Arduino Based Smart IoT Food Quality Monitoring System

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Abstract

Food safety and hygienic as well as health are significant issues to stop food wastage. The high quality of the food requires to be kept track of and it should be also protected against deteriorating and decaying by the climatic variables like temperature level, humidity, and dark. In this paper, a comparable food quality monitoring tool will be created that will keep watch of ecological factors like temperature level, moisture, alcohol web content as well as exposure to light for fruits and vegetables. The system is built on Arduino UNO where it is interfaced with various sensors like DHT-22 to keep track of temperature level and humidity, MQ3 to identify alcohol material as well as LDR to gauge direct exposure to light. It sends the measured sensor data to an IoT system via ESP8266 Wi-Fi Module. The IoT system will certainly be made use of for logging and checking sensing unit data and this is beneficial in monitoring the food storage from anywhere and anytime.

Keywords: Food Quality, Monitoring System, Internet of Things (IoT), Arduino

1. Introduction

In terms of both economic and social considerations, food safety is very essential. Many implications might result from a company's failure to meet food safety and security standards. Failure to provide adequate food safety throughout the production process may have a significant impact on the lives of those who are affected by the lack of food safety measures [1]. Contaminated foods may enter the food supply chain if proper food safety and health protocols are not followed. When a faulty product is discovered, the food service industry is vulnerable to major disruptions in their operations as they attempt to handle and remember the item's quality. The importance of food safety in today's society cannot be overlooked [2]. Problems with food safety and security are a major cause of more than 200 avoidable illnesses throughout the globe. In the United States, one in ten persons suffers from foodborne illness or injury each year. More than a quarter of the estimated 420,000 individuals who die each year as a consequence of eating poisoned food are kids [3]. Therefore, it is necessary to create a system that can assist consumers in determining whether or not food is fresh and also of high quality. In this paper, a food quality monitoring system is proposed. Several studies were done on this area. B.Yu, et al. (2020) proposed a monitoring system which integrated smart contracts and evaluation models for the automatic evaluation of the quality of fruit juice samples generated in each production stage[4]. A.Popa, et al. (2019) proposed a food quality monitoring system for vegetables stored in vacuum-packed foods[5]. However, to the best of our knowledge, there is no food quality monitoring system developed for fruits, vegetable and cooked food such as curry and milk in a single system.

2. Hardware structure

The block diagram of the design is shown in Fig.1. The system consists of power supply units, Arduino UNO microcontroller, WIFI module, Gas sensor (MQ3), LDR, Ph value sensor, DHT22 sensor, and LCD display. The flow line shows the inputs and outputs of the system. The main controlling unit of the system is Arduino Uno and it will be powered by a 12V battery. Temperature, humidity, alcohol, light exposure and moisture are monitored using the Arduino board, DHT-22, MQ3, LDR and pH sensors. Measurements can be conducted as quickly as feasible because to its high sensitivity and quick reaction time. The ESP8266 Wi-Fi Modem is connected to the internet via a Wi-Fi router via the Arduino. The sensor data is also shown on an Arduino UNO-connected character LCD. Sensor data is logged and monitored using this IoT platform. Several of these devices can be put at a site for better monitoring and quality control. The Arduino Sketch that runs on the device does a variety of tasks for the project, including receiving sensor data, converting it to strings, displaying it on a character LCD, and transmitting it to the IoT platform, Blynk Application.

2.1. *Flowchart of the system*

The DHT-22 sensor measures temperature and humidity[6]. The Humidity detecting component and the NTC temperature sensor are the two major components of the DHT-22 sensor (or Thermistor). Thermistors are variable resistors that change resistance in response to temperature changes. They both sense the surrounding region's temperature and humidity and communicate the information to the IC.

The LDR is used to detect light intensity. The LDR creates an analogue voltage, which is converted to a digital readout by the built-in ADC. The 16X2 LCD display is connected to the Arduino board by linking its data pins to the Arduino board.

