Monitoring Food Quality in Supply Chain Logistics

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Abstract. Food is indispensable for human survival and should be cared utmost. This paper monitors perishable food packaging quality over a supply chain logistics and helps to act fast to save perishable foods over the route. Internet of things, signifies that the things which surround us and help us to live better and healthy life, those are connected via computer systems and Internet wirelessly, can communicate within themselves and also with the master node and exchange data. Those things can be devices, sensors, appliances, machines etc. The location of containers has Global Positioning System (GPS) and is monitored remotely over a cloud. The perishable food items are in a container having environment indicators like temperature and humidity sensors. The communication aspect is critical for the better work scenario, precautionary measures and monitoring energy consumption too. Any security or risk hazard can be prevented if we can analyze and study that data continuously or periodically from any remote site.

Keywords: Perishable food, sensors, Internet of things (IoT), manufacturer, GPS

1 Introduction

Food is the foremost thing which makes humans strive for survival [1]. Food quality can be monitored by IoT [11]. The technology has spread to major sectors like industry, automobiles, health care, retail, government etc. The IoT infrastructure provides analytics to help with predicting failures before they occur, giving the ability to react at the right time [2]. A particular use case explored in paper is that there are plenty of processed perishable food which is transported from the production area to the distributor, retailer and finally the consumer. There are risks involved like refrigerator malfunctioning or fungi/microbe attack, that's how food getting stale midway and hence this model gets jeopardized.

The idea of the model is to use temperature, humidity, GPS sensors at each processed food storage areas with the adjustment of sensors performed concerning the amiable conditions [6]. Then keep on collecting the data from those sensors continuously to a remote location along with the GPS location of the sensor at that point of time and can monitor the times when the temp or humidity falls below a

threshold value set [13]. The server gathers the data from all the sensors and those results can be sent to a cloud from where all the beneficiaries gets informed by an application or a browser notification [9]. The food freshness index of each product is maintained by a barcode on the food item prior on its journey and is compared continuously with the monitoring server [12]. A proposed model, research analysis, and conclusion is prepared respectively in this paper. The motivation for this paper came as there was an instance of millions of dollars of processed food getting stale in USA as they were not monitored [12]. In the upcoming sections, a model is proposed on which analysis is performed and stated in the conclusion section.

2 Literature Survey

Nowadays, as the world is growing and processed food items are getting lesser because of scarcity of resources, it remains big concern to save our food for longer duration of time and be consumable at that point of time too. The dairy products, chicken strips, prawn, crab meats are few examples.

Sea food industry has few constraints like the shipment delay, weather changes, unavoidable delays and ultimately food getting stale by its usage day. This results in inflation of particular food items and so ultimately the food industry has everyone to suffer.

The current generation is more digitally connected than ever. Wireless communication models are experiential learning hubs and the devices like IoT help us to bridge the gap between the manufacturers and the consumers. IoT helps both the parties to view and manage the items more efficiently than ever and hence increasing the productivity of the cycle. Sensors in correspondence to the technologies can bring a revolution to the food industry and help in the cause of Eat fresh and Live fresh.

Similar problem and its discussion were concluded in [11,12], where authors realized the critical food industry requirements and the supply chain orchestration. In that paper a central data analytics model was implemented with the help of Radio Frequency Identification (RFID) for communications [4,9]. Continuous monitoring of perishable foods was done with help of radio waves, RFID and data transferred to an analytics and operations center which could be cloud hosted.

3 Proposed Model

This model uses hardware Raspberry Pi, Jumper wires, Temperature and Humidity sensor DHT (Digital Humidity and Temperature Sensor),[5], GPS Sensor, breadboard, 5V Power supply, resistors (4.7k ohm)

Connections: -

1. Connect PIN 1 of DHT Sensor to the 3.3V-5V pin of Raspberry Pi

2. Connect PIN 2 of DHT Sensor to any input pins of Raspberry Pi, here we have used pin 11.
3. Connect PIN 4 of DHT Sensor to the ground pin of Raspberry Pi.

An adafruit library for DHT22 sensor is use to read the sensor data. The function adafruit_DHT.read_retry() reads data from the sensor.

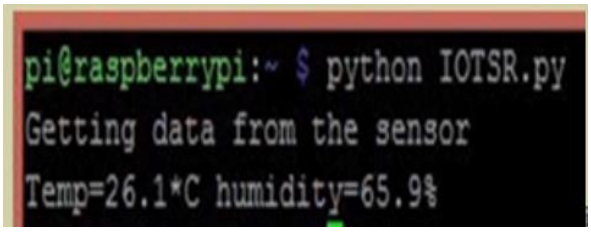

Fig 1. Snapshot of Capturing Data

The fig 1 depicts a screenshot on the raspberry pi device capturing data from the sensor. It shows the temperature and humidity parameters on a particular node at a stipulated instant of time. User Datagram Protocol (UDP) creates a 2-way communication between nodes, acting as a server and a client. Creating a socket s=socket.socket(Socketfamily,socketType,Protocol=0) Socket family can be AF_Unix or AF_INET. Unix based systems or general programming-based systems. Socket type can be socket-stream or sock-datagram. Protocol is set to default 0. For sending scripts from client to server, we need Internet Protocol (IP) address and port number of servers [3]. Clients can have many IP address but server will have one IP address. The client takes reading from the sensor and sends it to the server. The server receives the data from the client and saves it in text or csv file.

