Connectier (Home Appliances Controlling System)

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Abstract

In 21st century, Smart home concept is playing a major role in day to day life and lives also are much more dependent on electronic devices and smart refrigerator is very popular and attention seeking among these home appliances. Home automation has been increasing vastly in the past years due to much simplicity and affordability for home appliances. Earlier home automation systems were based on technologies like Bluetooth, ZigBee, Z wave and remotely controlled using GSM networks. Currently IOT technology is widely used in home automation which will allow users to control hardware devices through the internet. Smart refrigerators are major part of home automation. Current smart refrigerators come as a single component (as whole complete fridge), which is quite expensive and not affordable for everyone. This research presents a more affordable and useful way to keep track of the food items in the refrigerator using consumption trackers which come as add-ons. The automated approach of controlling the home appliances through mobile and web applications could ease the task using the IOT technology. Because of popularity and flexibility in Android operating system, this mobile application is based on android. The need of a simple and elegant way to keep track of the food items in the refrigerator is the major requirement of this research. A more simple way of allowing people the freedom of having complete control of their home appliances from anywhere is another requirement of this research. Therefore, implementing consumption trackers that can be kept inside the refrigerator, receiving notifications according to the consumption of food items, keeping track of them and a home automation system that reduces energy consumption, protects home environment from secondary effect are the purposes of this research. The result of this research, web and Cloud based home automation system that is flexible and scalable with wide range of home appliances, will promote the growth of IOT. Proposed Home Automation System will help to improve the standard of living at home and allow increasing work efficiency in future.

Introduction

Automation of home appliances is a step of automating the human lives and making them easy to live [1]. In the modern kitchen structure, refrigerator is the most frequently used electronic appliance. With the development of technology, refrigerator has become smarter. These days smart refrigerator are designed to sense and monitor what kind of products are being stored inside the refrigerator and keep track of the stock through a barcode or RFID tags. These kinds of refrigerators automatically provide notifications to the user of which the food items are running low and when they are expiring etc. It also provides information about the nutritional facts and consumption history of the food to the user [1]. Smart refrigerators are really helpful to people who are living the modern society as the modern life style is busier than ever in the history. They do not have time to look after their basic healthy habits and diets along with their stocks of food. The introduction of smart refrigerators which have above stated functions was unsuccessful, because of the consumer's perception of it being an unnecessary product due to its expense which is more than $20,000 [2]. In this research paper, a smart refrigerator add on kits are proposed. These are designed in order to modify the existing normal refrigerator as a smart refrigerator which enables the user to save a huge cost. Also, this proposed add on kits need minimum level of user interaction. In this kit, the weight changes of the food inside the refrigerator trays will be notified to the user. The weighing task will be done with the use of a load cell module which is connected with the arduino board. The notifications are sent to the user via an android application or a website. When user takes some food from the refrigerator, the system will notify the weight change of food inside refrigerator trays and notification will be sent to the user's mobile device or web application. Along with the

notification, the weight change is further confirmed by the user. Taken as a whole, a conclusion can be made that this research based add on kit will be a revolutionary step in the technology field as well as in the human lifestyle.

The remainder of this article is organized as follows. In section 2, we revise the related work in terms of the other attempts of smart refrigerators and technologies that were used relevant to the idea proposed in this paper. In section 3, we describe the methodology and design approach around our idea of a smart refrigerator. In section 4, we review the results of the proposed system and section 5 is the discussion about the proposed system. We conclude the paper in section 6 and finally in section 7 the references are listed down.

Background

This section explains previous work on home automation based on different technologies. Most of the researches can be broadly classified into two main approaches. One is using short distance wireless communication methods to remote control home appliances and other one is using internet as communication method to remotely access home appliances.

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Connectivity Technologies

SMS based connectivity

SMS is the best solution for communication in a power failure [2] proposed a GSM based system in which the user sends a sms command which is identified using a microcontroller. Hasan et al. [3] implemented a system in which status of home appliances is converted into a meaningful sms using a microcontroller and it is sent to the user. Rai et al. [4] provided an extra security to the system by adding subscriber identification based on the communication taken place for specific number of user's SIM Card. Additionally, Mahesh et al. [1-6] implemented an android application in which spoken commands are converted in to a sms and then it is sent to the main controller of the system. In case of emergency system is unable to overcome issue with sms delivery.

Internet/IOT based connectivity

Home Automation using IOT include two parts: server and client. This client/server mechanism uses different protocols to convey messages and to control signals through the internet [6] have explained about IOT and Cloud computing can work together to address the big data problems. Instead of using PC based web server, an electronic chip with an integrated Ethernet networking protocol is used [7] implemented 3G/4G mobile cellular accessibility additionally to provide a backup solution in case of no wifi connectivity.

