct

An error message will appear if the voice command is not recognized. In Figure 7, the message "Please try again" will appear on the screen and the text level color will be red. Then the user talks. Google TTS is used to translate the user's spoken word into text, and the text is compared to create its command. Text that matches a command will be turned into GPS coordinates, and Google Maps will be used to find the nearest retailer. As an alternative, it will warn the user if a voice command is incorrect if the converted text does not match [8].

Finding Nearest Stores

Using this feature, users will be able to locate nearby retailers including supermarkets and grocery stores. Figure 8 depicts the screen after clicking the Button[14].

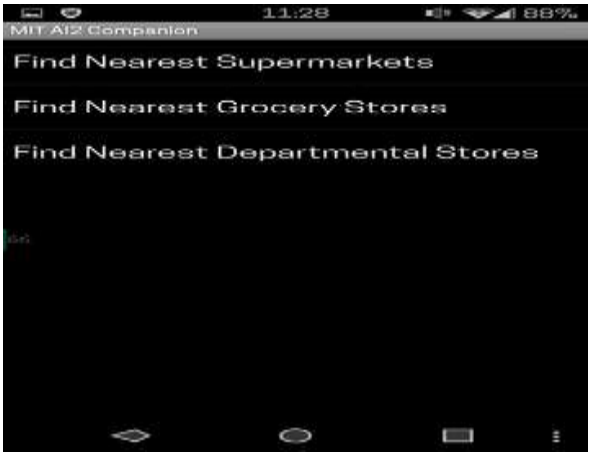

Fig.8 Search nearest shop location

Fig.9 Search result for nearest shop location

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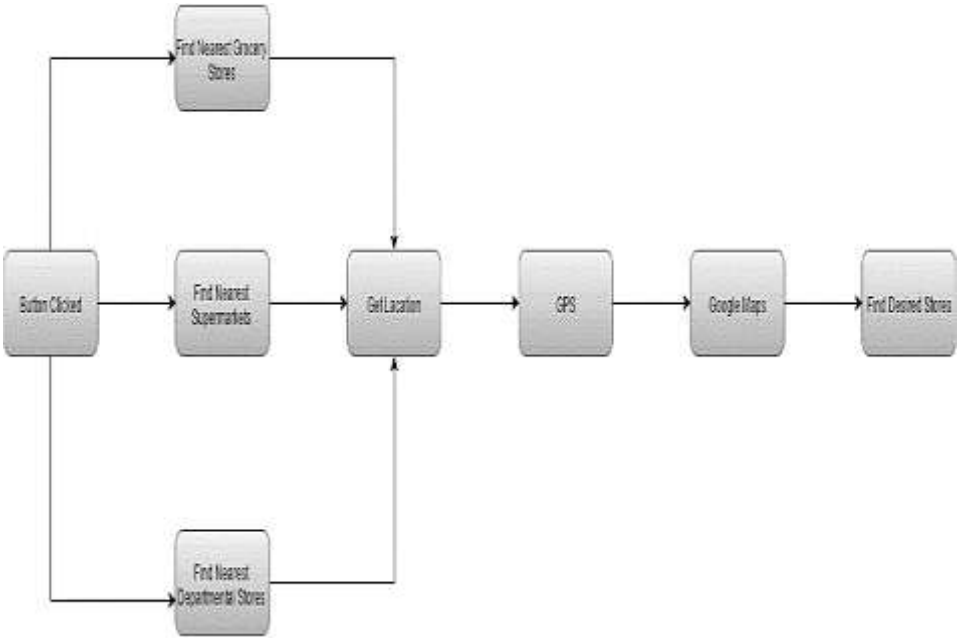

Fig.10 Block diagram of finding nearest shop location

Algorithmic Block Diagram

When the button is pressed, the program will launch Google Maps and begin searching for a location using coordinates. If the user selects the Meena Bazaar option, the app will begin a location action. '23.7816532, 90.3579781' is an example of the coordinates Latitude and longitude are both 23.7816532 and 90.3579781 and the phrase "Meena bazaar" is used to search for different maps[15, 16].

