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An Intelligent System for Detection of Adulteration in Edible Oils

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Abstract: *The problem of adulteration of edible oils is one of those problems which affect significantly the quality of the food and the safety of consumers. Usually, traditional approaches used to detect adulteration are very lengthy, costly and need some special equipment to be performed. That is why, this research aims at proposing the approach to use the modern technology of image processing and machine learning for detection of adulteration in the edible oils. First of all, the image acquisition stage involves taking pictures of the samples of the oil. Further, the image should be pre-processed by removing the noise and adjusting its size. The relevant features can be extracted using the techniques like colour and texture. The advanced algorithm of YOLOv5, SVM as well as various neural networks are applied for classification. Moreover, Torch and Torchvision frameworks are exploited to deal with images and neural networks. Finally, the web application is developed as the output component to provide the results.*

Keywords: Oil Adulteration, Machine Learning, Deep Learning, Computer Vision, Image Processing

I. INTRODUCTION

Due to the rising demand for oils, there has been an increased incidence of oil adulteration where inferior or cheaper oils are added to pure oils. Not only does it compromise nutrition, but it creates serious health hazards. However, while the old methods of detection such as chemical analysis and spectroscopy, both of which are highly accurate techniques, have proven to be less effective in terms of cost-effectiveness. Food adulteration detection is one area that requires a paradigm shift in its detection. Artificial Intelligence, a branch of computer science that involves the simulation of human cognitive abilities by computers, is becoming a new trend of revolutionizing this aspect. Machine Learning algorithms are used in the automation and optimization of food adulteration detection. The current study will focus on identifying the potentiality of implementing deep learning technology in detecting food adulteration.

II. PROBLEM STATEMENT

Adulteration of edible oil is one of the major concerns because it creates a lack of consumer trust, poses a threat to health, and violates the integrity of the market system. The most prevalent methods to detect adulteration are quite expensive and involve a lot of effort and time, in addition to the requirement of a well-equipped laboratory. It is necessary to note that these obstacles certainly increase the urgency of finding a proper way to solve the issue. Modern technological developments in the field of deep learning, which belong to machine learning, can help solve the task.

III. LITERATURE REVIEW

Over the past few years, ML has been established as an effective method for identifying food adulteration. Different algorithms like SVM, RF, K-Nearest Neighbour (KNN), and NN have been widely applied for both classification and prediction purposes. The application of ML helps with:

a) Feature Extraction from complicated datasets

b) Classification of pure oils and adulterated oil samples

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c) Adulteration quantification

There have been many ML and spectra-related studies proving high efficiency in detecting adulteration. ML-based Hyperspectral Imaging Systems were able to achieve the accuracy level of up to 98%, indicating efficient identification of the adulterated products [1]. Moreover, recent studies indicate the importance of applying ML with appropriate processing steps [2].

The adoption of spectroscopic techniques has been widespread owing to their non-destructive and fast analysis properties. FTIR and Infrared Spectroscopy: The technique of Fourier Transform Infrared (FTIR) spectroscopy coupled with multivariate analysis has shown remarkable results in determining oil adulteration. High levels of prediction have been recorded, with coefficient of determination values being reported $\geqslant 0.98$, which signifies excellent precision [3]. Hyperspectral Imaging (HSI) encompasses both spectral and spatial information, thus enabling the thorough examination of oil compositions. When combined with machine learning (ML) algorithms such as Support Vector Machines (SVM), Random Forests (RF), and Linear Discriminant Analysis (LDA), HSI becomes an accurate detection system [1]. Other Spectroscopic Techniques: Raman spectroscopy, NMR, fluorescence spectroscopy. These methods, often combined with chemometric and ML approaches, enhance the ability to detect adulterants and ensure oil quality [4].

The current developments mainly deal with sensor-based methods for the detection of contaminants. One of the commonly used methods is biosensors due to their high sensitivity, specificity, and fast response time. This method of analysis can easily detect any contaminants present in the oil at very low concentration levels. Another method of detection involves electronic nose which works through the analysis of volatiles from the oils and differentiates the pure from the adulterated oil. The system functions in the same manner as the human sensory systems and gives accurate results [1]. Gas sensors can be used to detect volatile compounds from adulterated oils. These sensors, when combined with ML algorithms, offer efficient classification and monitoring systems [5].