Radio signal based connectivity

Radio signal based connectivity has two types of functionalities. One is transmitting and the other part is receiving. These transmitting and receiving functions are done by two different devices (radio signal transmitter and receiver). These receiver and transmitter require less energy to the devices. It does not require any verification between two devices before the data transmission. Radio signal based connectivity is the best solution for the short distance communication. Disadvantage of the radio signal based connectivity is that anyone with the exact signal transfer frequency can easily receive, send or modify this radio signal.

Hardware Modules

Main controller/Arduino mega 2560

With the home automation systems home environment should communicate as a one entity and conserve the energy, be easy to use and energy efficient [8]. Arduino is an open-source prototyping platform that provides easy-to-use hardware and programming environment [9] discussed about using arduino as micro controller/main controller is economical and energy efficient solution for home automation systems. Arduino is responsible for collecting events from connected sensors and peripherals [7,10] discussed the elimination of wired connections between devices using arduino which will result in reduction of cost and enabling to work it as standalone device.

Temperature sensor

It is a precision integrated-circuit temperature sensing device with an output voltage linearly proportional to centigrade temperature. LM35 [11] device has an advantage over the linear temperature sensors calibrated in [9] mentioned about LM35 temperature sensor will provide accurate values on a large scale from minus values to higher positive values. Therefore, monitoring the temperature inside the refrigerator with this sensor will be ideal.

LPG and smoke sensor

Gas or smoke detection is important for protection of home environment. Most probably they are emergency cases. Subhankar et al. used MQ2 smoke sensor because it can detect H_2, LPG, CH_4, CO, alcohol, smoke and propane. Due to its fast response time on measurements, this can be taken as smoke sensor of this system.

Weight sensor

Khosla et al. [11] selected HX711 load cell for the weight measuring of each compartment in refrigerator because there is no programming needed for the internal registers. Also, it has a fast response time, high integration, immunity and other features. HX711 load cell will reduce the cost and improve the performance with reliability.

Research Gap

Classic home automation systems use technologies like Bluetooth, DTMF and GSM. But the most trending and reliable current home automation system is based on IOT. Therefore, a low cost and efficient home automation system is presented through this research. Classical technologies that have been used on home automation do not provide remote access from anywhere or there are coverage limitations on remote accessing to the system. To solve this issue, this research will provide a web and cloud based solution using IOT technology. Most of the researches mentioned above contain two modules: hardware module and software module for communication. But this system includes existing two modules and one clouded module which will be available at any time and maintaining a copy of the system information up to date.

Some home automation systems prefer Raspberry PI as the main controller due to its performance. But controlling home automation system from Raspberry PI is wastage of resources. System implementation mainly focuses on cost and efficiency; therefore, arduino will be used as the main controller. Arduino is suitable for this research because of its flexibility and open source programming environment. To maintain the level of performance in system, arduino Mega 2560 is used as main controller of this system. As well as other home automation systems, all communications and controls are passed through the main controller.

Most often home automation systems pass the system status to mobile devices. But this system totally differs from existing systems. System updates the status of home environment to a clouded database and all other devices get the data through clouded database. Home automation systems that have been mentioned above mostly used arduino Wi-Fi shield to maintain internet connection. Issue with those systems is, inflexibility with any Wi-Fi connection when the password is changed. Therefore, in this system main controller is connected to the internet through arduino Ethernet shield. System will update cloud with current environment of home appliances such as temperature, gas and smoke sensors. Because of clouded database, system will allow users to control appliances such as switching functionalities through mobile application and web application. Classical home automation system used MYSQL or SQLite to share information sources and to synchronize the status between system users. Those techniques are performance wise very low. This system will use Google Firebase database management system to do fast data exchanges and take data-driven decision on system. Mobile application will be built using Android OS due to its popularity and as well as its open source environment.

Methodology

In this paper, our main goal is to propose a system for home automation. Architecture of the proposed system is shown in the Figure 1 as a block diagram exhibiting the connectivity of the system. The home automation system consists of two main hardware components. Main Controller and Detector module. Main controller module consists of Arduino mega 2560, RF Transmitter (433 MHz), RF receiver (433 MHz), and Ethernet shield. Arduino mega requires a lesser operating voltage like 5 V. Arduino mega offers a variety of digital and analog inputs, serial interface and digital outputs. Thus RF transmitter and receiver are easily connected to it. RF transmitter and receiver transmit and receive commands from sensor modules. An Ethernet shield is attached to Arduino mega in order to synchronize data with database and to receive commands via internet.

There are four types of detector modules:

- Consumption tracker module.
- Power controller module.
- Smoke detection module.
- Temperature detection module.