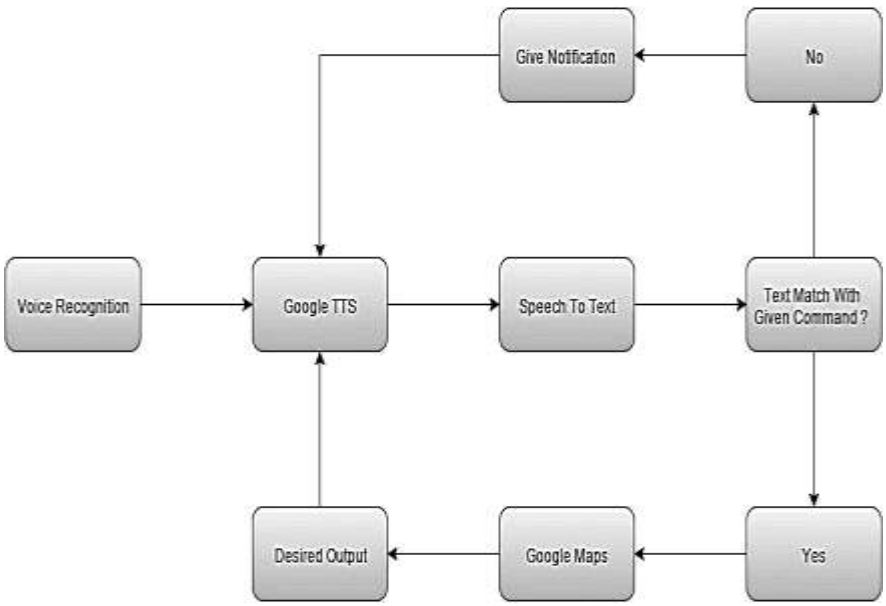

Fig.11 Block diagram of algorithm of nearest store finding

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Novelty of Our App

2. SIMULATION AND RESULT

This chapter explains the findings of the data analysis. A wide range of circuits and circuit implementations were used to generate the final output. Analyzing the output of a certain circuit was one of our primary objectives. As a result, we have a fundamental grasp of the intelligence refrigerator technology and the technology itself. With this result, future circuit layouts and the goals and principles of the technology are better predicted. This was a goal we were able to accomplish with our project. This chapter's conclusion highlights the importance of integrating theory and practice.

A. Colour Sensor

Fig. 12. Color sensor measuring meat freshness

Colour was measured for meat when it was fresh from the shop. Then the meat was kept unrefrigerated for one day and allowed to turn stale. Then the colour was measured again. The results are tabulated below.

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Table 1: Color sensor results

Color	When Fresh	When Stale
Red	145	125
Green	95	92
Blue	100	95
Time	2:41PM 25/11/2015	4:49PM 26/11/2015

When meat was fresh, it was reddish, but it turned a bit darker red when it turned stale. That was a human eye observation. The colour sensor's output matched the observed colour change. While green and blue remain almost the same, red changed from 145 to 125 [4].

