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Alerting Spoilage of Food in Refrigerator

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Abstract*: The era of smart homes wouldn't be complete without intelligent refrigerators. Thus we have proposed an idea for detecting the food kept in the refrigerator and alerting the user on their spoilage which involves all the processes of ML and IoT. In places where large stocks of food are stored, manual maintenance is very hard and also when they are transported to long distant places from the cultivated lands to the end-users, they get spoiled due to lack of governance. The existing systems have provided a solution for this and we decided to give this facility for the working women who have very little time to do their household. This system helps in preventing other items in the refrigerator from the fungal attack caused by the affected ones. The solutions provided by the existing systems recommend sensors to detect the food items. Each food item might need a different sensor and hence this might lead to a lot of hardware components to be added to the refrigerator. Thus our system uses ML prediction methods like image processing. Finally, the notification of the spoiled food is intimated to the user by displaying the message in the refrigerator door.

Keywords : RaspberryPi, RaspberryPi camera module, R-CNN.

I. INTRODUCTION

The world has grown from us making solutions with evergreen natural living things for our issues to non-living machines themselves predicting and solving our issues. One such domain that provides life to non-living things is Artificial Intelligence (AI). Artificial Intelligence has provided us the ability to make the machines learn from real-time examples through Machine Learning (ML). Image Processing helps in identification of fruits and vegetables in which color plays an important role [8]. Most system uses texture, color, and density for identification of the object [7] Machine Learning is the ability to make a machine understand situations and react to it in order to increase a system's ability to produce an accurate solution.

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Machine Learning algorithm is categorized into three types of learning: Supervised Learning, Unsupervised Learning and Reinforcement Learning. These trained machines help us to make a survey and thus prediction is done. To make these predictions speak we need to bring in the Internet of Things (IoT). Internet of Things (IoT) senses, accumulates and transfers data without any human intervention and thus makes things alive. Using IoT we can track, locate, monitor and control any device from anywhere[5]. Thus IoT gathers information from various devices and processes them to lessen human efforts. Thus our system relies on two major domains IoT and ML.

II. LITERATURE SURVEY

[1] If stored at a desirable temperature and moisture content, most of the food stocks(cereal grains) can be safely stored for an extremely long period of time. However, if exposed to moisture content the grains began to germinate, spoil, or even get contaminated due to some microorganisms like fungi. The moisture content absorbed by the grains can be detected as the relative permittivity of organic materials is lesser than that of the relative permittivity of water. As the corns are bigger in size when compared with the microsensors, a PCB (printed circuit board)capacitance fringing field sensor has been developed.
PCB sensors are better than traditionally used Micro-Electro- Mechanical Systems (MEMS) in which the fabrication times are shorter, the development cost of PCB is much lesser and also it can sense a wider area. Corn is typically harvested at relatively high moisture contents (22% to 25%) so that it can prevent yield loss that occurs when the kernels are allowed to dry on the stalk. Germination of cereals will generally be ensured when the moisture content is around 30%. The sensor was usually evaluated in air and in tap water at 21°C To yield a capacitance of 89.31 pF in air and 566.63 pF in water. Thus, the food items can be preserved from other issues by maintaining the temperature and moisture levels accurately. If the capacitance increases with respect to the moisture content then it indicates attention from we humans that the cereals are yet to spoil because of imbibition. The PCB is attached with the sensor interface electronics to get voltage proportional to the sensor‟s output.

[2] The purpose of this research paper is to provide an approach for the segmentation of rotten vegetables to annihilate infirmity with respect to human health. Segmentation techniques such as Marker Based Segmentation, Color Based Segmentation,and Edge Detection, produced promising and effective results.

Through the above-mentioned segmentation techniques, the rotten portions of a vegetable are detected effectively to separate the unhealthy vegetables from the good ones.

The process of edge detection involves a canny filter to smooth the images, this segmentation is used for the detection of the rotten part of vegetables. Here the filter is used to detect good results of both rotten tomatoes and healthy tomatoes. This filter gives the most promising results like the values of the images and the position of the camera. The detection of rotten fruits is fruitful to implement the canny filter method. In this segmentation, using a specific color we used to label the target things. This detects the output images based on the marker. Labeling is based on detecting images that were marked are the process is marked by color-based segmentation. Input images and corresponding output images with the detection of rotten parts using the marker-based technique. Color-based segmentation is used to differentiate between images or part of images on the position of the camera. First, the image is converted into grey and based on the color has been done. Here the affected area of a tomato is marked in the black and healthy area and is marked as white using the marker segmentation technique.

[3] The purpose is to provide the human being an easier life when facing his daily tasks. In this context, we propose a pilot design of an RFID based smart fridge. The latter provides, via the human user interface, all information about its content and provides recipes (via internet connection) regarding the inside ingredients. Added to this fact, the fridge guarantees distant access via mobile application synchronized to the cloud.

