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Perishable Food Quality Monitoring – An Internet of Things (IoT) Approach

Chanthini.B[1], Manivannan.D[2], Umamakeswari.A[3]
[1]Research Scholar, School of Computing, SASTRA University, Thanjavur - 613 401, India
[1]chanthinibaskar@gmail.com
[2]Senior Assistant Professor, [3]Associate Dean
School of Computing, SASTRA University, Thanjavur - 613 401, India

Abstract: Food safety is imperative to avoid food borne diseases and to ensure the public health. Monitoring of perishable food products and early detection of degradation will avoid loss due to food wastage and also ensures the freshness of food. In this scenario, remote monitoring of fruits during transportation from field to shelf can ensure the quality of fruit. In this work, a wireless sensor network was designed for monitoring of fruits during transportation and even after storage. Internet of things was also used for facilitating online monitoring of fruits from any remote location. Raspberry pi was used as sensor node and gateway node. It has performed the fusion of sensor data such as temperature, humidity and moisture to avoid redundant data storage and increase the efficiency of decision making.

Keywords: : Wireless sensor networks, Information fusion, Cloud storage, Food quality

1. Introduction

Food tracking is of high interest to ensure the freshness and quality of the food[1,2]. Tracking refers to providing details about the food trough out there transportation till they reach consumer[3]. Recent study in food safety states that over half of the fruit supplied was wasted because of improper temperature handling during transportation. Human maintained food chain is not feasible for complete cold chain monitoring[4]. Main reason for this is lack of temperature monitoring and maintenance between the fields to table. The International Food Safety Authorities Network (INFOSAN) works with other member organization in food quality management to ensure the food safety emergencies[5]. Fruits are highly perishable due to variation in temperature while they are stored[6,7]. Temperature monitoring throughout the entire cold chain is not a luxury but necessity. Usually break in the cold chain can take place in many stages between the field to the retailer[8]. Wireless sensor networks (WSN) can be employed to meet the demand in current situation. Passive components are already used to detect objects such as bar code reader, RFID, etc...

WSNs are mostly used in the applications such as home automation, healthcare monitoring, and surveillance maintenance. Wireless sensor nodes are usually less power consuming and battery operated for remote monitoring and controlling[3]. WSN consist of a sensing unit, processing unit and a wireless transceiver for data communication with the base station. As WSN is power constrained low power consuming processor and transceiver for remote monitoring is used. With the advancement in sensor technology low cost sensors are produced for their wide requirement. These sensors in collaboration with wireless technologies perform the recommended operation efficiently. With this advancement, introduction of Internet of Things (IoT)[9] paradigm plays a vital role in control and monitoring applications[10].

In this work, a wireless sensor node is designed using raspberry pi 2. It is used for sensor data processing and decision making and data from the node is transmitted using Wi-Fi (IEEE 802.11) protocol. Further the freshness of the fruit is communicated to avoid loss due to transportation of fruits.

2. Background

2.1 Monitoring of fruit characteristics

Fruits are one of most natural raw food consumed by human being. Quality of fruits depends upon the temperature at which they are stored from land

and they reach the consumer. With the advancement in latest technologies many tools are exploited for foods safety measurement. A report by UNEP states that over 35 billion are lost due to wastage of fruits and vegetables in world economy. World health organization (WHO) accounts that a food borne disease produces wide illness and tends to growing health problem. Temperature, humidity and gas are sensed for monitoring food quality. Usually different fruits have different lifetime depending upon their physical and chemical characteristics. By keeping Temperature and humidity at a particular level increases the shelf life of fruits. Rotten fruit produces ethylene oxide gas as they start to degrade and this ethylene on fermentation with air produces carbon dioxide. By detecting the amount of carbon dioxide rotten fruit can be detected. This method is proposed to ensure the fruit quality and reduce economic loss due to fruit spoilage before reaching the consumer.

