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Development of CNN Model to Avoid Food Spoiling Level

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ABSTRACT

Food spoilage is a pervasive issue that contributes to food waste and poses significant economic and environmental challenges worldwide. To combat this problem, we propose the development of a Convolutional Neural Network (CNN) model capable of predicting and preventing food spoilage. This paper outlines the methodology, data collection, model architecture, and evaluation of our CNN-based solution, which aims to assist consumers, retailers, and food producers in minimizing food waste. Researchers are working on innovative techniques to preserve the quality of food in an effort to extend its shelf life since grains are prone to spoiling as a result of precipitation, humidity, temperature, and a number of other factors. In order to maintain current standards of food quality, effective surveillance systems for food deterioration are needed. To monitor food quality and control home storage systems, we have created a prototype. To start, we used a Convolutional Neural Network (CNN) model to identify the different types of fruits and vegetables. The suggested system then uses sensors and actuators to check the amount of food spoiling by monitoring the gas emission level, humidity level, and temperature of fruits and vegetables. Additionally, this would regulate the environment and, to the greatest extent feasible, prevent food spoiling. Additionally, based on the freshness and condition of the food, a message alerting the client to the food decomposition level is delivered to their registered cell numbers. The model used turned out to have a 96.3% accuracy rate.

Keywords : Machine learning for health, smart system, food spoilage detection, food spoilage prevention, sensors.

I. INTRODUCTION

Food spoilage is a major concern in the food industry and households alike. It not only leads to significant economic losses but also exacerbates the global food waste problem, with detrimental environmental consequences. The development of predictive models capable of identifying food spoilage at an early stage can help reduce waste and save resources. Convolutional Neural Networks (CNNs), a class of deep learning models, have shown remarkable success in image recognition tasks, making them a promising choice for addressing this issue.

The food business has expanded quickly, and there is a high need for food preservation, which has led to the development of several techniques for spotting food deterioration caused by bacteria, fungus, and other pathogens. Today, food poisoning is a severe issue that is causing many individuals in the globe to experience a variety of issues. Food that has gone bad and contains hazardous germs like Shigella and Salmonella is the root cause of over 200 ailments.

Globally, 3-5 billion people get infectious diarrhoea each year, and 1.8 million people die as a result of food poisoning.

Early detection of spoiled food is essential for illness prevention. In almost every home, there will be food concealed in the refrigerator that will rot, change colour, and begin to smell owing to the growth of germs, which will only be noticed by people after a lengthy period of time, and that has to be thrown out. It would be helpful to have a tool that could detect food spoilage by sensing colour changes in the food. Having a technology that can identify food rotting not only in homes but also in businesses would be very beneficial for the executives to assess them.

Many challenges that normal sighted individuals may not be aware of are faced by colorblind persons. Colour blind individuals are unable to distinguish between true colours that are visible to others with normal vision. Because they can't distinguish the colours of a traffic signal, they also have trouble picking clothing, cooking, and even driving. People who have colorblindness are unable to identify ruined food by colour change. For them, this endeavour will be successful and will need less work on their part to identify the spoilage.

The project for detecting food rotting that is the subject of this essay consists simply of a software-based programme that, when fed photographs or photos of food, recognises the presence of spoiling. By using image processing and the k clusters technique, this research can identify food deterioration that results in the growth of fungus and forecast whether the food will deteriorate or not. The similar procedure may be used to anticipate fruit deterioration, however an additional step will be introduced that will first predict the fruit's name. Considering that certain fruits have strange appearances even when they are uncooked. The conditions of rotting vary depending on the name of the fruit.

II. RELATED WORKS

Machine learning and artificial intelligence have many uses that are not limited to performing specific tasks; these technologies have made significant contributions to a number of fields, including medicine, electronic platforms, robotics, remote control, business, virtual personal assistants, social media, video surveillance, email spam or malware filtering, fraud detection, education, transportation, and even finance. In a publication [1], odour tracking is used to detect food spoiling in smart homes. The publication [2] describes the detection of food spoilage and pathogenic bacteria using a ligation detection reaction coupled to flow-through hybridization on membranes. The study paper [3] explains how to use an electronic nose to measure the extent of deterioration of Filipino foods made with tomatoes versus time and temperature.