As multiple clients send sensor values and it assimilates over the server, we need to segregate it so that we can do processing over it. Also, there can be malfunctioning like data corruption, incomplete date, server not collecting data properly so filtering data becomes essential.

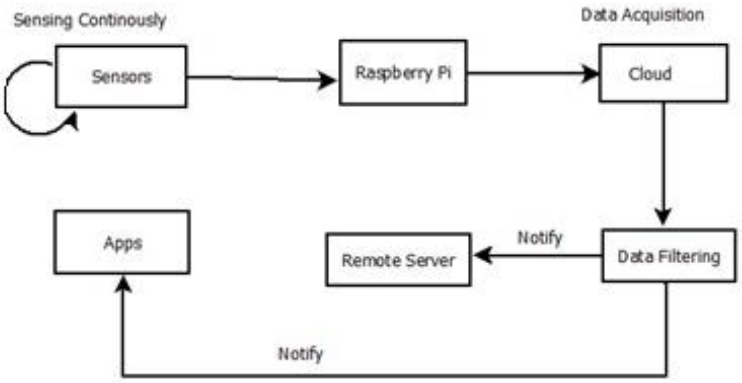

Fig 2: Block Diagram for Model

The Fig 2 depicts the path undergone for data analyzing of food item quality throughout the process indicting input and output side as well.

Firstly, the sensors are deployed at each container containing processed food batches which require same environmental conditions to be at bay. All sensors sense the environment continuously at each of the containers and monitors the temperature and the humidity of that particular place and sends it to the raspberry pi module connected to it. After that there is data acquisition over a cloud [13]. The Machine learning algorithms are applied and the filtered data which consists of aberrant readings like temperature/humidity increase over an increased span of time is taken as input to be send over a remote server and an application which is monitored by the team. The readings may contain location of the container according to the GPS coordinates and the abnormal readings. Also, the container/van owner is intimated and then any risk can be averted through manual intervention [12]. Proper aligning and cooperation of these above steps can be followed after trigger type setup is installed and initiated.

4 Research Analysis

Suppose for a particular processed food item, the ambient temperature is 6-12 degrees Celsius and the humidity should be between 35-55 units. So, the readings will be according to time:- item_id, item_name, gps_coordinates, container_no, temp_value, humidity_value etc. The Boolean NOT expression is used as the processed food item freshness constraint violates when both temperature and humidity at a single time is not in the mentioned range and hence we use NOT(~) expression. Once we get to know the container_no and gps_coordinates, we can inform

the specified driver and make the necessary arrangements. Also, same application can be installed at the driver's smartphone thereby reducing the work of intermediary servers.

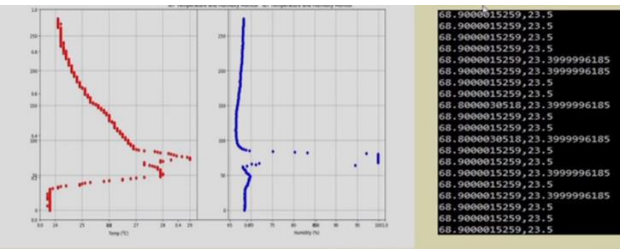

Fig 3: Temperature and Humidity values and its graph

The Fig 3 uses the matplotlib library function and shows the temperature and humidity on x axis and that varying with the time elapsed on y axis and similarly the right figure shows the digital values of humidity and temperature respectively. The monitoring server at the cloud keeps the data of all sensors with GPS location. The data is collected at remote server and also at cloud and is available for analyzing.

The main idea is that sensors are deployed at the containers having processed food and they record the environmental factors namely temperature and humidity continuously, then the data is sent to cloud where filters are applied to it, any aberrant data is reported or notified back to remote server and application [11]. The data to cloud is sent every second and filtered continuously for any anomaly and notified to appropriate persons. This way the perishable processed food is made available for longer duration with the help of caretakers at each container.

5 Conclusion

IoT in conjunction with recent communication technologies can bridge the gap between different industries and can effectively offer transparency to the parties involved therein. The scope of this paper is to propose a model which can track the food item continuously and monitor its quality by indicating temperature and humidity factors which are most influential in degrading a food item's quality over a span of time. After this setup, any perishable food can be detected due course time and can be act upon in time.

The challenges we face on a broader term it is that if multiple parties are involved in this trajectory, for example manufacturers, dealers and suppliers, then the visibility, mutability, security of data becomes a major concern. Any party would like to modify/delete any particular data at an instant without other party noticing it and hence may be able to deceive other party. The food item concern-

ing all should be visible to all participants at all times (for tracking) and also the security shouldn't be jeopardized. These above thoughts can be accumulated if all the parties involved are brought together and assimilated in a blockchain environment [7,8,10]. As we know blockchain is immutable, visible and secured at a very high level, the trust among all parties will be automatically restored and there will be a secured environment for all.

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