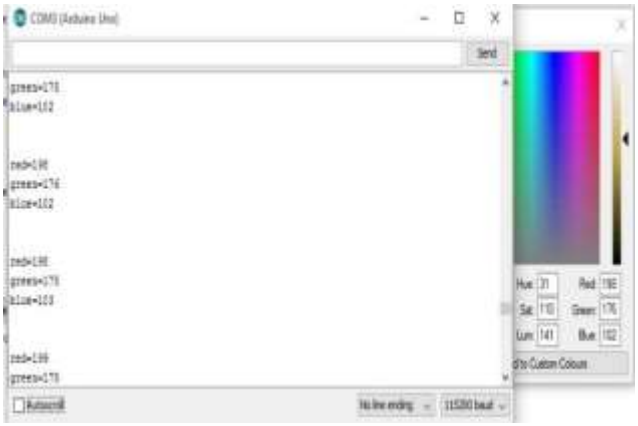

Fig.13 Colour sensor output result in Arduino Serial Monitor

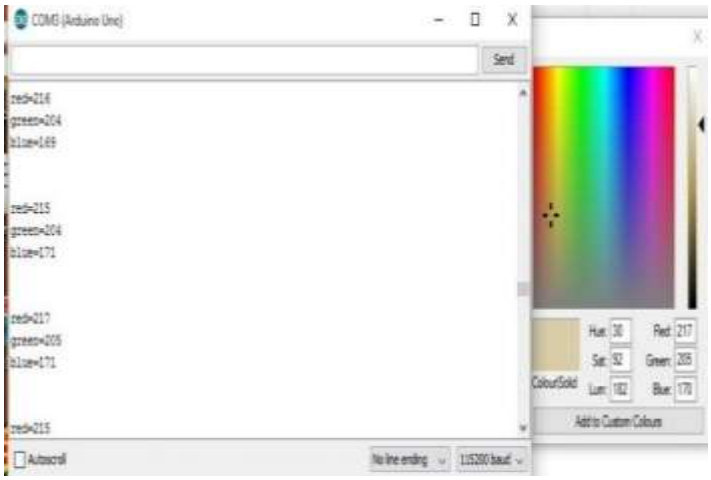

Fig.14 Experimental result and associated colour for RTP

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The result of the colour sensor was obtained in two steps. At room temperature, the object's hue was first assessed. Red = 255, green = 255, and blue = 128 were the anticipated outcomes based on the reading of red = 245, green = 219, and blue = 134. The colour was then once more measured while the colour sensor was still inside the refrigerator. A table with the outcomes is provided. We utilized Microsoft Paint to examine what those principles stand for. Steps one and two resulted in a close, or occasionally exact, match of the colours, however it was found that measurements recorded at a cooler temperature flickered far more quickly than readings taken at normal temperature. Additionally, flawless colour was produced when the item was a specific distance away, however our code was done in such a way that at fridge temperature 4 more result was taken. Result is shown in Table 2.

Table 2: Colour sensor result for different colour with comparing original colour

Case	Temperature	Experimental	Expected
Case1	Normal Temperature /RTP	Red =245 Green =219 Blue =138	Red =255 Green =255 Blue =128
Case2	Fridge Temperature	Red =204 Green =165 Blue=51	Red =255 Green =255 Blue =128
Case 3	Fridge Temperature	Red =216 Green =205 Blue=171	Red =255 Green =255 Blue =128
Case4	Fridge Temperature	Red =216 Green =205 Blue=171	Red =255 Green =255 Blue =128
Case5	Fridge Temperature	Red =216 Green =205 Blue=171	Red =255 Green =255 Blue =128
Case 6	Fridge Temperature	Red =254 Green =290 Blue=197	Red =255 Green =255 Blue =128

From the case 2 to 5 the fridge temperature was same but distance between colour sensor and the object was varied. We wanted to see how variation of distance between colour sensor and the object affect colour output [4].

B. FORCE SENSOR

During the project experiment, weight has been measured for 500 grams, 1 kilogram, and 2 kilograms. The corresponding output voltage of the force sensor with respect to the force has been given below:

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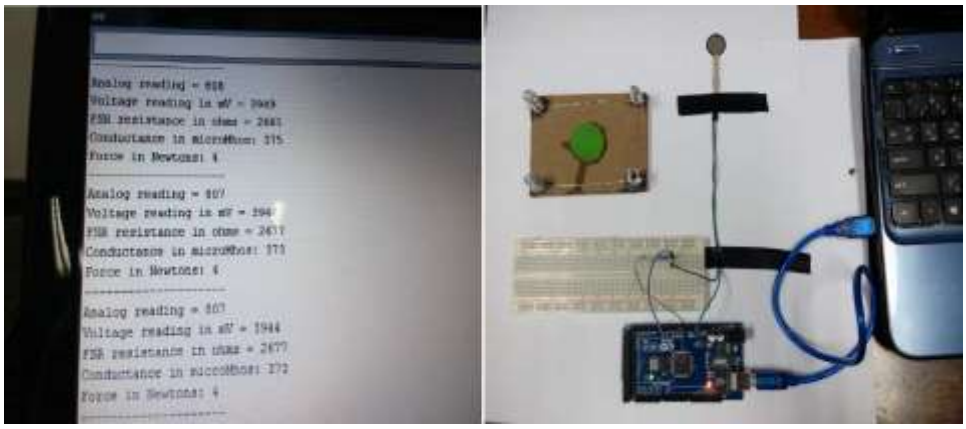

Fig.16 Result of a measuring food item for 500gram and snapshot during project experiment

Table 3: Corresponding output in Newton of the force sensor across the load

Load	Accepted value	Experimental value	Error (%)
500 grams	5 Newton	4 Newton	20%
1 kilogram	10 Newton	8 Newton	20%
5 kilograms	15 Newton	12 Newton	20%

5 Newtons equals 500 grams, and 1 kilogram equals 10 Newtons in the unit scale. Customers may see how much food is remaining in their refrigerator by looking at the computed weight shown on an LCD monitor. Refrigerated food, such as beef or fish, can be measured in this experiment. We can't acquire the exact weight using this method because of an error. In order to be seen by as many people as possible, this smart refrigerator incorporates both high-profile and medium-profile components that are extremely cost-effective. However, in terms of weighing food, this inaccuracy is inconsequential.