Consumption tracker module

This module consists of an Arduino pro mini, a load cell that could weigh up to 5 kg, a RF transmitter and a receiver and a humidity sensor DHT11 which can measure both humidity and temperature. Load cell module is connected to analog and digital pins in the arduino pro mini through HX711 circuit. HX711 has two input channels which are analog and we can obtain a gain up to 128 by programming these channels. So HX711 module amplifies the low electric output of load cells and then this amplified and digitally converted signal is fed into the arduino to derive the weight. There is no need for programming the internal registers in HX711. This is the reason behind choosing it. Every control to the HX711 is passed through the pins. HX711 not only has a few basic functions compared with other chips, it also contains high integration, fast response, immunity, and other features. This chip improves performance and reliability at the same time lowering the cost of the consumption tracker module. Figure 2 is an image of the proposed consumption tracker. Since both temperature and humidity can be measured using the humidity sensor DHT11, it is used to derive values of temperature and humidity.

Power controller module

This module consists of an Arduino pro mini, 5 V 10 A Relay Switch, RF Transmitter (433 MHz) and RF receiver (433 MHz). Relay switch is a switch module that is electrically operated and allows users to turn

on and off a circuit current which is higher than the micro controller's voltage. It has no connection between the high-power circuit and the low voltage circuit operated by the microcontroller. The relay secures each circuit from each other (Figure 3).

Pin configuration of the relay switch is as follows: required operational voltage to the relay will be supplied by the Arduino mini. Digital output from Arduino mini will be used to change between two channels. Pin Configuration:

- VCC: 5 V DC.
- COM: 240 DC.
- IN: 5 V DC.
- GND: ground.

Arduino pro mini will be using a digital reading to check the operational channel of the relay. Specifications of the 5 V 10 A Relay Switch

- On-board 5 V, 10 A.
- Protected from current using diode.
- Short response time.

Smoke detection module

This module consists of an Arduino pro mini, MQ-2 smoke sensor, RF Transmitter (433 MHz) and RF receiver (433 MHz). The major reason behind choosing MQ-2 Smoke Sensor for our proposed smoke detection module is its sensitivity to smoke and to plenty of other flammable gases such as LPG, butane, propane, methane, alcohol and hydrogen. The resistance of the sensor differs depending on the
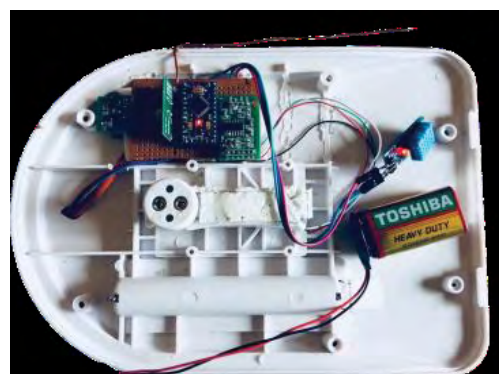

Figure 2: Image of the proposed consumption tracker.

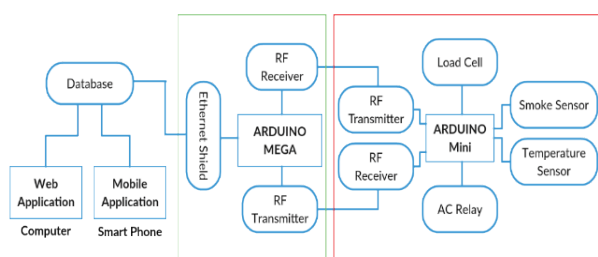**Figure 3:** Image of the proposed power controller module.

Figure 1: Main controller module and detector module.

type of the gas. The smoke sensor has an inbuilt regulator allowing the user to alter the level of accuracy of detecting the gas (Figure 4).

Required operational voltage for the MQ-2 smoke sensor will be supplied by the Arduino mini. The output can be an analog signal (A0) which can be read with an analog input of the Arduino or a digital output (D0) which can be read with a digital input of the Arduino. MQ-2 Arduino library will be used to programmatically to convert and derive required readings for LPG, carbon monoxide (CO) and smoke density in ppm.

The voltage output of the sensor alters proportionately with the smoke/gas concentration in that particular environment.

Temperature detection module

This module consists of an Arduino pro mini, Arduino Compatible ARD2 Non-Contact Infrared Temperature Sensor GY-906, RF Transmitter (433 MHz) and RF receiver (433 MHz). The major reason for choosing this sensor is its capability of sensing between 70°C-380°C down to a resolution of 0.02°C. Operating temperature of GY-906 sensor is 40°C-125°C. GY-906 sensor includes an unsoldered 4-pin header. Those pins are VIN, GND, SCL, and SDA. Required operational voltage for the MQ-2 smoke sensor will be supplied by the Arduino mini through VIN and GND pins. Two analog readings will be taken from SCL and SDA analog pins. Using MLX90614-infrared-thermometer arduino library, readings will be programmatically converted and required temperature output will be derived (Figure 5).

