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Design and Implementation of Smart Refrigeration System using IoT Devices

***Praful R. Pardhi* [*1], *Dilipkumar A. Borikar* [2]**

[1, 2] Shri Ramdeobaba College of Engineering and Management, Nagpur, Maharashtra, India.

****Authors for Correspondence***E-mail:pardhipr@rknec.edu

Abstract
Home appliances have eased the day-to-day requirements of storing vegetable and fruits for longer time in the kitchen. A refrigerator has become an integral part of the home setup. The refrigerators come in different configurations and make. The existing refrigerators comprises of single tire architecture. It requires considerable efforts in hardware installations for intelligent control and monitoring leading to higher costs.
In this paper we propose the design of a smart refrigerator using the IoT devices to communicate efficiently between the hardware and the user. It uses ARM processors and sensors for acquisition of system parameters and processing them to initiate appropriate operation or to signal messages. Our approach implements the smart refrigerator using a standard setup configuration and generates alerts based on parametric evaluation against the current state of the system. The refrigerator can effectively address the issues in quantity monitoring, quality monitoring, perishable items and the quality of shelf life in event of expiry of the packaged goods. The results are encouraging when the refrigerator was put to operation.

Keywords: *IoT, Smart appliances, Sensors, GSM, ARM processors, ASIC RFID*.

INTRODUCTION

Refrigerator is used on a large scale. It is a very important home appliance which consists of daily home essentials that are used by humans. Throwing away food is like stealing from the table of those who are poor and hungry, a lot of food inside the refrigerator gets spoiled as people are unaware of the expiry date of packed food and quality of vegetables that are kept from many days inside the refrigerator and due to lack of concentration on such home appliances those stuffs are not used by the people at the right time and after they are spoiled they get wasted and are thrown away which leads to food wastage. The said model being designed is a smart refrigerator which communicates with the user information the communication is about the products in the refrigerator and this communication is done using various sensors [1].
The existing system requires GSM module which has a drawback of injecting it into every system so it has to be purchased separately for every system which directly increases the product cost [3]. The system being designed uses a technology called Internet of the Things (IoT). IoT is making our life easy by transforming our surrounding objects into an ecosystem of information that will enrich our lives. From refrigerators to parking space to houses, it is digitizing almost everything in our everyday world. It is estimated that the IOT will be a multi-trillion dollar industry in near future [4][5].
The various sensors used to monitor the system are IR sensors, pressure sensors and gas sensors respectively. These sensors are used to achieve objectives like quality and quantity analysis. The third most important aspect of this system is to self-monitoring. The system detects the packaged products via barcode imprinted on them. All these sensors are connected to the Arduino microcontroller to fetch the current status of the refrigerator. As the system uses IOT, it becomes easy for all the systems around the world to get updated fast anywhere, at any time and at anyplace [7].

RELATED WORK

An approach to designing a refrigerator incorporating use of AI has been proposed in [1]. The proposed system keeps tracks of the count of vegetables and also their shelf age. The system indicates the vegetables that were on-shelf over a month with a view to minimized food wastage.
Likhita and Nagasree have proposed the architecture of a smart IoT fridge using a GSM module. The system evaluated the quality and quantity of on-shelf vegetable products and fruits using various sensors [2]. The GSM module and other user specific functionalities were customized in the hardware that could restrict generality. It also introduced use of RFID tag to be attached to every on-shelf item, making it less viable.

In a different research on development of GSM based interactive refrigerator, Prapulla and Shobha realized a setup that can remotely notify the user about the lowered food stock on-the-shelf [6]. A smart ordering system using GSM when the on-shelf quantity reaches the reorder level was implemented and the user was alerted via SMSs. Although the system was able to provide necessary alerts, it lacked on retaining the nutritional value of the products and on providing alerts on the least used stocks.

PROPOSED SYSTEM

The proposed system ensures the core functionality of smart fridge for food management with the help of sensors by a assessing the shelf life qualitatively and quantitatively. It attempts to overcome the limitations where the network module could not communicate with internet [8]. Our approach integrates the IOT in ensuring communication among all smart environments.

The prime objectives of the design include –

1) The quantity monitoring that facilitates assessing the quantity of the on-shelf food items and generates notification alerts for the low stocked products.
2) The quality monitoring that assesses quality of the food items by periodically checking the on-shelf time of the product and alerting for critical cases where the food item has been stocked beyond reasonable time making it unhealthy to consume.
3) The shelf-life monitoring that would periodically scan the e-tags (barcodes, batch nos) and ascertain the expiry of the food items. It would indicate relocation of food item to specific shelf when it reaches the specified shelf life.

