Freshness of Food Detection using IoT and Machine Learning

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Abstract*— In today's world, food spoilage is a crucial problem as consuming spoiled food is harmful for consumers. Our project aims at detecting spoiled food using appropriate sensors and monitoring gases released by the particular food item. A micro controller that senses this, issues an alert using internet of things, so that appropriate action can be taken. This has widescale application in food industries where food detection is done manually. We plan on implementing machine learning to this model so we can estimate how likely a food is going to get spoiled and in what duration, if brought from a particular vendor. This will increase competition among retailers to sell more healthy and fresh food and create a safe world for all consumers alike.

Keywords—food safety, machine learning, IoT

I. INTRODUCTION

We are in the 21st century and food sector is very big part of our economy .One of the biggest problems that it faces is food spoilage, i.e. food items ,more specifically meat items or fruits and vegetable going stale .The bigger problem is these spoilt items going undetected and onto the hands of the consumer .In all fruits and vegetables industries , the process of checking of quality of items is done manually , mostly by a person sitting across a conveyor belt as the items pass by. Hence, if an automated process is brought into place, it would not only increase the accuracy of spoilt food detection, but also reduce manual manpower required.

To automate this process, we plan on using a collection of smart sensors with microcontroller like the Node Mcu. On detection of a spoilt or stale food item, a sound buzzer can be rang to draw attention, moreover this data will be sent to the cloud, as an application of IoT. This enables appropriate authorities to view how often they get spoilt food items and create transparency.

II. PRINCIPLE OF SENSING

The detection of whether or not a food item is spoilt or not is made using the following two principle:

- *Oxygen Level Detection***:** The underlying theory is that if food item ,say fruits or meat , is inhabited by germs ,the oxygen levels in the immediate surrounding is going to be lower than it normally is .The reason being that , the germs inside the food item are consuming the oxygen , and this change in the level is what we plan to detect.
- *Ammonia Gas***:** Meat items like fish, are known to release ammonia gases when they go stale. A gas sensor captures the readings of the ammonia levels near the food item, and sends an alert to the microcontroller when abnormal levels are detected.

III. ALTERNATIVE WORK GOING ON IN THE FIELD

- *Artificial Intelligence Approach:* An alternative approach is using artificial intelligence, on which some work is being done currently. The concept is basically using computer vision and analysing the image of a food item to conclude if it is spoilt or not. However, the problem is, by capturing images we can only get hold of an idea of the exterior of the food item and not its interior.
- *MIT research:* A MIT team has done research on this field by developing a sensor that detects spoilt meat items. But since it only detects a particular gas, it can have a lot of false negatives.
- *What our system proposes***:** To maximise accuracy of detection, instead of relying on value of one sensor, we plan on using cumulative value of both oxygen and ammonia sensors to arrive at a decision. This reduces the possibilities of false negatives. Also, by incorporating an oxygen sensor, our smart sensor can be used to detect germ infection on practically any food item.

Combing IoT and Machine learning only increases the inter-operability and application.

IV. Methodology

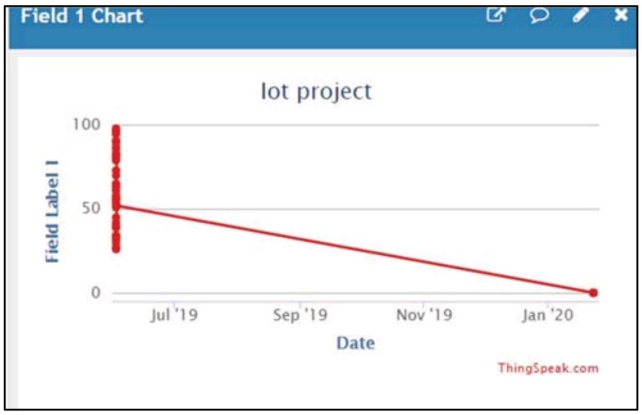
- Sensor monitors the food quality. Oxygen and ammonia sensors measure the oxygen and ammonia content for particular food item.
- Machine learning model uses trained model to predict if the given food item is spoilt or not based on the oxygen and ammonia content.
- Node Mcu (microcontroller) sounds a buzzer when it encounters a spoilt food item. This data is sent to a cloud platform.
- Number of spoilt food occurrences can be monitored and machine learning model can be deployed again to predict average shelf life of given food items

A. Cloud Platform Integration

Popular Cloud platforms like ThingSpeak can used for cloud analysis of data. For applications in food industries, we can obtain insights like:

- Occurrences of spoilt food items in a day.
- Peak time duration, in which most food items are found spoilt (day, afternoon, evening).
- How may spoilt food items are successfully separated.
- A sample plot on Thingspeak is shown below, which shows the number of spoilt food items on different days of the month, providing easy analysis.