The designed application allows the user the notification of the shopping list and to synchronize this info to the cloud and created an administration interface to pilot the RFID reader by setting the IP address. Update his shopping list synchronized to the cloud. In this work, a smart fridge design is proposed by the use of passive UHF RFID technology. We believe that the proposed features make daily tasks easier. As a perspective, we think to add functionalities with regard to the ecosystem such as direct consultation of markets stock and availability.

[4] The main idea of this paper is the detection of food quality using sensors. In these techniques, they transfer RFID tags into sensor tags based on the read range. Here taken a food sample as beef. They used to measure both the range of permittivity and pH for every 12hours continuously. The function of a certain food will change due to the degradation of bacteria or any other things. This approach having two tags that are designed to meet the difference between read range distance.

[5] Smart Refrigerator is an appliance that converts an ordinary refrigerator into a smart refrigerator. Various features offered by this refrigerator include the ability to know the number of items in the refrigerator, order low stock goods and provide notifications to the user. Notifications provided are the items expiring soon, temperature rise in the refrigerator, as well as a wide variety of error messages that are sent by the refrigerator. The components used in Smart Fridge using raspberry Pi 3 are photodiode which is used as a sensor, temperature sensor to measure the internal temperature, multiplexer which converts 2^N inputs into N+1 outputs, Barcode scanner(The purpose of barcode scanner is to help the system in identifying the items by scanning the item's barcode), nodeMCU (NodeMCU‟s main functions are to process data from sensors to decide what user does with the refrigerator, notify the user about system failure, and send information to the server), Raspberry Pi 3 (Raspberry Pi 3 is a powerful mini computer. The main purpose of this system is to convert the conventional refrigerator into a smart refrigerator, so this system should be portable. To insert a new item into the refrigerator, the user should scan the barcode first and then put the item above one of the sensors. When the new item is placed, NodeMCU will identify the change in sensor values and make sure there is no failure.

III. EXISTING SYSTEM ADVANTAGES AND DISADVANTAGES

TABLE 1. Advantage and Disadvantage for Existing SystemDisadvantage

Existing System Title	Advantage	Disadvantage
A PCB Sensor for Status Monitoring of Stored Food Stocks	Using PCB maintaining the temperature and moisture level to preserve foods.	The use of a temperature sensor in the refrigerator in the refrigerator will not be efficient.
Segmentation Techniques for Rotten Fruit detection	Detect the quality of vegetables by a multi-level process reducing the manpower with proper accuracy.	The segmentation technique is not efficient in case of blurred images.
RFID Based Smart Fridge	The use of RFID sensors increases the speed and accuracy of the system.	The major disadvantage with RFID sensors. sensors are its high cost and the frequent signal issues.
Approach for quality detection of food by RFID-based wireless sensor tag	The use of PH and permittivity accurately detects the meat.	This method cannot be implemented for detecting other food items in the fridge.
Smart fridge design using NodeMCU and home server based on Raspberry Pi 3	Give notification like date of expiry, inserted and taken items using the sensor.	Using sensors sometimes make the issues in giving the accurate value or dates.

IV. RESEARCH TO PROVE THE NEED FOR THE PROPOSED SYSTEM

A. Analysis Of Veggies In Refrigerator

As our research involved details about the lifespan of vegetables in the refrigerator we chose to examine the number of days a vegetable would stay healthy in a fridge.

First, we took the tomatoes for the test. They proved to exist for a period of 5 to 7 days. Then we examined veggies like carrots, potatoes, beans, ivy gourd, snake gourd, and ridge gourd. We have collected a huge dataset on the vegetables, fruits and non-veg category of food items with their expiry date stored in an excel file form the survey.

TABLE 2.Vegetables and their lifespan

Veggies	Lifespan
Tomato	5 - 7
Potato	4-5
Carrot	10
Beans	10
Ivy gourd	7-8
Snake gourd	6
Ridge gourd	10-15

B. Survey on Food Spoilage

We decided to take a survey on the food that gets wasted in our refrigerator. We created a Google form and forwarded it to about 100 women to find how many people waste food kept items in refrigerators. It was found that out of 100 people who attended the survey 85.3% were working women, among them 62.7% leave food items to get spoiled in refrigerators and 73.3% of them spoil food as they keep new food on top of it. We have also taken a note on the other reasons for wasting food in the refrigerator. We have also found the category of food which people waste the most (vegetables- 60%, fruits- 35%, seafood & meat- 25%).