C. pH SENSOR

The water's pH level was analysed, and the average result was 7.19, when water should actually have a pH of 7. An error was recorded for the additional value of 0.19. This sensor is capable of sensing temperatures as low as 4.0 degrees Celsius and as high as 40 degrees Celsius [16].

Table 4: Results of pH level for different liquid

Liquid name	Exact PH value	Experimental value	Error (%)
Water	7	7.19	2.71%
Milk	6.4	6.6	3.10%
Mango juice	4.4	4.6	4.5%

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Fig.17 pH Measurement of fresh milk and when it turned stale.

The pH was measured for milk when it was freshly brought from the shop. The pH level was 6.37 the next morning. pH was measured when it turned stale. The measured pH was 4.34 [11, 13].

D. TEMPERATURE SENSOR

Temperature of compressor unit of a working fridge was measured and monitored for an hour. Also, temperature of room was measured to compare.

Fig. 18. Measuring and monitoring temperature of compressor unit

The temperature of the room on the day of the experiment was 26.37 degrees Celsius, and the compressor unit was 37.11 degrees Celsius. 45 degrees Celsius is the threshold above which a user gets notification about passable overheating [6,7].

E. GSM MODULE

The GSM module successfully transmits and receives SMS to the user's mobile device. If the user doesn't have a smartphone, it is their primary method of communication with the refrigerator [9].

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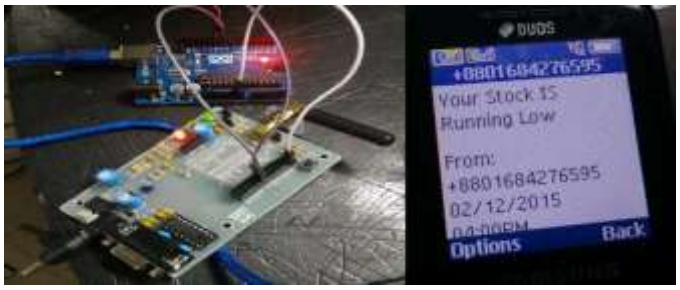

Fig.19 GSM module setup and SMS notification

When freshness or stock information is changed, the user needs to receive a notification for that matter. Arduino receives information from sensors, and if stock is running low or not fresh, Arduino will send input to the GSM modem. GSM modem will send SMS to users' mobile phones, and SMS is very specific, for example, "Your meat or fish is not fresh" or "Your stock is running low." This is helpful for users who don't own smart phones. If the user has a smart phone, our companion app will take it from there [11, 16].

Continuous Monitoring

An Internet protocol camera, or IP camera, is a type of digital video camera commonly employed for surveillance and which, unlike analogy closed-circuit television (CCTV) cameras, can send and receive data via a computer network and the Internet. Although most cameras that do this are webcams, the term "IP camera" or "netcam" is usually applied only to those used for surveillance. Continuous monitoring was done using an IP camera related app [11].

Fig.20 IP camera setup

Limitation and Future Work

Despite the fact that numerous smart fridge concepts have received a lot of attention and effort, there are still some glaring shortcomings. The following examples are provided. The technology is too complicated for the majority of home users, who require a more user-friendly interface for individuals who have little to no computer knowledge. There is a meager network connection, either because there isn't adequate support or it isn't a high-speed connection.

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Later on, this topic may incorporate a variety of functions with beneficial functionality. Other fundamental and more sophisticated criteria can also be used, as only a few of the primary criteria for an intelligent refrigerator have been illustrated in this study [13, 14].

Moreover, there are other approaches to build this project.

- Notification of when to clean the fridge due to bacteria accumulation.
- Power management for load shedding.
- Food nutrition features can be added, which can be used for monitoring how much different kinds of nutrition, such as carbohydrate, protein, and fat, are available in the stock food in the stock food in the refrigerator.
- The whole circuit can be designed in a different way, which will make the whole device faster than before.