A new technique uses RF and dielectric sensors for identifying adulterated oil. Several investigations combining RF sensors with machine learning techniques such as XGBoost and LightGBM have proven to be successful for the classification of adulterated oils [6]. Moreover, microwave reflectometry and dielectric spectroscopy have proven their usefulness for oil quality analysis [7]

IV. PROPOSED SYSTEM ARCHITECTURE

The system that detects adulteration of edible oil proposed in this project is designed as an intelligent process pipeline where images are processed one by one, analyzing and providing results at each step to the end user. In the image acquisition stage, images are obtained using the camera or the smartphone of the individual. Oil samples can be imaged inside transparent vessels under constant light conditions. It is clear that input images are extremely important and significantly affect the output result of the system.

In the next step, some preprocessing operations are carried out. Preprocessing is required to prepare the images for analysis in the best possible way. Firstly, noise reduction methods are employed in order to reduce any kind of distortion or background interferences. Then, the image size is adjusted to a specific constant dimension so that all inputs have the same size to achieve the highest level of efficiency. Other changes, such as changing the brightness or contrast of images may also take place

The next stage after data preprocessing is feature extraction, where relevant features of the oil picture are recognized. Features could be color composition, texture, intensity level, and other visual qualities that differentiate pure oil from adulterated oil. It is an essential stage since the selected features will act as the input to the machine learning algorithm.

During the prediction process of the model, the machine learning or deep learning model, which has been trained using the data extracted from earlier samples, is used to analyze the features of the new sample. The model has learned from the earlier data (training data set) how to classify between pure and adulterated oil samples. With the help of this knowledge, it is predicted whether the oil sample is pure or adulterated, and in some instances, it even predicts the extent or type of adulteration. Predictions are made very swiftly, making this system fast and user-friendly.

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Lastly, an interactive web interface of the system provides ease of use for non-technical users. Using this web interface, users can upload images of the samples of oil and obtain immediate results. This web interface provides the simplicity needed in order to enable users to operate it easily. The interface gives the outputs in the form of "Pure," "Adulterated," and even with more details in some cases.

The proposed system consists of the following components:

- Image acquisition (oil sample images)
- Preprocessing (noise removal, resizing)
- Feature extraction
- Model prediction
- Web interface for user interaction

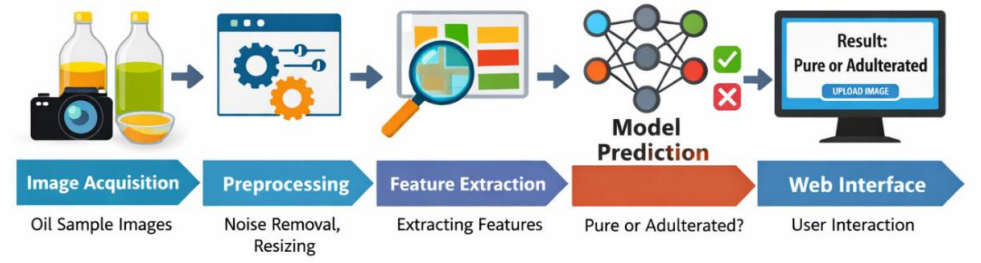

Fig 1: Stages of Execution

V. DATASET

The dataset comprises chemical properties such as viscosity, refractive index, fatty acid composition, and spectroscopic data from various edible oil samples. The dataset used is from click a photo from different oil. It includes spectral data obtained through atr-mir spectroscopy for pure oils (e.g., sesame, sunflower, mustard, olive) and samples adulterated with palm oil in varying concentrations. This dataset provides a robust foundation for deep learning analysis to detect and quantify adulteration levels.

Deep learning models: The following dl algorithms were implemented

1. Yolov5: for binary classification of pure and adulterated oils.
2. Support Vector Machines (svm): for non-linear classification.
3. Torch and Torchvision: to handle complex interactions between variables.
4. Neural networks: for deeper insights into high-dimensional data.