2.2 Wireless sensor network based fruit quality management

WSN is an advanced technology which consists of an automatic control, remote monitoring and controlling, incorporates sensing technologies, data communications with storage, processing capability and data analyzer. When comparing with existing techniques it is low cost, easily deployed, maintenance less technology used for continuous monitoring without manpower[3]. Usually WSN is deployed for sensing and collecting environmental conditions. It is an important in analyzing natural events. Many research in WSN focus on environmental monitoring but limited research is undertaken in food quality using sensor networks. Temperature and humidity of the fruit is monitored during transportation and the data is transmitted to cloud database.

3. Smart Sensor Node

The low cost, embedded single board computer raspberry-pi is used in this work as sensor node and middleware. Raspberry-pi helps in selecting smart application parameters. It can be either battery powered or USB powered. The board has a powerful Broadcom System on chip that is capable of running various operating systems from NOOBS to windows 10. Pi is capable of providing video output through HDMI composite RCA. Raspberry-Pi comes with a coprocessor which supports multimedia operations. It has 40 GPIO pins that help in connecting more number of sensors, expansion boards and connectors. One of the most important things is that the new versions of pi are backward compatible. The new versions of Raspberry-Pi offers improved power management. It operates at 600mA. Four USB ports are attached to the Pi which increases the probability of connecting more number of power hungry devices.

Almost all the application uses sensor devices and the data rate is enormous, which becomes so difficult to analyze and process the entire set of data. Data collected from multiple heterogeneous sensors tend to be redundant. As sensor nodes are resource constrained, the data collected cannot be stored as such in the local databases. To overcome this problem the data collected should be fused before processing. There comes the concept of data fusion which takes multiple sensed data as input and produces single fused information or action to be taken as the output. Aggregation is a form of fusion which takes several input data and averages it to produce single consolidated output based on which the future decisions could be made.

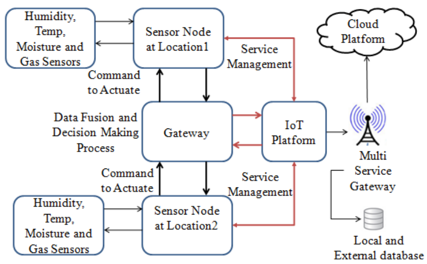

Figure 1. Smart sensor node architecture

Since the concept of local storage is not global, in this work cloud storage is used. Cloud provides anytime anywhere access. Several open source cloud platforms are available which are compatible with Raspberry-Pi. Cloud storage is where the data is remotely managed, maintained and backed up. Remote monitoring could be done using cloud facility. Unused nodes and those which send redundant data could be shutdown remotely through cloud monitoring. Cloud storage enables future references and acts as a rich collection of data and successful actions. Fig.1 shows the smart sensor node architecture.

4. Implementation and results

This work is implemented as three modules as follows: Connectivity module; fusion module; cloud module.

4.1 Connectivity Module

Raspberry Pi which works as a sensor node as well as central base station are installed with MySQL open source database server to support data storage functionalities. After installation MySQL makes the user to provide username and password for secure access to the databases and their tables. The sensor values are stored in the local database and sent to the base station by connecting to database using its IP address. This connectivity is done by altering the configuration file of MySQL and granting appropriate access permissions on the database table. Tables in both sensing nodes and gateway should be identical in order to avoid any misplacement of sensors values.

4.2 Fusion Module

The central base station retrieves the value of each sensor from its database at regular intervals. It was accomplished by retrieving values based on their sensing time. Each sensor value was aggregated to a single meaningful value. The data are aggregated to eliminate redundancy and to reduce storage space. The time interval at which the data are retrieved for aggregation plays a major role in making appropriate decisions. Threshold values are set for each sensor and it was compared with the aggregated values. The thresholds are in the range of values that, each one pertaining to a particular situation of the deployed environment. Each range of values identifies a particular case and the corresponding action. Better results are obtained when aggregation is carried out at short intervals. Any abnormal condition is quickly identified and responded with necessary actions.