The ESP8266 Wi-Fi Module is an (SOC) self-contained system on chip with that can connect to a Wi- Fi network and has an integrated TCP/IP protocol stack. The ESP8266 may either install apps or representative all Wi-Fi networking functions to a separate application processor. Each ESP8266 module comes with pre-programmed AT instruction set software. The ESP-01 and ESP-12 variants of the module are available. The ESP-12 has 16 pins accessible for the interface, whereas the ESP-01 only has 8 pins.

pH is the measurement unit that we use to determine the acidity of a chemical. The undesirable log of the hydrogen ion concentration is defined as "H." The pH values range from 0 to 14 on a scale of one to fourteen. A pH of 7 is measured neutral since distilled water has an exact pH of 7. Essential or alkaline levels are more than 7, whereas acidic values are less than 7. The pH scale is used to assess the amount of acidity and basicity in a fluid. It can have results ranging from 1 to 14, with 1 indicating the most acidic fluid and 14 indicating the most standard fluid. The pH of 7 refers to things that are neither acidic nor basic.

The purpose of an analog pH sensing device is to determine the pH value of a substance as well as the acidity or alkalinity of the substance. It is commonly used in a variety of applications such as farming, wastewater treatment, industry, environmental monitoring, and so on. The component contains an on-board voltage controller authority chip that supply a wide voltage range of 3.3-5.5V DC, making it well-matched with both 5V and 3.3 V control boards such as Arduino.

The system flowchart for this project is shown in Fig. 2. A dedicated link is established between the sensing units, the Wi-Fi component, and the microcontroller. The information from the three sensing devices is pre-processed by the microcontroller before being sent to the web server. AT commands will be given to the Wi-Fi component to interact with the pre-processed data and send it to the web server for further processing and visualization.

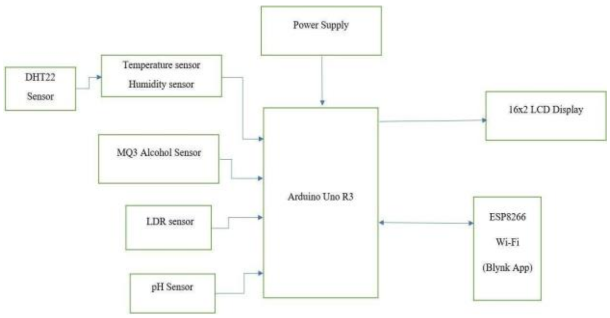

Fig. 1. Block diagram of the system

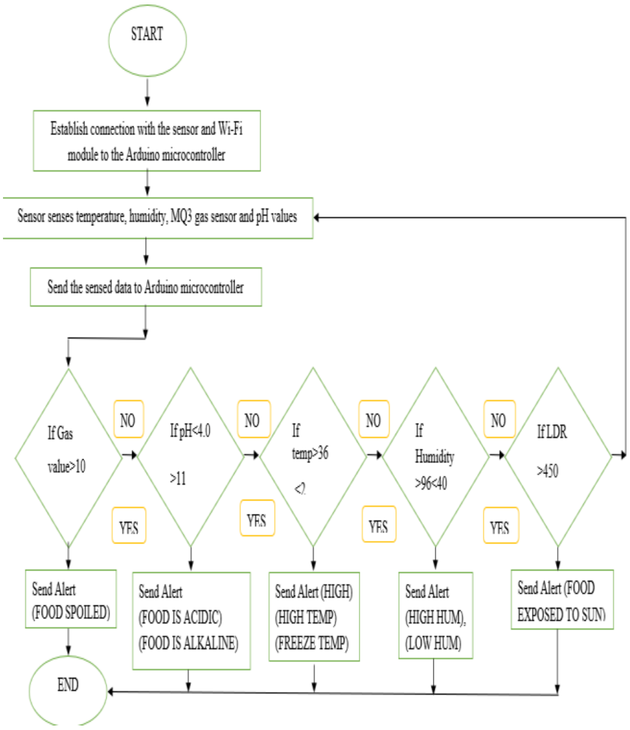

Fig.2. Flowchart of the system

The Wi-Fi module's status will be checked on a regular basis to ensure network connectivity schedule and dependability. A link reset should be performed if the status of the Wi-Fi and web server connections is discovered to be disconnected at any time. The information from the Wi- Fi module will undoubtedly be analyzed and considered by the web server. As soon as the device is turned on, the microcontroller will begin refining data over the Internet.