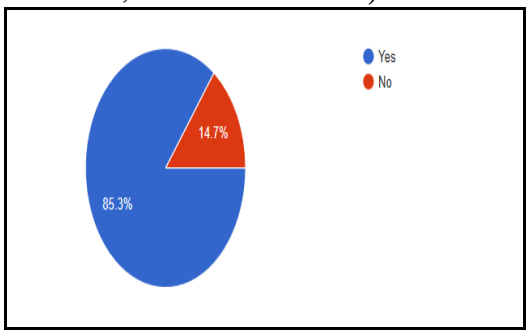

Figure 1. Survey on food spoilage 1

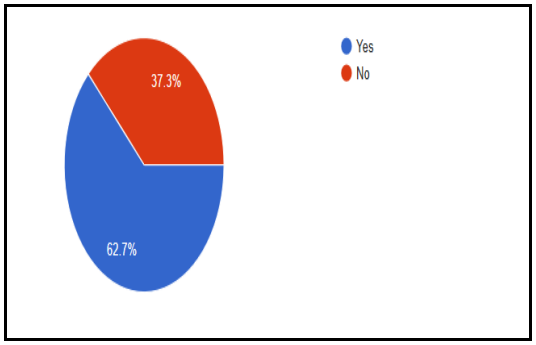

Figure 2. Survey on food spoilage 2

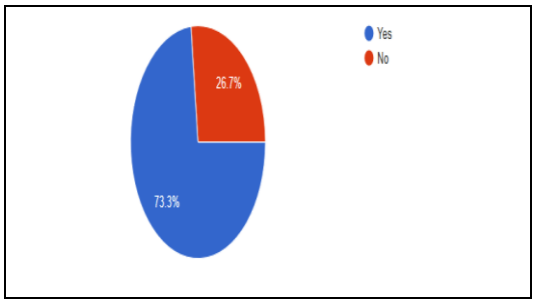

Figure 3. Survey on food spoilage 3

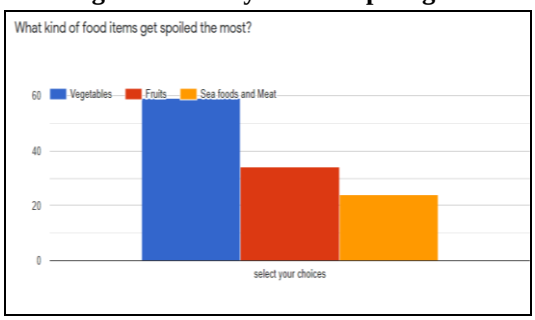

Figure 4. Survey on food spoilage 4

V. PROPOSED SYSTEM

A. Proposed System Architecture

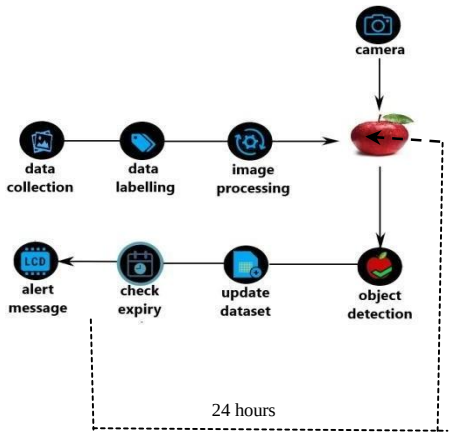

Figure 5. System Architecture

The architecture is designed to be implemented in refrigerator. In the first stage, we had to train the system to classify the food items present in the captured images. This stage involves data collection, data labeling, and image processing phases. In the second stage, the refrigerator's environment has been captured using a webcam. The food items in the captured image are classified with the help of the trained data module obtained in the first stage. Here the object detection is done using the TensorFlow framework and R-CNN algorithm. Tensorflow object detection algorithms together with R-CNN act as an Image classifier.

Dataset update is done every 24 hours, for each new item placed in the refrigerator. Each item has a self-life that is termed as the date of expiry. If the item days count reaches the expiry date an alter message will be displayed in a 18X2 LCD display.

B. Flow Diagram

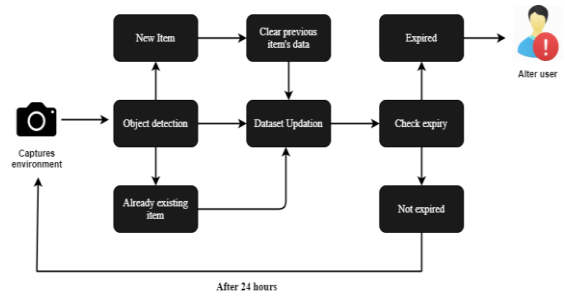

Figure 6. Flow Diagram

The flow diagram explains the detailed working of the proposed system. The system is designed to capture the refrigerator's environment every 24 hours. This helps the system to perform 3 operations in the data set,

- Incrementing the days count for the existing food items.
- Adding the newly kept items to the dataset and updating their day's count.
- Removing the items from the data set which are removed from the refrigerator.

Every 24 hours, the day's count will be incremented for every item in the refrigerator and the data of new items is taken into account. Whenever an image is captured the system checks for both the new items placed in the refrigerator and also for the existence of all the previously updated items.