4.3 Cloud Module

IoT is a network of connected objects which enables these objects to share and communicate data. It allows easy management of interconnected objects that are embedded with electronic components, interfaced with sensors. Xively is one of the IoT platforms which is compatible with Raspberry Pi. IoT was included to make the proposed work to emerge as a smart application framework. Raspberry Pi was connected to the IoT platform by creating an account in Xively platform. On the hardware side Xively supporting files are installed in the Pi .This include the language that can be interpreted by both Pi and Xively platform. Raspberry Pi was added as a device to the created account and the sensors are added as channels to the added device. Many such devices and their corresponding channels can be added. Added devices can communicate with each other and a better solution can be obtained. Raspberry Pi device is provided with four channels for each sensor value it needs to store for future reference. The FEED-ID and API-KEY pair is used to uniquely identify a device connection and provide secure access to the storage. Fig. 2 shows the data fusion data from the all the parameters such as temperature, humidity and moisture from the plant. Data fusion takes place gateway unit. Fig.3 depicts the display at cloud storage for online monitoring.

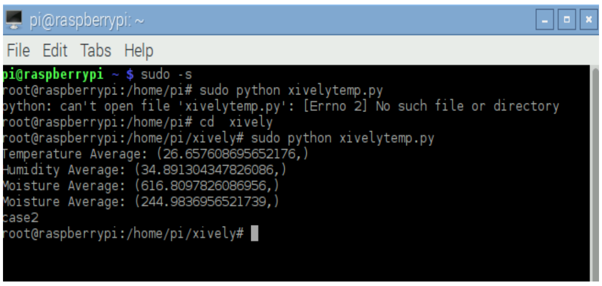

Figure 2. Data fusion output

Figure 3. Cloud storage output

5. Conclusion

Food safety plays important role in countries economy and human health. WSN plays a vital role in controlling and monitoring applications, which further connected to IoT enables remote monitoring. Data storage is another problem in sensor networks and cloud databases. In this work, information fusion was implemented in Raspberry Pi, which yields good results in various working environments. Information fusion reduces the amount of storage space as well as increases the computational power considerably. Observations show that fused data provide accurate decision to the prevailing condition. The fused data was safely stored and made available to authorized users. The system incorporated with information fusion and connected with cloud platform was used for perishable fruit quality monitoring during transportation.

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References

[1] Van Long NN, Dantigny P. "Fungal Contamination in Packaged Foods". Antimicrob. Food Packag. p. 45–63, 2016,.

[2] Yeni F, Acar S, Soyer Y, Alpas H. "How can we improve foodborne disease surveillance systems: A comparison through EU and US systems". Food Rev Int, 33, 406–23, 2017.

[3] Piramuthu S, Zhou W. "RFID and Sensor Network Automation in the Food Industry: Ensuring Quality and Safety through Supply Chain Visibility". 2016.

[4] La Scalia G, Nasca A, Corona O, Settanni L, Micale R. "An Innovative Shelf Life Model Based on Smart Logistic Unit for an Efficient Management of the Perishable Food SupplyChain". J Food Process Eng . 40, 2017.

[5] Grace D. "Food safety in low and middle income countries". Int J Environ Res Public Health 12. 10490–507, 2015.

[6] Badia-Melis R, Mc Carthy U, Uysal I. "Data estimation methods for predicting temperatures of fruit in refrigerated containers". Biosyst Eng;151, 261–72, 2016.

[7] Kirezieva K, Bijman J, Jacxsens L, Luning PA. "The role of cooperatives in food safety management of fresh produce chains: Case studies in four strawberry cooperatives". Food Control;62:299–308, 2016.

[8] Raak N, Symmank C, Zahn S, Aschemann-Witzel J, Rohm H. "Processing- and product-related causes for food waste and implications for the food supply chain". Waste Manag;61:461–72,2017.

[9] Verdouw CN, Wolfert J, Beulens AJM, Rialland A. "Virtualization of food supply chains with the internet of things". J Food Eng .,pp. 128–36, 2016.

[10] Bodbodak S, Rafiee Z. "Recent trends in active packaging in fruits and vegetables". Eco-Friendly Technol. Postharvest Prod. Qual., pp. 77–125, 2016.