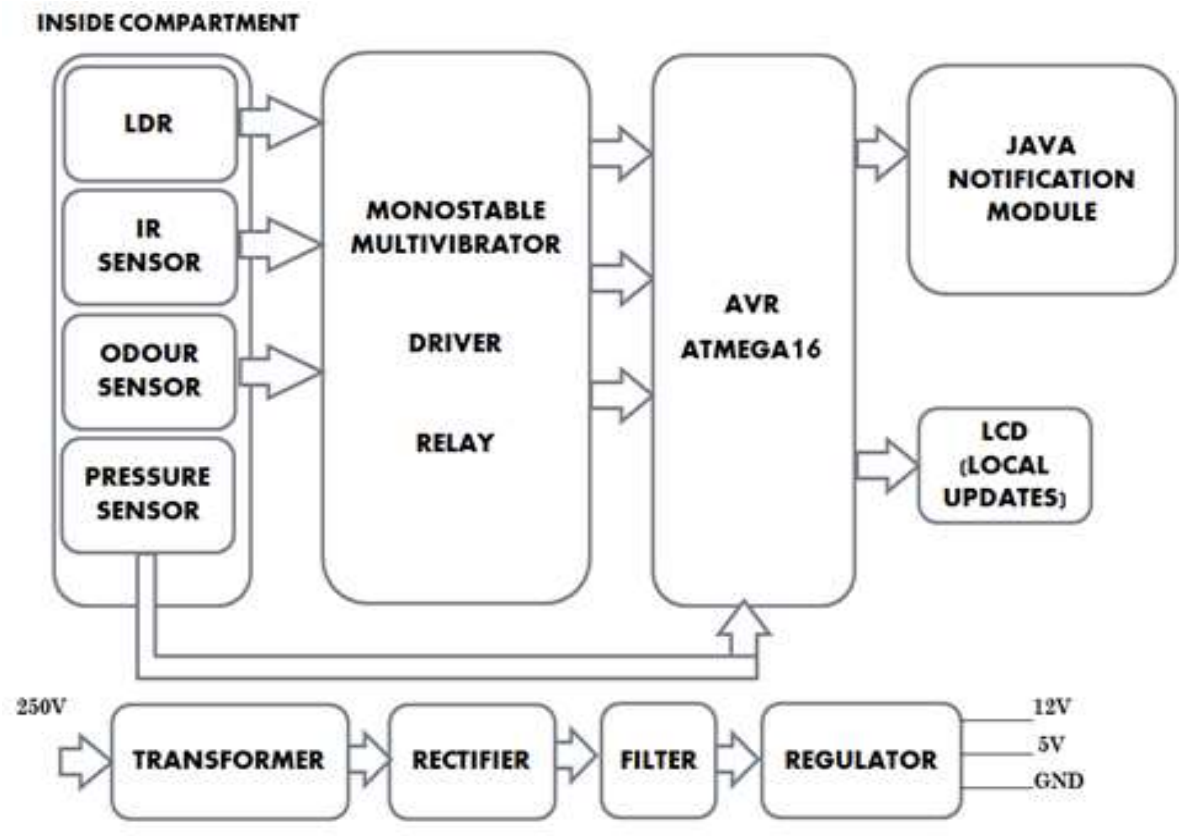

Fig. 1 Block diagram of the Smart Refrigerator

The general architecture of our refrigeration system using IoT devises is depicted in Fig. 1. The system is divided into individual compartments each for quality, quantity and shelf monitoring and embeds various sensors, viz. IR sensors, pressure sensors, gas sensors, etc., that are integrated into the system via a microcontroller. In addition, counters are also placed in each compartment to indicate the quality of the product in the compartment. For example, the IR sensors can be used to count eggs in the compartment.

The IR sensors will detect the objects on the shelf and the microcontroller will then count the individual items. Simultaneously, it will alert for low count and signal the user to add items to the shelf. Pressure sensors can be used to detect the level of liquid (milk, juice, etc) in the jar.
ASIC RFID transmitter and receiver setup is used to monitor the shelf life of the food items in the refrigerator compartments. A predetermined threshold is used to analyse the contents of the refrigerator.
When the item count falls below the threshold it signals the requirement for refilling the stock. Otherwise, if the item is stocked over the predefined duration on the shelf or exceeded the expiry date and the counter values do not fall below the threshold, it would signal an alert for quality violation and indicate replacement of the stock. In addition for the products nearing their expiry date, a trigger will be generated and transmitted in the form of message to the user [9].

