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Recognition of Deterioration in Fruits Using Machine Learning

Kavya R[1], Janani M[2], Lavanya Bhairgond[3], Kishore Kiran[4] and Megha Menon K[5]

[1-4]UG Students, [5]Assistant Professor

Department of Computer Science and Engineering,

East Point College of Engineering and Technology, University of VTU,

Bengaluru ,India

***Abstract*— Life cannot exist without food. Food is essential for healthy life. However, the food that we eat today lacks any nutritional value. Numerous preservatives are added to the fruit, which reduces its nutritional content, in order to lengthen its shelf life, improve its texture, and improve its quality. Adulteration in fruits is mainly caused by a chemical named Formalin. Formalin is a colorless, aqueous solution of formaldehyde. Formalin is very dangerous for human life. In our project, we're putting an IoT model into practice that will extract the formalin content of fruits and determine if they're safe to eat or not. A wet sensor and HCHO gas sensor connected with an Arduino is used to extract the formalin content from real fruit, and an LED is used as an output to show if the fruit is safe to eat or not. Convolutional Neural Network (CNN), is being used to classify the fruits based on feature extraction. Our study uses an IoT model and supervised machine learning algorithm to assess whether the fruit is tainted and whether it is safe to consume.**

***Index Terms*—Extraction of formalin content, convolutional neural network algorithm.**

I. INTRODUCTION

Consumers are seriously concerned about adulteration in fruits because it can affect their health and well-being. The identification of adulteration in fruits has become a promising application of machine learning and the Internet of Things (IoT) in recent years. The potential for improving accuracy and efficiency in fruit quality control exists with this approach. To ensure the safety and quality of fruits, we can integrate sensors with machine learning algorithms to detect instances of adulteration accurately and identify them without fail. The focus of this paper is on the use of machine learning and IoT to detect adulteration in fruits, specifically apples and oranges. To collect data on the chemical composition of fruits, including the presence of harmful chemicals or gases, we will utilize gas sensors and Arduino microcontrollers. To accurately detect instances of fruit adulteration, machine learning algorithms like support vector machines and decision trees will be used to analyse this data. This approach has several other benefits in addition to detecting adulteration. By monitoring storage conditions like temperature and humidity, it can assist in enhancing the shelf life of fruits, for instance. Identifying fruits at risk of spoilage or contamination can also aid in reducing food waste. In this case study, adulteration in apples and oranges was detected using gas sensors and Arduino microcontrollers. Using the chemical composition data of both adulterated and non-adulterated fruits, we trained and tested several machine learning models. The effectiveness of this approach for detecting adulteration in fruits is demonstrated by our results, highlighting its potential to improve food safety and quality. Finally, the combination of machine learning and IoT technology shows considerable potential for detecting fruit adulteration. This technique can help assure food safety and quality while also decreasing waste and enhancing sustainability.

II. RELATED WORK

1) M. A. Hossain et al. (2021) in their paper proposed a deep learning-based approach for the detection of fruit adulteration. The proposed approach uses a convolutional neural network (CNN) to classify fruit samples into two categories: adulterated and non-adulterated. The authors tested their approach on a dataset of apple and mango samples, and achieved an accuracy of 97.08% for apple samples and 98.33% for mango samples.

2) A. K. Das et al. (2021) in their paper presented an ML-

based approach for detecting adulteration in pomegranate juice. The proposed approach uses a support vector machine (SVM) classifier to classify juice samples into two categories: pure and adulterated. The authors tested their approach on a dataset of pomegranate juice samples adulterated with water, sugar, and salt, and achieved an accuracy of 98%.

3) M. Iqbal et al. (2020) in their paper proposed a hybrid approach for detecting adulteration in fruit juices. The proposed approach combines a CNN and SVM classifier to classify juice samples into two categories: pure and adulterated. The authors tested their approach on a dataset of orange juice samples adulterated with water, sugar, pulp, and achieved an accuracy of 95%.

III. EXISTING SYSTEM

Quality of fruits or vegetables cannot be determined .in general the existed method was by viewing the physical appearance of the fruit such as colour, shape etc. adding of chemical substance to the fruits resulted in the formation of adulteration. Many a times after the involvement the concept of adulteration humans were not able to differentiate the fruit is able to consume or not. To overcome this a mixture of ideas was come into Existence. one of the thought was the idea of vision, some developers was able to develop the concept of image processing, which would able to detect the adulteration of the fruit using the conceptualization of machine learning.