The research study [4] discusses the detection of food spoiling in the smart home using neural and fuzzy processing of odour sensor outputs. The study paper [5] suggests an electronic nose based on metal oxide semiconductor sensors as a substitute method for classifying the degree of red meat rotting. A CMOS fish resistance to the period converter with calibration circuits is described in article [6] for applications that detect seafood deterioration. The study paper [7] suggests recent advancements in quick multiplexed bioanalytical techniques for the identification of foodborne pathogenic microorganisms. Multispectral imaging is mentioned for the purpose of spotting spoiled pork in the study publication [8].

A article [9] describes the rapid and quantitative detection of meat microbiological deterioration using Fourier transform infrared spectroscopy and machine learning. Rapid qualitative and quantitative detection of beef fillet rotting using Fourier transform infrared spectroscopy data and artificial neural networks is presented in the study article [10]. In a work [11], fruit detachment and classification techniques for strawberry harvesting robots are described. The research paper [12] presents a computational analysis of the Sobel Edge Detection Algorithm's software and hardware implementation.

The categorization of grapes following pesticide exposure is described in the study publication [3]. In paper [4], a fruit detection and grading system based on image processing is reviewed. In an article [5], it is discussed how fungus spores cause food to deteriorate. Developing a framework for fruit detection from photos is provided in the research article [6]. In a publication [7], an Active Thermography Method for Immature Citrus Fruit Detection is described. A Modified Canny Edge Detection Algorithm for Fruit Detection & Classification is provided in the research article [8].

Continuous sensing is a special type of sensor that can discriminate between different daily activities and flag potentially unsafe circumstances for the occupants of a smart home. Food spoilage is one such instance and is the focus of this investigation. Using an electronic nose with a metal-oxide sensor (MOS) basis, the scientists assessed the scent signatures of two common meals (milk and yoghurt) that were maintained at 25°C for a week. The greatest absolute sensor responses were utilised to build feature vectors, and as the data grew older, the components of these feature vectors followed a smooth trend. Principal component analysis (PCA) revealed that the two compounds took separate paths during the rotting process.

By merging image categorization with machine learning methods and artificial intelligence, Rajesh Megalingam et al. (20) present a novel approach for detecting food degradation. To detect food spoilage, they have employed AI, deep CNN networks, computer vision, and ML approaches like the k clusters method for colour categorization in photos and its HSV values. This project is completed on the Jupyter notebook platform using the anaconda prompt. Additionally, Iwendi et al. used a network classifier to detect and analyse IoT security levels using an artificial intelligence technique. The research reveals a remarkable accuracy rate for the suggested application. According to this perspective, AI is currently applicable to practically every industry.

III. BASIC FOOD SPOILAGE SYSTEMS

Food spoilage is a complex process involving various chemical, physical, and biological changes in food items that render them unsuitable or unsafe for consumption. Understanding the stages and mechanisms of food spoilage is essential for preventing it and ensuring food safety. It's important to note that various food products may spoil differently based on their composition and characteristics. Preventing food spoilage involves a combination of factors, including proper storage, handling, packaging, and the use of preservatives and additives. Additionally, food safety measures must be implemented to prevent the growth of harmful pathogens that can cause foodborne illnesses.

When a food product is rendered unsuitable for consumption by the consumer, food spoiling occurs. The type of food item, how it is packaged, and the processing it goes through all have an impact on the components of this process. Due to food waste, one-third of the world's melded that are produced for human consumption are lost each yea. In Figure 1, it is seen that as soon as bacteria begin to attack new apples, gas emission occurs, and within a few hours, the apple is fully damaged.

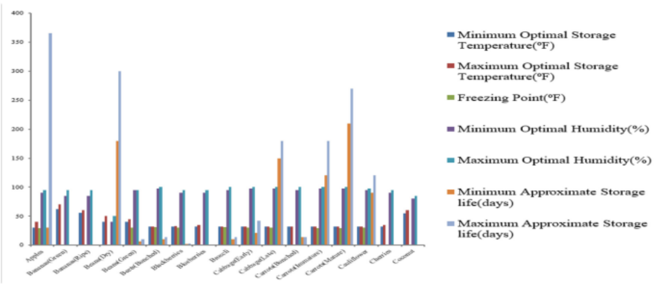

Fig 1. Comparison among different fruits and vegetables with respect to their various attributes.

Food deterioration is caused by bacteria, viruses, protozoa, fungus, and bacteria. Consumers may experience negative effects from these elements, but we may use preventative methods to preserve the life and nutritional value of food. Food poisoning is often not caused by bacteria, and the majority of the microorganisms that do so are flavourless and odourless, unless mycotoxins and microbial wastes are present. Therefore, it is never advised to ingest damaged food. Food can get contaminated by the harmful germs Clostridium perfringens and Bacillus cereus.