RF Transmitter and receiver (433 MHz)

RF Transmitters and Receivers (433 MHz) are used in main hardware components: Main Controller module and Detector module. RF transmitters and receivers are attached to every Arduino pro mini and arduino mega 2560 in the proposed system and those are used to transfer and receive data between the main controller and detector module of the proposed system. Arduino pro mini is programed to transfer and receive data simultaneously. Both RF transmitter's and receiver's frequency range is 433.92 MHz (Figure 6).

Results

After thorough research, the Connectier team identified the need of a full-fledged system to monitor the home environment and the importance of keeping track of food consumption. According to the user requirements, the development team has implemented a home automation system including a web application and a mobile application. Main controllers controlled by software program are capable of gathering information from other components and uploading to the server, downloading commands and transmitting to other components. It does not have any physical interface (no GUI) to interact with user.

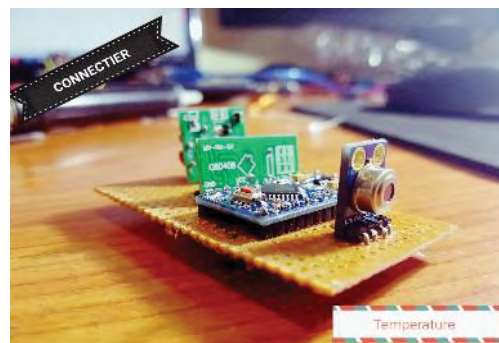**Figure 4:** Image of the proposed smoke detector module.

Figure 5: Image of the proposed smoke detector module.

Figure 6: RF Transmitter and receiver

Figure 7: Fire base.

System uses single point of communication which is Google Firebase to maintain real-time environment between hardware and software. Database stores all the system information regarding user, main controllers, detectors and rooms. Object oriented database design allows the deployment of the system to support automatic scaling. It enables the project to go to the commercial level where thousands (or even millions) of main controllers are handled (synced across devices) simultaneously. All the query executions on database will be performed on client device (Figure 7).

The android mobile application is a user friendly tool to operate home appliances from anywhere with internet connectivity. The application enables the user to get notified on home environment instantly and real-time. Simply user can turn on/off home appliances which are connected to power controllers. Smoke and temperature sensor will help user to provide safe environment inside home that can get affected from condition like fire. Mobile application has the ability to alert user instantly in such conditions.

Discussion

The system is expected to be very reliable and accurate. With the independent functionality development, the system was thoroughly unit tested. Unit test levels were important and very effective since most of the problems have been identified and eliminated in early stages of development. The Connectier team faced so many technical problems from designing phase to implementation phase of the system. Following section lists the problems and tactical actions taken to tackle them.

How to connect main controller and firebase real-time database?

The solution was to have a web server in middle so that each device could connect with it and transmit data. Single point of communication will let our team easy to monitor and validate different kind of request comes from main controllers. Server validates data and update Google firebase database through firebase PHP software development kit (SDK).

How to connect main controller and detector wirelessly?

To use and configure the detectors in home environment flexibly, radio frequency has been chosen for transmission between detectors and main controllers. The team used 433 MHz RF transmitter and receiver as the transmission hardware.

How to measure consumption of food item in the consumption tracker?

Team decided to mount the load cell below the consumption tracker as it allows continuous weight monitoring. Furthermore, the module is programmatically calibrated in order to respond with consistent values without considering about light weight changes (0-5 g).

How to maintain real-time behavior between hardware and software?

As a solution, the team chose to adopt a system developed by Google. It is called "Google Firebase Real-time Database". Firebase allows storing and synchronizing data between devices real-time and it facilitates to access same database from any device through mobile or web application. Firebase is capable of maintaining an offline cache and automatic synchronization when relevant devices come online.

Conclusion

This research presents a much affordable and a useful way of tracking the food items in the refrigerator using consumption trackers which come as add-ons. The automated approach of controlling the home appliances through mobile and web applications could ease the task of using the IOT technology. Because of the popularity and flexibility in Android operating system, this mobile application is based on android. The need of a simple and elegant way of tracking the food items in the refrigerator is the major requirement of this research. A much simple way of allowing people the freedom of having complete control of their home appliances from anywhere is another requirement of this research. Therefore, implementing consumption trackers that can be kept inside the refrigerator, receiving notifications according to the consumption of food items, keeping track of them and a home automation system that reduces energy consumption, protect home environment from secondary effect are the purposes of this research. The result of this research, web and Cloud based home automation system that is flexible and scalable with wide range of home appliances, will promote the growth of IOT. Firebase real-time database system has been used as the database of this system to make sure that the users will get a real time experience of observation of their home appliances. Proposed Home Automation System will help to improve the standard of living at home and allow increasing work efficiency in future.

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