3. CONCLUSIONS

With a new smart fridge app, we've added a number of practical features. It's feasible that the smart fridge could lead to a healthier diet and lifestyle. It's designed to keep track of what's in your pantry and provide you with a shopping list based on what's out of stock. Additionally, it can monitor supply and freshness, among other things. Features, functions, and design aspects of the fridge are explained in great detail. A smart refrigerator like this one, we believe, will play an important part in the future smart home.

4. REFERENCES

1. Suhuai Luo, Jesse S. Jin, and Jiaming Li, “A Smart Fridge with Ability to Enhance Health and Enable Better Nutrition” published in International Journal of Multimedia and Ubiquitous Engineering Vol. 4, No. 2, April, 2009.
2. S Luo, J Jin, J Li. “A Smart Fridge with an Ability to Enhance Health and Enable Better Nutrition”2013, International Journal of Multimedia and Ubiquitous Engineering, Vol. 4, No. 2 April, 2013
3. Shweta A.S, "Intelligent refrigerator using ARTIFICIAL INTELLIGENCE," 2017 11th International Conference on Intelligent Systems and Control (ISCO), 2017, pp. 464-468, doi: 10.1109/ISCO.2017.7856036.
4. Arivazhagan, S., Shebiah, R., Nidhyanandhan, S., Ganesan, L., "Fruit Recognition using Color and Texture Features", Journal of Emerging Trends in Computing and Information Sciences, 1 (2), (2010), pp. 90-94.
5. Suhuai Luo; Hongfeng Xia; Yuan Gao; Jesse S. Jin; Rukshan Athauda, “Smart Fridges with Multimedia Capability for Better Nutrition and Health", 2008 International Symposium on Ubiquitous Multimedia Computing.
6. B. Bostanci, H. Hagras and J. Dooley, "A neuro fuzzy embedded agent approach towards the development of an intelligent refrigerator," 2013 IEEE International Conference on Fuzzy Systems (FUZZ-IEEE), 2013, pp. 1-8, doi: 10.1109/FUZZ-IEEE.2013.6622303.

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7. S. Luo, H. Xia, Y. Gao, J. Jin, R. Athauda "Smart Fridge with Multimedia Capability for Better Nutrition and Health" IEEE International Symposium on Ubiquitous Multimedia Computing, 2008, pp. 39-44.
8. Wohlin, C., Runeson, P., Horst, M., Ohlson, M.C., Regnel, B., Wesslen, A.: Experimentation in Software Engineering. An introduction. Kluwer Academic Publishers (2000)
9. Deboux BJC, Lewis E, Scully PJ, Edwards R. A novel technique for optical fiber pH sensing based onmethylene blue adsorption. J Lightwave Technol 1995; 13:1407– 14
10. A Trémeau, S Tominaga, K Platanista's, Colour in image and video processing: most recent trends and future research directions. EURASIP Image Video Process. 2008(1), 581371 (2008)
11. M. A. Fonseca, J. M. English, M. von Arx et al., "Wireless micromachined ceramic pressure sensor for high-temperature applications," J. Microelectrodes. Syst., Vol. 11, pp. 337-43, 2002
12. J. Li, G. T Poulton, G. C. James, A. Zeman, P. Wang, M. Chadwick, and M. R. Piraveenan, Performance of multi-agent coordination of distributed energy resources, WSEAS Trans. System and Control. 2007; 2(1):5258.
13. Domingo Mery, Franco Pedreschi, "Segmentation of colour food images using a robust algorithm", Journal of Food Engineering 66 (2005), pp. 353- 360.
14. Perumal T, Sulaiman, Musthapa, Shahi A, "Proactive Architecture for Internet of Things (loTs)", published in2014 IEEE 3rd Global Conference on Consumer Electronics (GCCE),7-10 Oct. 2014.
15. VH Bhide " A Survey on the Smart Homes using Internet of Things (loT)" 2014, International Journal of Advance Research in Computer Science and Management Studies.
16. Rocha, A., Hauagge, D., Wainer, J., Goldenstein, S (2010), "Automatic fruit and vegetable classification from images", Elsevier, pp. 1-11.