IV. DEEP CONVOLUTIONAL NEURAL NETWORKS

Deep neural networks include convolutional neural networks (CNN). Images are compared and classified mostly using it. Utilising numbers at every pixel, a computer can comprehend any image. This technique separates a picture into fragments and compares each component separately. These components are referred to as features or filters. Convolution layer, ReLU layer, Pooling layer, and Fully Connected layer are the four layers that make up CNN. Every feature or filter will be moved to every area of the input picture in the convolution layer. This layer consists of a few phases. First, we align the image's various components. After that, we multiply each picture pixel by the values of the associated feature pixels. The multiplication is followed by the formation of a new matrix. The matrix's total number of pixels is then multiplied and added. The next step is to build a map and place the filter value on it. Then we move the filter around the image to observe how it fits in each location. The output matrix is then formed by filling the map.

For every filter, a fresh matrix is created in the same manner. The Rectified Linear Unit (ReLU) layer, which is an activation function, is the following layer. All of the negative values in the filtered pictures are eliminated and replaced with zeroes in this layer. The pooling layer, which comes next, reduces the size of the image.

The filter matrix will be divided into sections based on a window size. The only value taken in that window area is the highest value. The whole values of the new matrix, whose size will be less, are obtained when the window is moved across the matrix.

We now repeat all three processes to obtain the smaller sized matrix. The last component, the fully linked layer, is where the actual categorization takes place. Here, every image that has been downsized has been compiled into a single list. The list or vector is what it is known as.

The list changes depending on the image. A fresh input is run through each CNN layer to produce the final list when it is provided. This list categorises the image in accordance with comparisons made with earlier lists. For this to occur, the model must be trained with several photos of the same object, which improves the classification's accuracy.

This model was selected because it can forecast the fruit by comparing it to the model's training photos, which aids in recognising the fruit that ripens differently from other fruits.

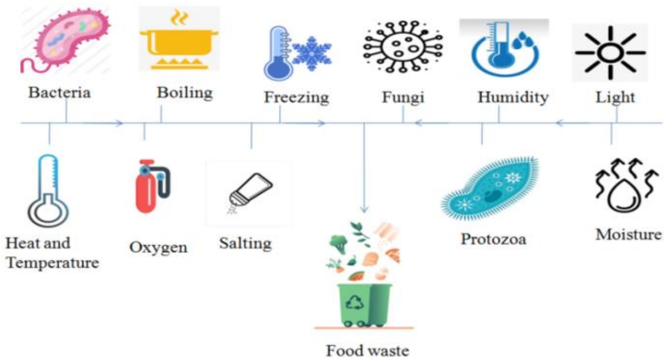

Fig 2. Factors of food spoilage.

V. ARCHITECTURE

The proposed solution includes new device architecture with few configuration modifications as per the requirement. The new device architecture includes a humidifier to maintain the humidity of the device and a cooling module that maintains the temperature for the food items. The prototype of the device is represented in Figure. Various electronic instruments have been used for monitoring. Furthermore, the registered values are used for monitoring purposes. The information gathered by various sensors can be correlated to the target values. The speed control kicks in and interprets the provided procedure to keep it running in the correct direction if the sensor readings do not match the key parameters. This theory can be used to create a method that can protect raw foods. This architecture consists of the following components:

Controller: Arduino is used as a microcontroller.
Gas detection sensor: A gas detector is a device that measures the number of gases in a given environment, and is often used as part of a protection system. Operators in the field where the leak is happening will be alerted by a gas detector.

Humidifier: A humidifier is a system that raises humidity (moisture) in a single room or a whole house. It is essentially an electrical appliance. Point-of-use humidifiers are widely used in the home to humidify a single room, and humidifiers are used inmedical ventilators for greater patient convenience.

Heat sensor: The key function of a heat sensor is to detect the heat that is present inside it.When the temperature around the heat sensor rises above its fixed point, it detects the heat and alerts us, allowing us to protect the devices from injury.

Humidity sensor: A humidity sensor is a sensor that senses humidity and converts the information into an electrical current. Humidity sensors are available in a range of shapes and sizes, as well as with different features. The Humidity sensor first senses any humidity or moisture in the fruits or vegetables and it sends some value to the microcontroller if any moisture content is detected then an alert message sends to our mobile phone if the moisture content is not detected then again taking values from the microcontroller.

Cooling module (TEC1-12715-Thermoelectric Cooler 15A Peltier Module): The heater, condenser, and fan device are all included in this element. A heater and a condenser are included in this module.