With the help of the Blynk Application, Arduino can be controlled via the Internet. A visual user interface is created using a digital dashboard to ease the monitoring of the sensors' readings.

3. Results and Discussion

3.1. *Detecting the Quality of Fruits*

Each fruit and vegetable have a different expiration date, fragrance, and color. Also, different food has different parameters such as humidity, temperature, and pH value. Food rotting may also be influenced by changes in temperature. When it comes to fruits and vegetables, storing them at the correct temperature is critical to extending their shelf life. It is possible for rotting to be accelerated by extreme temperatures. Water in plant cells freezes into ice crystals when frozen, causing cell wall ruptures and discoloration as well as a slimy appearance. Temperature and humidity can be measured using the DHT22 sensor. -40 to +125^{0}C, with a +-0.5^{0}C accuracy, is its temperature range. With a range of 0 to 100 percent, the DHT22 sensor can measure humidity with a 2 to 5 percent accuracy. It is discovered with the help of the DHT 22 sensor, it is possible to keep produce fresher and more flavorful by storing it at lower temperatures. The growing of pathogenic fungi that cause spoilage of fruits and vegetables in storage is also slowed by low temperatures.

Continues with MQ3 Sensor which has been used to detect alcohol parts per million. This sensor plays an important role in this system where this sensor has been used to detect fruit and vegetable whether the fruit or vegetables is spoiled or not by detecting the gas of ripening fruit emitting which is ethylene gas. Heavy exposure to direct sunlight and light air flow shows a uniform effect of accelerating ripening and decay so LDR sensor has been used to sense the light intensity in the storage box. Therefore, observation is done from the storage box of the fruit and vegetables. The results have found that the healthy fruit has strong cell walls that must contain the humidity level, preventing the fruit from decaying faster. When fruits are exposed to either high temperature or direct sunlight, its cell walls can lose their natural moisture quickly which could then lead them into a condition of dry storage. For this, we have placed an LDR sensor to measure the lux value of direct sunlight. From the LDR sensor that has been used, it has been found that in direct sunlight the value is shown 450 when it reaches 450 or more than that, it will notify the user in both Blynk App and LCD screen to alert the users. In addition, warm days will create an environment that is perfect for fungi growth as well as increase susceptibility to insects harmlessly feeding on the fleshy areas. Sunlight will also promote fungal growth due to its ability to damage cells at a cellular level through a process known as photodynamic degradation.

In this study, two types of fruits, Apple and Banana and a vegetable, tomato were used. Based on Fig.3, the ppm values for the fruits and vegetables kept increasing every day. The banana and tomato spoilt on the 4th day and 6th day, respectively. The ppm value for banana and tomato were recorded as 10 ppm and 9 ppm, respectively. The apple also started to spoil with the value above 10ppm on the 6th day. This shows that the fruit and vegetables release Ethylene gas as they decay.