METHODOLOGY

A. Working of IR sensor module

Fig. 2 represents the working of the pair of IR sensors mounted on the egg compartment. The sensors (the transmitter and the receiver) are placed on opposite walls of the compartment. When the eggs are present in the compartment, there is no contact with the items and the sensors.

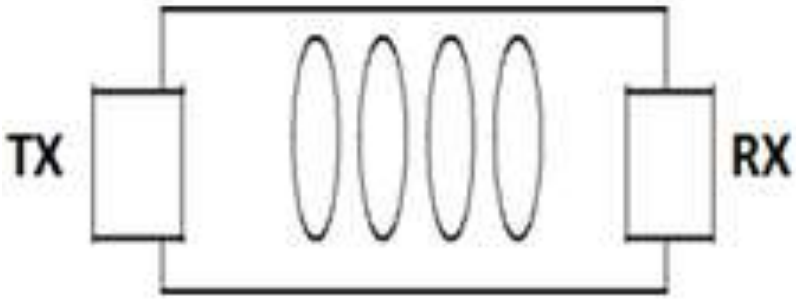

Fig. 2 IR Sensor configuration when item are present

When all the eggs are taken out one-after the other, it creates direct contact between the transmitter and the receiver as shown in Fig. 3. It generates a signal to a microcontroller for processing. The microcontroller generates “eggs finished” signal and sends the signal to the user on the mobile. The one touch app would allow auto-ordering of the items from the predefined grocery shops using the Wi-Fi module.

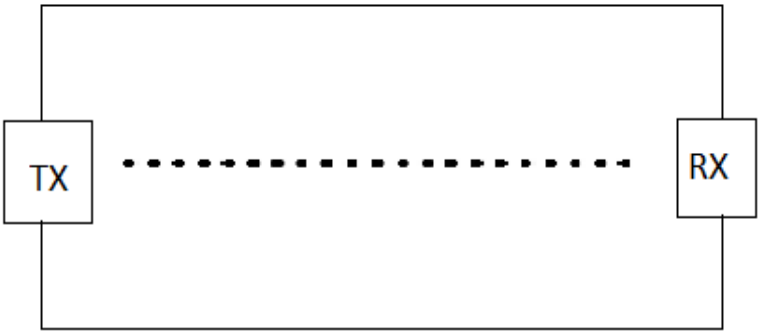

Fig. 3 IR Sensor configuration void of any item

B. Working of load cell

Fig. 4 details the process of quantity monitoring in vegetable detection using pressure sensors (the load cell). The load cell is mounted beneath the vegetable tray and continuously measures the weight of vegetables in the tray. When the weight of vegetable tray goes below threshold weight (default weight is 500 g), it sends the LOW signal to the system which is transmitted to user on mobile app.

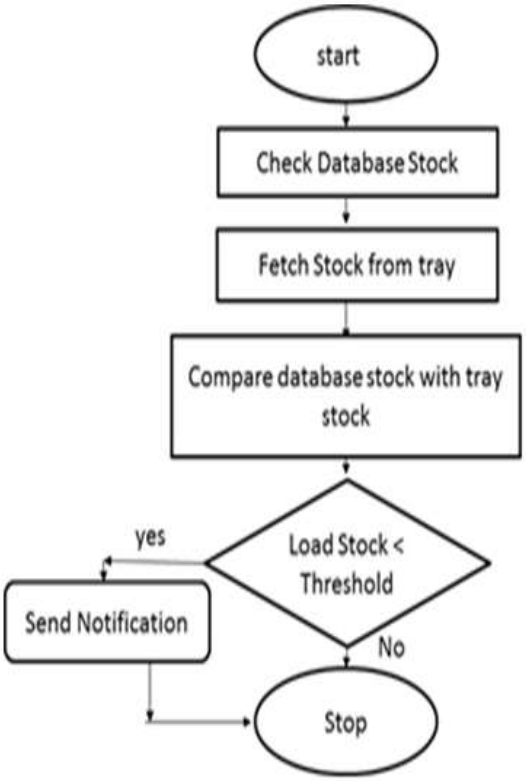

Fig. 4 Quantity Monitoring Flow using Load Cell

C. Working of gas sensor

Fig. 5 details the process of quality monitoring in vegetable compartment using the gas sensors. The food items and vegetables often perish they are stored for longer duration. The perished or rotten vegetables gives out a foul smell generated through the gases released. The gas sensors are fixed inside the fridge to detect the odour of the rotten vegetables. On detecting the presence of the specific gases the alert is generated and appropriate messages are displayed on the front panel of the refrigerator and on the mobile device.