Light sensor: Light sensors are electronic devices thatmonitor the intensity of natural or artificial light.

Light energy is converted into an electrical signal by these devices. Light sensors are used in a variety of manufacturing application areas.

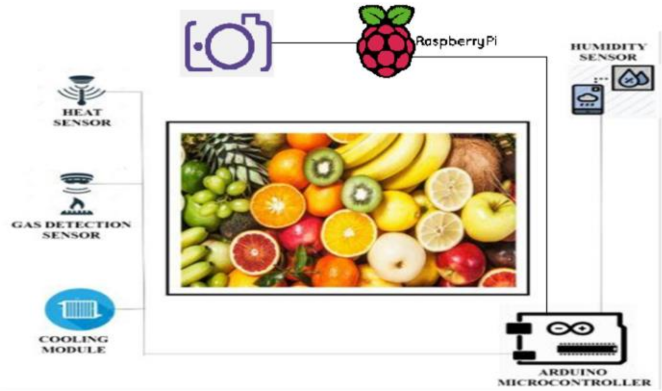

Fig 3. The architecture of Monitoring and analysis of food spoilage using Machine Learning.

The identification and monitoring of food rotting rely heavily on several types of sensors. The camera sensor, humidity sensor, gas sensor, and heat sensor are all included. The picture of the fruit or vegetable is recorded by the camera sensor. The environment's humidity is detected by the humidity sensor. When the humidity falls below the threshold, the humidifier raises it until it reaches the desired level. The temperature sensor keeps track of the temperature in relation to a set threshold value that is managed by Arduino. The Raspberry Pi, which functions as a little computer with its own processing power and memory, is immediately connected to Arduino. The cooling module activates whenever the temperature exceeds the threshold setting. Through the detection of a little amount of gas released from the food products, the gas sensor may identify early deterioration. It transmits the value to the Arduino, which then pushes the value to the cloud after receiving it. The web application informs the user via buzzing, through voice commands, or by displaying messages.

VI. RESULTS AND DISCUSSION

It takes a lot of time and effort to obtain information. Whatever the subject of research, accurate data collecting is essential to preserving cohesiveness. Nowadays, food spoiling is a highly worrying issue since a robust immune system is required, and there is no available option that helps to avoid rotting to some level. The data collection utilised in this investigation is called Fruit360. A dataset must be downloaded from the Kaggle dataset page.

Images of a variety of fruits and vegetables may be found in the dataset. This dataset was used to train CNN models to identify objects. Veggies and fruits. A dataset has been produced following thorough investigation. The dataset includes information on 50 different varieties of fruits and vegetables, including their freezing point, ideal storage temperature range, ideal humidity range, and approximate storage life range. For the creation of spoiling alarm messages on mobile devices, a dataset is used. The dataset attribute in Table 3 is described along with its value, type, and description. Except for the first column, every number in each column indicates numerical and floating-point values.

Figure 3 shows the relationship between the characteristics of 17 fruits and vegetables, including the minimum and maximum recommended storage temperatures, Freezing Point, minimum and maximum recommended humidity levels, and minimum and maximum recommended storage times. For our experimental objective, we have chosen 15 fruits or vegetables from a total of 50. This graph compares the settings for the various food products' standard parameters. The food item is then placed in the suggested gadget, which does more analysis on it and adjusts the parameter values accordingly. Finally, the suggested method is employed to keep an eye on the object and adjust the surroundings as necessary.

A fruit or vegetable's average shelf life is the amount of time that it may be eaten while still being healthy. Consuming this fruit or vegetable after this point is unhealthy since spoiling may have already occurred before the fruit or vegetable's typical shelf life. Each type of fruit or vegetable has a certain minimum ideal storage temperature below which they begin to rot. Therefore, it is important to maintain the minimal temperature for optimal storage. Both the training and validation data are presented on the performance graph for our model. We provide the CNN model for fruits and vegetables's training data loss vs. validation data loss graph, training data accuracy, and validation data accuracy for object detection. The performance graph plot displays the accuracy gain as the number of epochs rises as well as the accuracy of our model's training. The graphs in Figures 1,2 illustrate the CNN model's training data loss vs. validation data loss, training data accuracy, and validation data accuracy. The model may be fitted in three distinct ways: overfitting, underfitting, or ideal fit.

Over fitting: This situation arises when the Training loss is significantly smaller than the Validation loss.
Under fitting: When the Training loss is more than the Validation loss, or when Training loss > Validation loss, this condition arises.
Perfect fit: This situation arises when Training and Validation losses are about equal or converge over time, proving that our methods are effective.