VI. LIST OF MODULES

A. Annotating The Images

Data collection is the initial step of this module. The pictures of different vegetables are taken in a white background. We chose a white background as it can increase the efficiency of our system. The photoshoot involved all possible angles and combinations of all the food items that can be placed in a refrigerator.

After capturing images we have done with the labeling of those images since it helps to identify images with these names. By using anaconda prompt we opened the labelImg software which is used to label the images. The labelIng needs three things to be installed, the first one is that the python and the next one is the pyqt5 and finally lxml. The images are stored in .xml format which includes the height, width, position or coordinates of the image which is very helpful in case of performing the detection of the object.

B. TFRecord Generation

Once we label the images we split the data labeled into two categories which are for training and testing. 90% of data has been segregated for training and the rest of the data for testing purposes. The generated XML files are converted to a CSV file. This is followed by generating tfrecord.

A TFRecord is TensorFlow's file format. The TFRecord file format is a simple record-oriented binary format for ML training data. This approach makes it easier to mix and match data sets and network architectures.

C. Training and Testing

After the labeling process, the whole dataset is divided into train data and test data. The test data folder consists of 10% of the train data folder's image details. This is where the supervised machine learning comes in. The train data contains both the input for the system and the related prediction. After training the system is checked for its accuracy with the images in the test folder. Data training is done by using the Tensorflow framework and R-CNN algorithm. TensorFlow, which is a deep learning framework, helps to build Faster R-CNN architectures to automatically recognize objects in images. Tensorflow has an official Object Detection API. This API provides implementations of object detection pipelines, including Faster R-CNN, with pre-trained models.

D. Object Detection

Now the system is ready to detect any vegetable in any environment. This is done with the camera module which captures the environment and the trained module helps us to detect the objects in the image captured. In our case, the system detects the vegetables in the image captured.

E. Check Expiry

This is the important module of our project as it is only here the healthiness of a detected food item is checked. The initial step of this module includes collecting a dataset that has the lifetime of the vegetables that are stored in the refrigerator. We self-evaluated the lifetime of vegetables in a refrigerator and collected the data in an excel file. We also took note of the life of fruits, meat, and seafood for future enhancement.

We use the DateTime package of python to note the date and time that a food item is kept in the refrigerator. Thus for every new vegetable, the date of storing it is noted and thus the date of expiry of the vegetable is calculated with the help of the dataset collected. This module is looped for every 24 hours which helps in detecting the new vegetables stored and also in checking the healthiness of the preexisting ones.

F. Alerting User

While updating these datasets, if any of the items are found to have the days count reaching the expiry date. It will be notified to the user by giving an alert. The alert has been given on the refrigerator using an LCD display. The 16x2 LCD screen is connected to the Arduino. The information returned from the python code is taken by the Arduino software and the corresponding alert message is displayed to the user. Pyserial helps in connecting the result of the python code to the Arduino software.This system has two possible outputs. The first one is displayed a day before the food item to get spoiled as the user can consume it. Consider the case of tomatoes, then the alert message will be " one day left for your tomatoes to get spoiled". The other display message is to intimate the user about the spoiled food item in the refrigerator which might affect other items in the refrigerator. In the case of tomatoes, the message will be "Take care of your rotten tomatoes".

VII. SOFTWARE AND HARDWARE REQUIREMENTS

Software

- Raspbian OS

- Tensor Flow
- LabelImg
- Pyqt5
- Google Collab
- R-CNN

Hardware

- Raspberry Pi
- Raspberry Pi camera module
- 18x2 LCD Display

VIII. RESULT ANALYSIS AND DISCUSSIONS

The result of our system is the alert message in the LCD screen which can be placed in the door of the refrigerator.

TableIII. Result Analysis

FOOD DETECTED	DAY ON WHICH FOOD WILL GET SPOILED	OUTPUT ON THE Xth DAY	TIME TAKEN BY THE SYSTEM (Seconds)
Tomato	7	Yours tomatoes are rotten	13
Green Capsicum	14	Yours Green Capsicums are rotten	12
Yellow Capsicum	21	Yours Yellow Capsicums are rotten	15

VIII CONCLUSION

We have enhanced the existing smart fridge concepts to detect the food items kept in refrigerators and alert the users depending on the food spoilage time. This helps all the working people to be reminded of keeping their edible products safely and reduces wastage of food items due to carelessness. While today's smart fridges don't have exactly those features, they have come a very long way from the ice boxes of days past. The problem there was that the sensors couldn't detect specifically which items were being removed, and which needed to be replenished. The idea, is that this analysis will take place automatically, with little to no intervention from the user . The status of the vegetable is used to display in the LCD which makes the user very helpful because sometimes they open the refrigerator but they don't notice the spoilage of fruit or vegetable.

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