Existing system has proposed many algorithms such as support vector machine, logistic regression, KNN based on the existing dataset 61% on train dataset and 31%-33% test set accuracy of support vector machine algorithm followed by 70% of train data and 35%-40% test accuracy of logistic regression algorithm,

Finally 87% of trained datasets and 80%-83% on the test set accuracy of KNN algorithm is done respectively.

MODEL DEVELOPMENT:

Development is based on Rule based classification. Features are extracted as trained datasets. Firstly the kind of fruit is identified or classified, further it runs on several algorithms and the outcomes are derived.

- Random forest algorithm
- Decision tree algorithm
- Naive Bayes algorithm
- ML algorithms to the current system SVM (Support vector Machine)

IV. PROPOSED SYSTEM

This work focuses on developing a user-friendly tool that detects disease levels and classifies them accordingly the initial model uses convolutional neural networks for classification. The proposed system also classifies the fruits based on the percentage of infection in this project. We have considered only two fruits i.e. apple and mango which can classified based on infection level this model works in several stages and consists of the inception v3 model image pre-processing and transfer learning techniques shows the flow of advanced architecture and working model the inception v3 model is mainly used for image recognition and is a predefined convolutional neural network it has a total of 28 floors inception already has a dataset called ImageNet that contains 1000 different object classes and is 781 percent accurate so this architecture uses inception v3 the proposed work captures an image of a fruit and resizes the images to 299x299x3 which is provided as input to the inception v3 model it uses an initial model with pre-processing flexibility the image can be pre-processed from moderate to complex the complex pre-processing requires a large array of expensive hardware which is not required for this model so moderate pre-processing is used in this process it also performs image cropping and resizing it will be resized to 299x299x3 which is the standard image size of the original v3 model made the base model and transfer of the final group layer were used by them and this technique is called transfer learning in transfer learning the lower layers of the inception model do not need to be removed or modified only the outer layers are sufficient after transfer learning different classes were predicted and the image was classified into a certain class .

The main purpose of this system is to find the quality of the fruit and concentration of formalin content in it using CNN model the CNN model takes in an input image of size 2242243 colour channels and applies a convolution of size 33 with 64 kernels output channels with a stride of 1 and a padding of 1 the model extracts the learning features such as texture colour shape and size and chemical components and classify the fruit image as adulterated or not if adulterated then the system will show the formalin content effected area quality fruits whether it is healthy or unhealthy to consume.

ADVANTAGES:

-> Increased in the amount of datasets leads to more accurate results in the adulterated fruit.

-> Efficiency is high using the proposed model more than other Image processing.

-> The method of detecting the area of affected area in fruit.

V. SYSTEM ARCHITECTURE

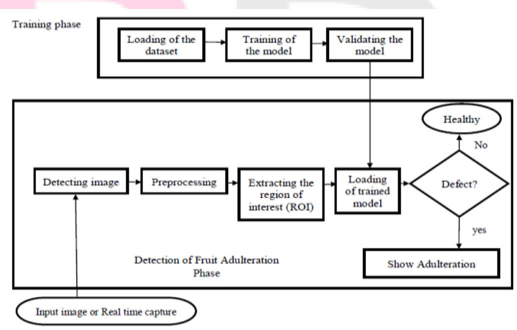

Fig 1: Software Architecture of the Proposed System

The system architecture consist of two phases the training phase and the detection of fruit adulteration phase in the training phase first we load the data set of cns which contains naturally added formalin as well as the artificial added formalin in it once the data set is loaded then we will train the model and validate the model for the training dataset for better accuracy once the model is trained we will test the trained model for the various images of oranges and apples in the fruit adulteration detection phase first we are

going to take the input image or real time capture image from the user and then the system is going to detect the image for the required resolution after detecting the image the system pre-processes the image and extract the region of interest the trained model is loaded and the pre-processed image is given to the model to check whether the fruit is healthy or not if the fruit is healthy then the system will display the fruit is healthy if not then the system will show it is unhealthy and displays the concentration of formal in it
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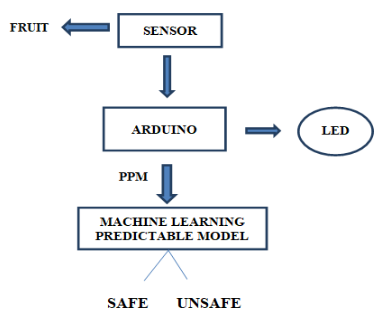