Table 4. Experimental analysis of fruits and vegetables.

Name of fruits or vegetables	Minimum temperature (°F)	Maximum temperature (°F)	Average shelf life (days)	Maximum approximate storage life (days)	After experimenta analysis (days)
Broccoli	32	32	11	14	16
Cabbage (Early)	32	32	41	42	44
Carrots (Immature)	32	32	35	180	181
Cauliflower	32	32	14	120	122
Cherries	30	31	6	14	15
Grapes	31	32	6	56	55
Kohlrabi	32	32	7	90	91
Gooseberries	31	32	3	28	29
Leeks	32	32	11	90	91
Parsley	32	32	6	90	91
Plums	31	32	4	35	36
Eggplant	46	54	2	7	9
Blackberries	32	33	6	3	4
Corn (Sweet)	32	32	7	8	9
Cucumbers	50	55	11	14	15

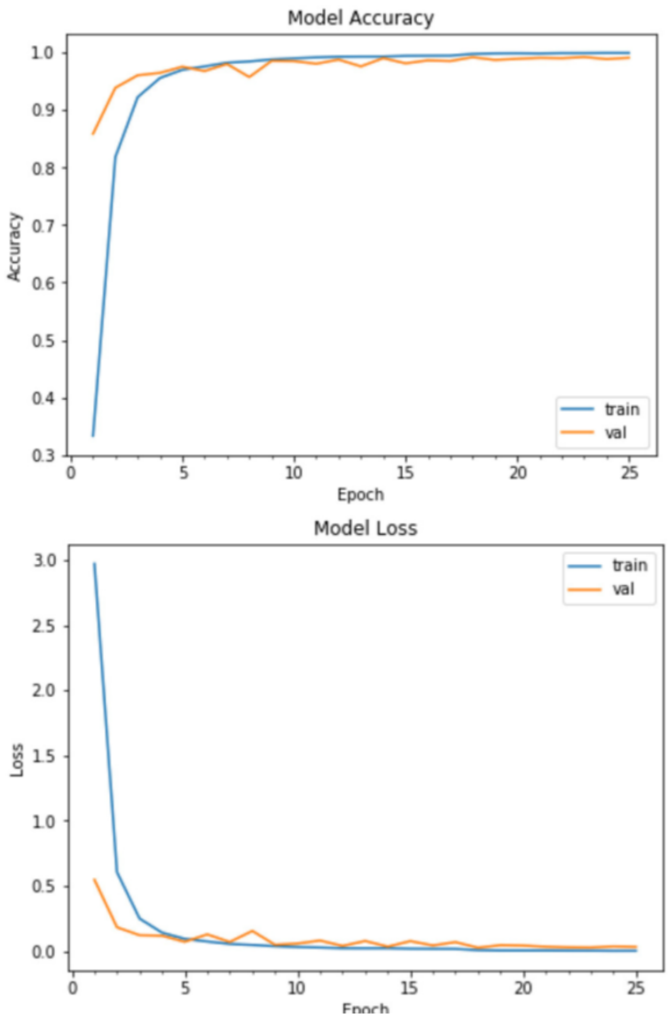

Fig 5.Performance graph of training accuracy vs. validation accuracy.

VII. CONCLUSION

In this work, a unique sensor-based monitoring and analysis approach for food deterioration is presented. The technology suggested in this study has a longer shelf life for food. Additionally, by lengthening their shelf lives, food items may avoid becoming bad. It continuously analyses the food quality and warns the user via voice commands or a display. It also creates notifications for the user with the estimated amount of time the food will remain fresh. The suggested gadget displays a 95.3% accuracy rate. By using image processing and machine learning methods to identify early spoiling, the suggested smart gadget can be enhanced. This may be used in refrigeration systems to monitor for food spoiling and to detect food items and their occurrence. The gadget may be placed into food transportation containers, allowing tracking and detecting any transportation-related spoiling that may have occurred. The apparatus might potentially be evaluated for a range of meals. Without the use of a food spoilage sensor, a project to identify spoiled food utilising artificial intelligence and machine learning techniques using computer vision was successfully constructed in the Jupiter notebook platform in Python and delivered reliable results. According to the results of the research, it is possible to precisely identify food and fruit that has been spoiled. The variation in camera lenses, sizes, as well as the use of daylight and tube lighting, might result in infinitesimal neglect while shooting images with various cameras.

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