Fig.1. Sample plot on Thingspeak



V. Scope of Machine Learning

Machine learning is the science of learning of data and making predictions. When applied to this project, it can enhance its productivity multiple times. Following are the applications of machine learning in the given project:

A. Industrial Application

- After making an analysis of data of spoilt food items, it can successfully predict which part of the day, are most occurrences of spoilt food items occurring. It can also be analysed which particular food items are getting spoilt more frequently. Accordingly, more people can be employed during the peak times and less during other times. This saves considerable amount of manpower.

B. Commercial Application

- When this concept is applied to retail stores and grocery shops, we will obtain a collective data of how frequently a food item gets spoilt if brought from a particular vendor.
  This pushes vendors to sell food items that have a longer shelf life, and creates consumer awareness to buy food with longer shelf life.

C. Consumer Application

- When incorporated into refrigerators, this smart sensing system can send email notifications directly user to whenever spoilt food is detected. This ensures consumers, especially children don't consume harmful and spoilt food.

VI. Development of Machine Learning Model

- *Input*: Source of Food item
- *Output*: Food item is spoilt or not
- *Training Data*: Instances of spoilt/unspoilt food item, oxygen and ammonia concentrations for each sample.

A. Learning Algorithm

Logistic Regression:

- This is a machine learning model that outputs the probability of a particular input instance belonging to a particular class.
- In this case output class are binary: 'Spoilt', 'Not Spoilt'. Hence, we obtain its probabilities of being spoilt for different days.
- Hence before even buying a food item, we already know the expected shelf life based on the source of food vendor.

B. Evaluation of machine learning model

Dataset-We created a sample dataset of 40 instances of foods that were spoilt and non-spoilt with their corresponding ammonia and oxygen gas concentration, in ppm. Dataset looks like:

Fig.2. An image of a portion of the dataset

8	10	29	0	Not Spoilt
9	30	12	1	Spoilt
10	40	25	0	Not Spoilt
11	30	20	1	Spoilt
12	28	10	1	Spoilt
13	25	3	1	Spoilt
14	27	6	1	Spoilt
15	20	39	0	Not Spoilt
16	15	50	0	Not Spoilt
17	4	30	0	Not Spoilt
18	27	15	1	Spoilt
19	29	10	1	Spoilt
20	0	20	0	Not Spoilt
21	19	5	1	Spoilt
22	19	3	1	Spoilt
23	14	38	0	Not Spoilt
24	12	29	0	Not Spoilt
25	12	1	1	Spoilt
26	12	32	0	Not Spoilt
27	32	1	1	Spoilt
28	7	25	0	Not Spoilt
29	40	20	1	Spoilt

We ran several machine learning models on the following data set with the following results:

- 1)*Linear Regression:*
  Mean -squared-error= 0.165

- **2)***Support Vector Machine:*
  Mean-squared-error=0.654

- **3)***Logistic Regression:*
  Mean-squared-error=0.00

Since Logistic Regression performs best in the given dataset, we chose that model. We take input of ammonia and oxygen gas values from the sensor and the machine learning model tells us if the food is spoilt or not. Here is how the output looks like in the python program:

Fig.3. Output of python program

```
Enter ammonia concentration in ppm15
Enter oxygen concentration in ppm30
The food item is Not Spoilt
>>>
 RESTART: C:\Users\Lenovo\AppData\Local
h.py

>>>
Enter ammonia concentration in ppm30
Enter oxygen concentration in ppm10
The food item is Spoilt
```

Further Scope of Machine Learning: Our machine learning model is dependent upon the dataset we are using. As we gather more data, various extensions can be added as well like predicting how long afood item can last based on the food vendor it is brought from. This can greatly help food sellers manage the inventory and create a general awareness about food safety.

VII. Implementation

- *Retail Stores:* Inside shelves and containers, our array of ammonia and oxygen sensors can be placed. As a spoilt food item is detected, management is alerted. Also, food items, having a shorter shelf life can be given a higher priority to sell first, greatly assisting the inventory management.

- *Industry:* In the food industry, large number of items are processed along a conveyor built. Our sensors will be placed across the belt, and management will be able to track, what parts of the day, most occurrences of spoilt food items took place and take action accordingly.

- *Household:* Refrigerators can have the array of sensors installed inside them. As soon as a spoilt food item is detected, a buzzer is sounded and a mail is sent to the owner, instructing them to avoid the food item.

VIII. Conclusion

An exhaustive research has led us to conclude that the food industry can be revolutionised by a simple combination of sensors, IoT and machine learning. After integration, this model will create a competition between food manufacturers to sell more healthy food and create awareness among consumer to purchase more healthy food.

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