Fig 2: Hardware Architecture of the Proposed System

An Internet of Things (IoT) system architecture was created to identify whether actual fruit is adulterated or not using wet and gas sensors. Wet sensors identify wet content in fruits, while gas sensors identify the gas content of fruits. The sensors were then connected to the Arduino board, which was programmed using the sensor values, and power was supplied by connecting a laptop. An LED then displays the value that is detected by sensors and indicates whether the fruit is safe or unsafe to eat.

VI. MODULE SPECIFICATION

Module 1
Dataset Collection: The dataset was manually compiled using Google Images and CFS. Fruits that have been artificially added formalin as well as fresh fruit are included in the datasets. Images of apples and oranges are gathered and used in training.

Module 2
Data Pre-Processing: In this module, the image is resized first, and then it is converted from RGB to grey scale using the ski-image approach. An open-source Python library for image pre-processing is called Ski-image.

Module 3
Feature Extraction: The features of fruit, such as texture, colour, chemical composition, and shape, are used in this module to identify the fruit. After the fruit has been identified, the affected area is removed using the contour area method. Here, the main goal is to recognise and represent the apple or orange fruit as the target item for segmentation. It takes some prior understanding of the shape of the target object, particularly for complex objects. Following the determination of the fruit's shape, the contour is used to isolate a region of the image that differs from the rest in some important ways.

Module 4
Building and Training CNN Model: The processed dataset will be used to train the CNN network. The layers offered by the Keras library are used to build the CNN model. The CNN has a large number of hyper-parameters, but they concentrate on having convolution layers of 3x3 filter with a stride 1 and always use the same padding and max pool layer of 2x2 filter of stride 2, and they follow this arrangement of convolution and max pool layers consistently throughout the entire architecture.

Module 5
Formalin Area: The threshold value is computed in this module. The threshold value is used to determine the mask of the image, and the background separation and contour area approach are then performed once again to identify fruit patches and unhealthy areas. Formalin concentration is approximated.

Module 6
Predict the Quality of the Fruit: This module essentially informs the user of the fruit's status and rates its quality according to the amount of formalin present and the percentage of affected surface. Fruit is safe to eat if the formalin concentration is low and there is no more than 50% of an infection on it. Fruit is unsafe to eat if the formalin concentration is high and there is more than 50% of an infection on it.

VII. SOFTWARE AND HARDWARE REQUIREMENTS

Software Requirements:

Python 3.7.0	Python is an interpreter, high-level and general-purpose programming language. Python design philosophy emphasizes code readability with its notable use of significant white space.
Pip	Pip is a package-management system written in python used to install and manage software packages.
NumPy	NumPy is a library for the python programming language, adding support for large, multi-dimensional array and matrices, along with large collection of high-level mathematical function to operate on these arrays.
PyTorch	An open-source machine learning library used for application such as computer vision natural language processing.
TensorFlow	It is a free and open-source software library for dataflow and differential programming across a range of tasks.
Web Framework	Flask: A web application framework written in Python.

Hardware Requirements:

HW-103(Humidity Sensor): The HW-103 humidity sensor is a type of sensor that can measure the relative humidity of the air. It is commonly used in various applications such as indoor climate control, agriculture, and industrial processes. The HW-103 humidity sensor typically consists of a humidity-sensitive element such as a capacitive polymer, which changes its capacitance as the relative humidity of the surrounding air changes. The sensor is connected to a signal conditioning circuit that converts the capacitance change into an electrical signal that can be read by a microcontroller or other digital device. When using the HW-103 humidity sensor, it is important to ensure that the sensor is calibrated correctly to ensure accurate readings. Calibration can be done by exposing the sensor to a known humidity level and adjusting the signal conditioning circuitry to produce the correct output. Overall, the HW-103 humidity sensor is a reliable and cost-effective option for measuring relative humidity in various applications.