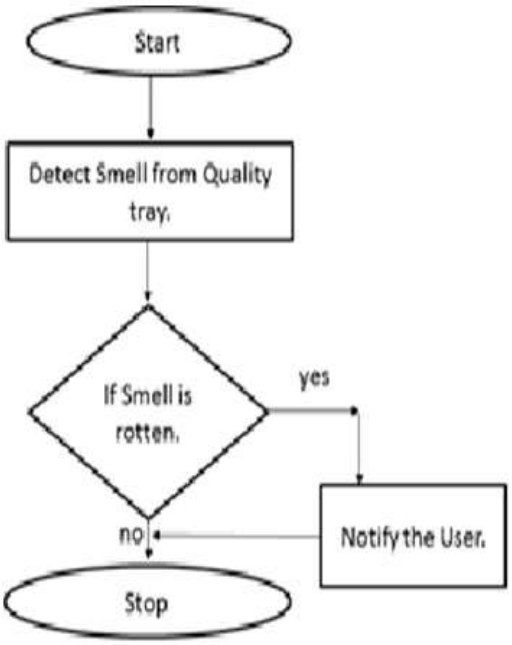

Fig. 5 Quality Monitoring Flow using Smell Sensor

D. Ice ready indication

Typical temperature in the freezer is -5 to -10 degree Celsius. At this temperature, the water in ice tray takes nearly 30 minutes to turn into ice. The IR sensors are fixed in an ice tray section. When the ice tray is placed in the freezer, it signals presence of the tray. When 30 minutes are elapsed, the timer signals the ice formation to the user.

E. Notification module

The modified system integrated with the Internet when operational compares the day-to-day performance of the refrigerator with the standard reference values from the reference dataset. The shelf life monitoring flow is presented in Fig. 6.

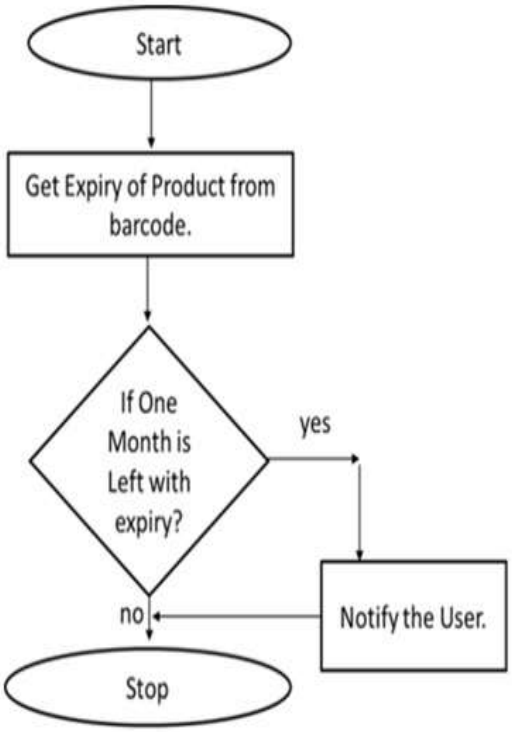

Fig. 6 Flowchart for shelf life monitoring

The product expiry information acquired and stored is aligned with the operations of the system. It sends signals to the user when the item nears the expiry date of less than 30 days. In such cases the user must act to consume the products or discard on passing the expiry date.

RESULTS AND DISCUSSIONS

The GUI of the refrigeration system that determines the quantity of the product in the compartments using an android generated app is displayed in Fig. 7. The image shows the full stocked refrigerator with egg tray containing 8 eggs.

Fig. 7 Full stocked refrigerator

Fig. 8 shows the refrigerator when 2 eggs were removed leaving 6 eggs in the tray. Also notice the accumulation of frost on the walls of the freezer compartment where ice tray is placed. The notification to the user mobile is sent by comparing the systems dataset with the reference dataset.

Fig. 8 Refrigerator after removing items (with 6 eggs)

In Fig. 9, the freshly loaded refrigerator containing few eggs, vegetables and fruits can be seen. The image indicates absence of the frost on the walls of the freezer. The same is reflected in the interface to the user.