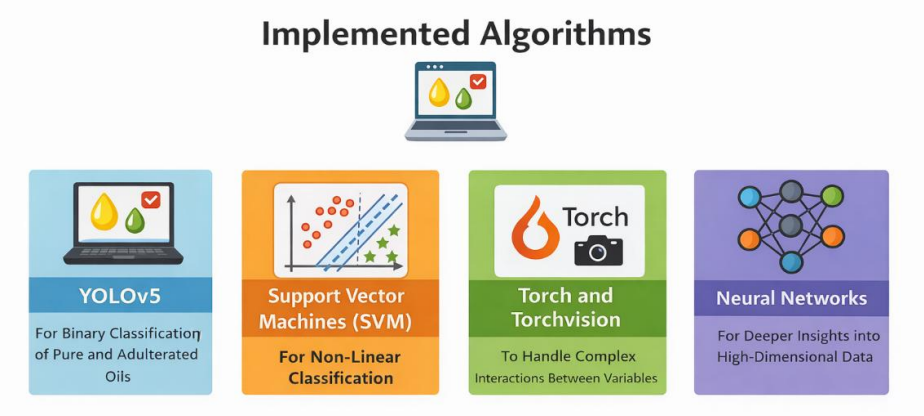

Fig 2: Algorithms Implemented

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VI. RESULTS AND DISCUSSION

The classification algorithm assigns each edible oil sample to one of three categories according to its value:

 Pure Oil (> 90): Those samples with values greater than 90 belong to the pure oil category and are deemed fit for consumption. It implies that the system is capable of detecting any form of contamination or adulteration in the sample.

 Moderately Contaminated/Not Fit for Use (50-90): Those samples with values ranging between 50-90 fall under the moderately contaminated/not fit for use category. This implies that there are adulterants present in the oil but not in such large quantities to make them harmful.

 Highly Contaminated/Unsafe (< 50): Those samples with values lower than 50 are considered unsafe and hence highly contaminated.

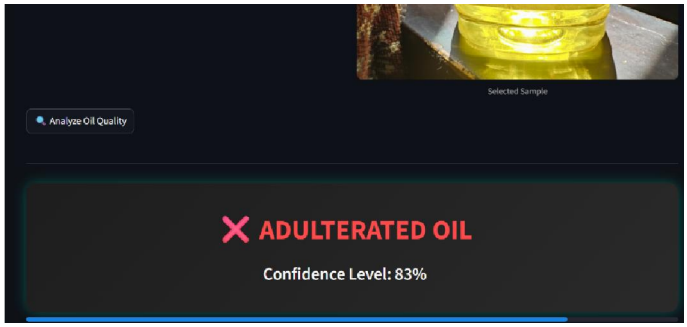

Fig 3(a): Sample 1 outcome

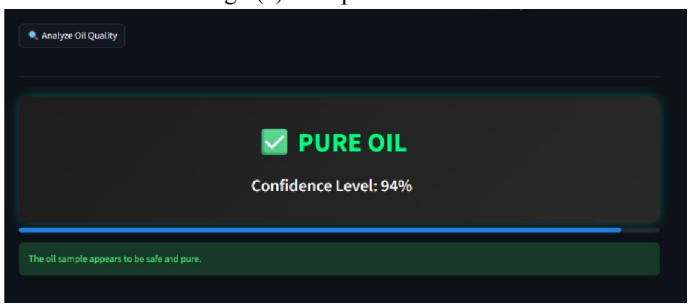

Fig 3(b): Sample 2 outcome

The classification demonstrates a threshold-based intelligent decision system, which is simple yet effective for real-time oil quality assessment.

- The upper threshold (⩾ 90) ensures high confidence in identifying pure oil, reducing false positives.
- The mid-range (50–90) acts as a warning zone, allowing early detection of adulteration before it becomes severe.
- The lower threshold (< 50) clearly flags dangerous samples, helping prevent consumption of harmful oils.

VII. FUTURE WORK

Looking ahead, there are several avenues for further research in this domain. One promising direction is the integration of machine learning models with Internet of Things (IoT) devices to create real-time adulteration detection systems. Such systems could involve the deployment of sensors that measure the chemical properties of oils as they pass through production lines. Data from these sensors could be fed into machine learning models, providing instant feedback on the quality of the oil. Future research should focus on expanding the dataset to include a broader range of oils and adulterants.

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VIII. CONCLUSION

This study highlights the potential of deep learning techniques in ensuring food safety and quality by detecting adulteration in edible oils. The proposed models demonstrated high accuracy and reliability, making them suitable for large-scale industrial applications. Future research could explore real-time implementation using IoT devices and extending the approach to other food products.

IX. AUTHORS AND AFFILIATIONS

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