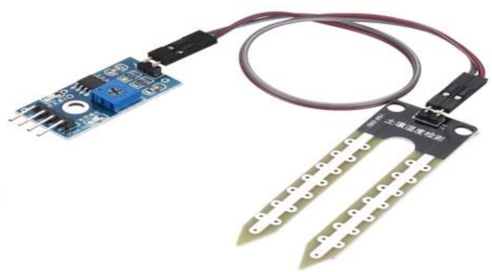


Fig 3: HW-103 Humidity Sensor

HCHO Gas Sensor: An HCHO gas sensor is a type of sensor that can detect the presence of formaldehyde gas in the air. Formaldehyde is a colourless, strong-smelling gas that is commonly found in indoor environments and is a known human carcinogen. HCHO gas sensors typically use a sensing element that reacts with formaldehyde molecules in the air, causing a change in electrical resistance, capacitance, or other electrical property. The sensor is connected to a signal conditioning circuit that converts the change in electrical property into an electrical signal that can be read by a microcontroller or other digital device. When using an HCHO gas sensor, it is important to ensure that the sensor is calibrated correctly to ensure accurate readings. Calibration can be done by exposing the sensor to a known concentration of formaldehyde gas and adjusting the signal conditioning circuitry to produce the correct output. Overall, HCHO gas sensors are useful tools for monitoring formaldehyde levels in indoor environments and can be used in a variety of applications, including industrial hygiene, environmental monitoring, and building air quality control.

Fig 4: HCHO Gas Sensor

Arduino UNO: Popular microcontroller board known as Arduino Uno is built around the ATmega328P chip. There are six analogue inputs and 14 digital input/output pins on the Arduino Uno board, six of which can be utilised as PWM outputs. Additionally, it has a USB port, a power jack, an ICSP header, a reset button, a 16 MHz quartz crystal, and other features. The C/C++-based Arduino programming language comes with a straightforward integrated development environment (IDE) that makes it simple to write, upload, and test code on the board. the Arduino platform popular due to its adaptability and simplicity of use.

Fig 5: Arduino UNO

LCD Display: Liquid Crystal Display(LCD) is a type of flat panel show which uses liquid crystals in its most important form of operation. In Arduino projects, LCD displays are commonly used to display information such as sensor readings, status messages, and user inputs.

Fig 6: LCD Display

Power Supply: We are using a USB cable to link the laptop and Arduino UNO by which power is provided to the Arduino UNO.

VIII. EXPERIMENTAL SETUP

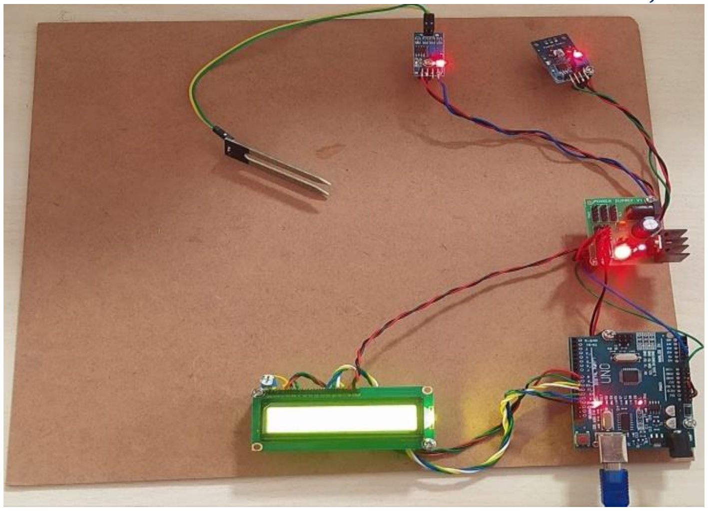
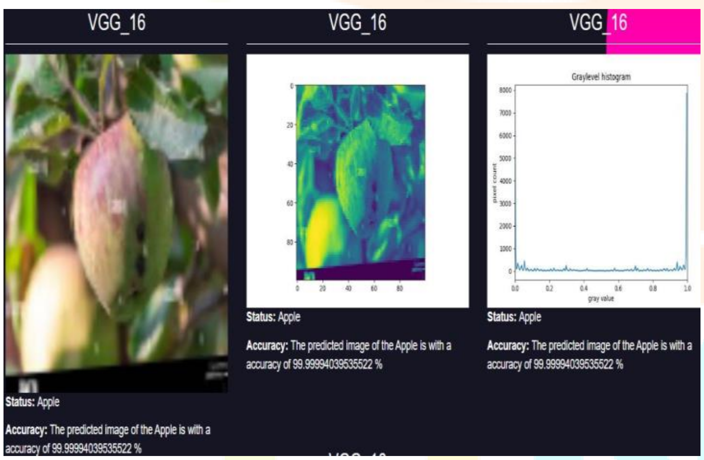
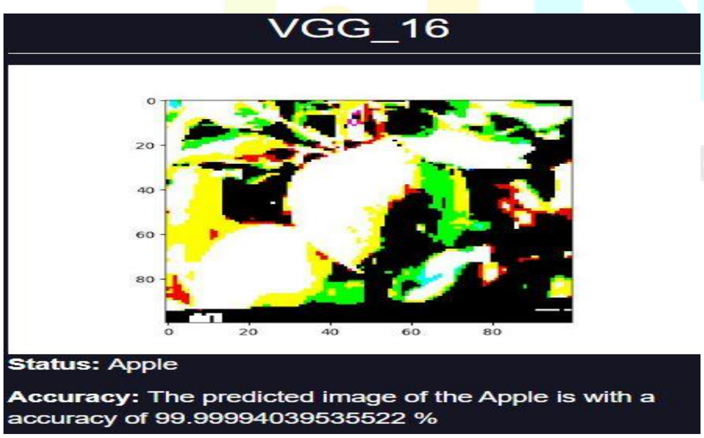