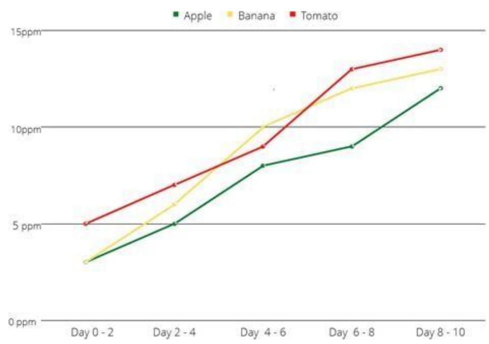

Fig.3: PPM values for Apple, Banana, and Tomato

3.2. *Monitoring System*

We used an IoT app to monitor the food in this system (in the storage box). In order to monitor temperature, humidity, light intensity, ethylene gas concentration, and pH, there are five gauge- typewidgets (see Fig.4). The gauge widget's measure has the greatest importance when seen as an average value against a maximum value. However, multiple values have been set and ranged and some to the highest value has been shown on blynk's widget app and the lowest value has been used. This will show data in the form of a gauge. The widget will show the most current data that has been gathered. When the widget is set to "gauge" mode, the data series configuration field (which displays the gathered data's maximum, minimum, or mean) has no effect on how the data is shown.

3.3. *Quality of Cooked Food*

The humidity and temperature of cooked food are effortless to detect in order to determine the quality of it. The quality of cooked food can be determined with pH value. When the food's pH value is detected from 0 to 6, the foods are acidic, if from 8 to 14 the foods are alkaline and if the pH is 7 the foods are neutral. Several foods have hard surfaces while the rest have smooth surfaces. For example, the vegetables with hard surfaces will be long-lasting whereas the vegetables with smooth surfaces will expire early. The spoiled milk, result of an over-growth of bacteria that compromises the quality, flavor, and texture of milk. Once you open a carton of milk, it's exposed to extra bacteria from the environment. Over time, these small microbial communities can reproduce and eventually cause the milk to spoil. Signs the milk has spoiled, it develops an unpleasant, acid odor where it can be found using the pH meter. Based on Fig. 5, the pH value of milk and curry decreases every day. The curry spoiled on the 2nd day and its pH value was below 6. For milk, the pH value dropped to below 4 when it is spoiled on the 3rd day. This shows that the acidity of milk and curry increases as the food is spoiled. The proposed system could measure and monitor the real time values using Blynk app for monitoring the condition of the food.

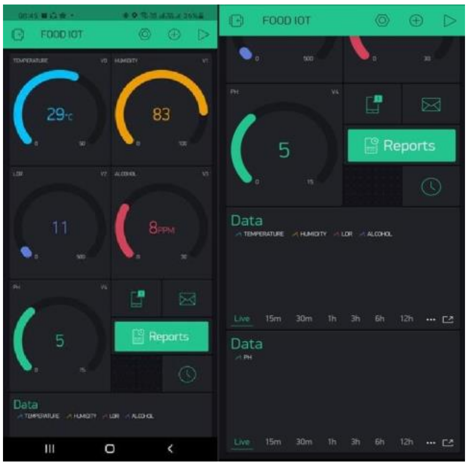

Fig. 4. Blynk Application

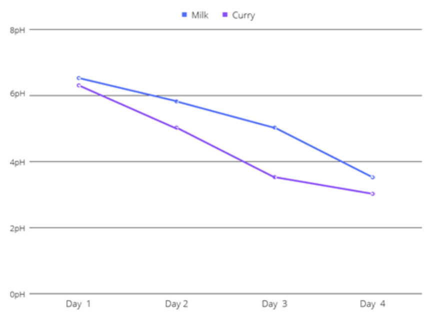

Fig. 5. pH Value for Milk and Curry

4. Conclusion

In conclusion, the system is capable to monitor the of temperature, humidity, alcohol, and light exposure in fruits and vegetables storage using DHT 22, MQ3 and LDR sensors. In addition, the proposed system could also detect if the cooked food such as curry and milk has spoilt using pH sensor. The proposed system is capable to send the data from the sensors to the IoT platform, Blynk Application. This enables the users to monitor the condition of the food from anywhere and at any time. This system is beneficial in food industries as the system could monitor the condition of the food can be monitored all the time automatically. This system can be further improved by using image processing to enhance the efficiency of the detection.

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