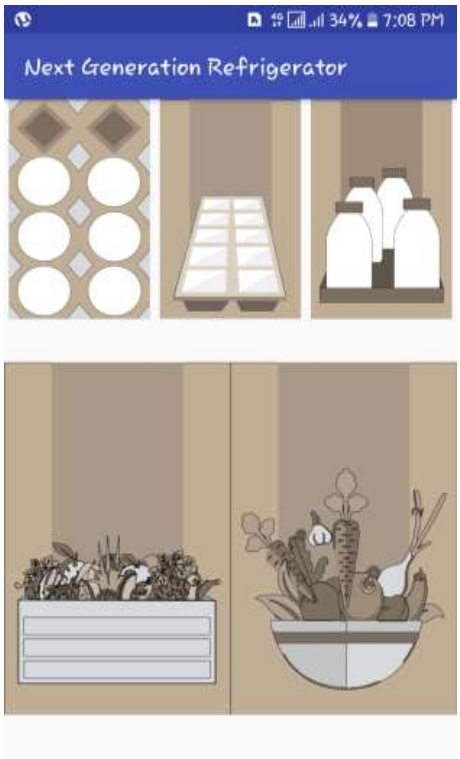

Fig. 9 Refrigerator with no frozen ice on the walls

For quality monitoring, the gas sensor detects the pollution density in air. The obtained density is compared with the reference density of fresh air to assess the quality of air. In event of unwanted gases identified, the user alert is generated indicating degrading quality of the food items.
For determining shelf life, the packaged products are scanned for their barcodes and the vital information regarding expiry date, batch number, etc is acquired. When the products are on-shelf and nearing expiry (say 30 days of below), the user in notified to initiate corrective actions.
For other situation when the item quantity falls below the reorder value, the user is signalled and the order for replenishing the stock is placed with the listed grocery vendors.

CONCLUSION

This paper discussed the design of an intelligent refrigerator with IoT devises. This synchronizes with the idea of smart home appliances building on the technological advances in both electronics and software. Our design includes integration of sensory subsystems with the Arduino microcontroller and an android mobile application interface. The system minimizes the food wastage by notifying the user at appropriate time to initiate necessary actions. It also helps monitoring the shelf life of the food items and providing the healthy lifestyle.

REFERENCES

1. Shweta A.S, “Intelligent refrigerator using Artificial Intelligence”, Conference: 2017 11th Int. Conf. on Intelligent Systems and Control (ISCO), January 2017. DOI: 10.1109/ISCO.2017.7856036,
2. Likitha R.V, R. Nagashree, Shruthi. “IoT Smart Fridge”, Int. Journal of Advanced Research in Electronics and Communication Engineering (IJARECE), Volume 5, Issue 4, May 2016, ISSN: 2278 – 9094689.
3. Hüseyin Gürüler, “The Design and Implementation of A GSM Based User-Machine Interacted Refrigerator”, Innovations in Intelligent Systems and Applications (INISTA), 2015, International Symposium. [978-1-4673-7751-5/15].
4. Robert R. Harmon, Enrique G. Castro-Leon, and Sandhiprakash Bhide; “Smart Cities and the Internet of Things”, 2015 Proceedings of PICMET '15: Management of the Technology Age.

5. Sangole K. M. et al.; "Smart Refrigerator Using Internet of Things (IOT)"; International Journal of Advance Research, Ideas and Innovations in Technology, Vol. 3, Issue 1, 2017.
6. Prapulla S. B., Shobha G., Smart Refrigerator Using Internet of Things, Journal of Multidisciplinary Engineering Science and Technology (MEST) ISSN: 3159-0040 Vol. 2 Issue 7, July – 2015.
7. Suhuai Luo, Jesse S. Jin, and Jiaming Li; A Smart Fridge with an Ability to Enhance Health and Enable Better Nutrition; International Journal of Multimedia and Ubiquitous Engineering Vol. 4, No. 2, April 2009.
8. Somayya Madakam, R. Ramaswamy, Siddharth Tripathi; 'Internet of Things (IoT): A Literature Review', Journal of Computer and Communications, 2015, 3, 164-173. (Published Online May 2015 in SciRes).
9. Deepti Singh, Preeti Jain, "IoT-based Smart Refrigerator System", International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE) Volume 5, Issue 7, July 2017.
10. Folasade Osisanwo, Shade Kuyoro, and Oludele Awodele, 'Internet Refrigerator- A typical Internet of Things (IoT), 3rd International Conference on Advances in Engineering Sciences & Applied Mathematics (ICAESAM'2015), March 23-24, 2015, London.