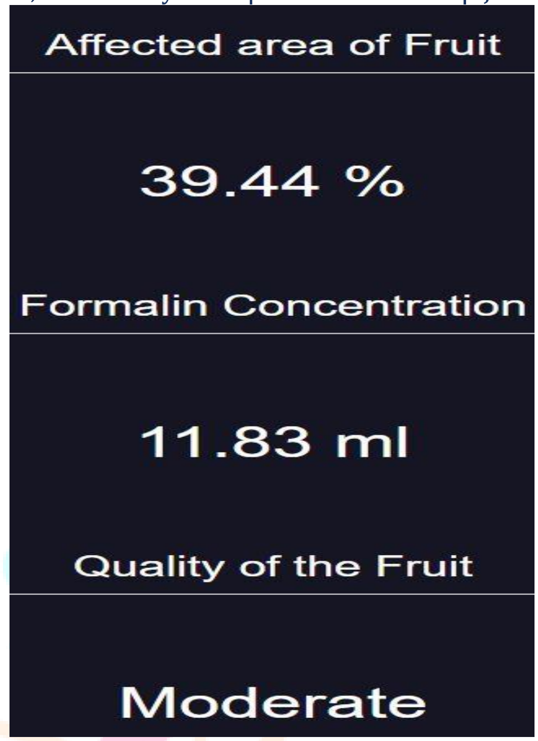
Fig 7: Experimental Setup

The Arduino Uno should be connected to the HW-103 humidity sensor and the HCHO gas sensor. Link the Arduino Uno and LCD display together. The Arduino Uno should be powered by the power source. The threshold values for the gas sensor and the humidity sensor are both known. In front of the sensors, place the fruit. An LCD display will display the value after a wet sensor or a gas sensor has detected it. The fruit will be recognized as having been tampered with if both sensors' levels increase.

IX. RESULT







X. CONCUSION

The paper demonstrates the use of machine learning algorithms for formalin identification as a result. The level of formaldehyde cannot be measured precisely using the manual method. Based on machine learning methods, this system offers a flexible and reliable way to identify food and formalin. One of the easy approaches that yields results by detecting the resistance existing in the food is the use of an Arduino for food contamination detection. It may be misleading to detect raw formalin without first having a model of how it forms naturally. The formalin concentration in any food item is recognized using this machine learning approach for formalin detection, and ingestion decisions can be made depending on the food products' safety status. Overall, the use of machine learning techniques and sensors for detecting fruit adulteration has the potential to improve food safety and protect consumers from harmful chemicals. It can also promote fair trade practices by detecting fraudulent sellers who engage in food adulteration to increase their profits.

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