Real-Time Quality Assurance of Fruits and Vegetables with Artificial Intelligence

Methodology

This proposed system will use image processing to classify and grade the quality of fruits and vegetables by extracting features such as color, shape, and HOG (Histogram of Gradient) to classify the given fruit or vegetable. Image pre-processing techniques like data-augmentation and normalization along with Principle- Component Analysis (PCA), and Deep learning (CNN) are used for getting good accuracy and for dimensional reduction. An artificial neural network (ANN) is used to detect the shape, size, and color of fruit samples. Estimating the freshness of the given fruit by finding edibility using sensors.
In this proposed method, we have split the process into two parts:

a) The first part is about the classification of fruit or vegetable and its quality grading using machine learning algorithms and image processing.
b) The second part is about developing an android application for carrying out the told process in the first part by converting the part one into a tensor-flow-lite model using Keras for deployment in android studio.

The accuracy and efficiency of the system are founded on two aspects which are feature extraction algorithms and the database used

Component Used

- Python and Jupiter Notebook
- **Dataset Images Format:** .jpg
- This application is developed using the' Kotlin language. Using this 'Kotlin' language, we set up the functioning of the application.
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Algorithm

The proposed system uses **Convolutional Neural Networks (CNN)**, a deep learning algorithm, which consists of a class of neural networks as a classifier for image recognition by a specialized way of processing on the grid of pixels. This process trains the system for classifying and grading.

Findings

Testing Model	Reliability	Accuracy	Compatibility	Safety
Acoustic impulse	Not reliable	Nice	Thin-skinned	light damage
Laser-Induced Fluorescence	Highly reliability	High	Any	heavy damage
Ultra-Sonic	Low reliability	Bad	Thin-skinned	No damage
Computer Vision	Highly reliable	Very High	Any	No damage

Table 1: Fruit and Vegetable Quality Monitoring using Hardware and Software Methods

Type	Accuracy	Execution Speed	Data-set Size
KNN	90.3%	Very Slow	Small
SVM	85%	Faster	Only for small
Linear Regression (LR)	92%	Slow	Moderate
Convolutional Neural Networks (CNN)	95%	Very Fast	Very Large

Table 2: Comparison of ML Algorithms

Convolutional Neural Networks (CNN) model was found to be more efficient than other machine learning techniques.

Analysis

Quality Analysis

For detecting the quality of the fruits or vegetables, five main modules or stages are used, described as images data-set collection as input, image pre-processing, feature extraction, feature selection, classification, and detection. The general block diagram of detection of quality is shown in figure below.

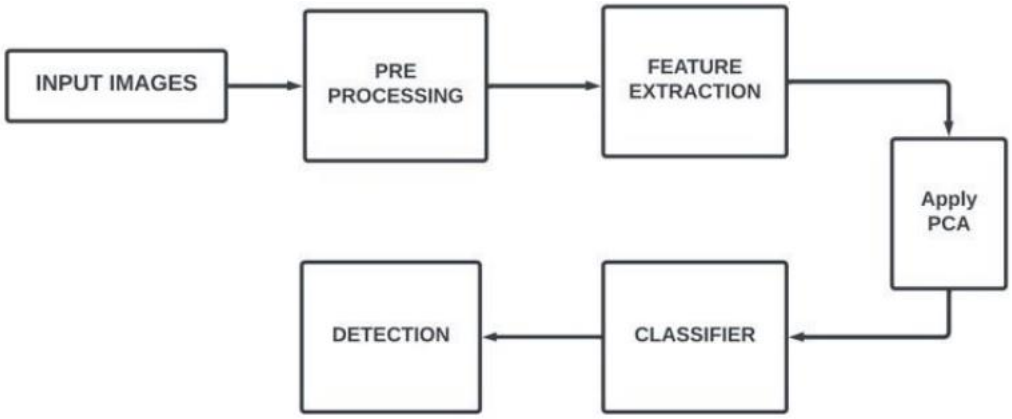

Figure 1: General Block Diagram of the Quality Detection System

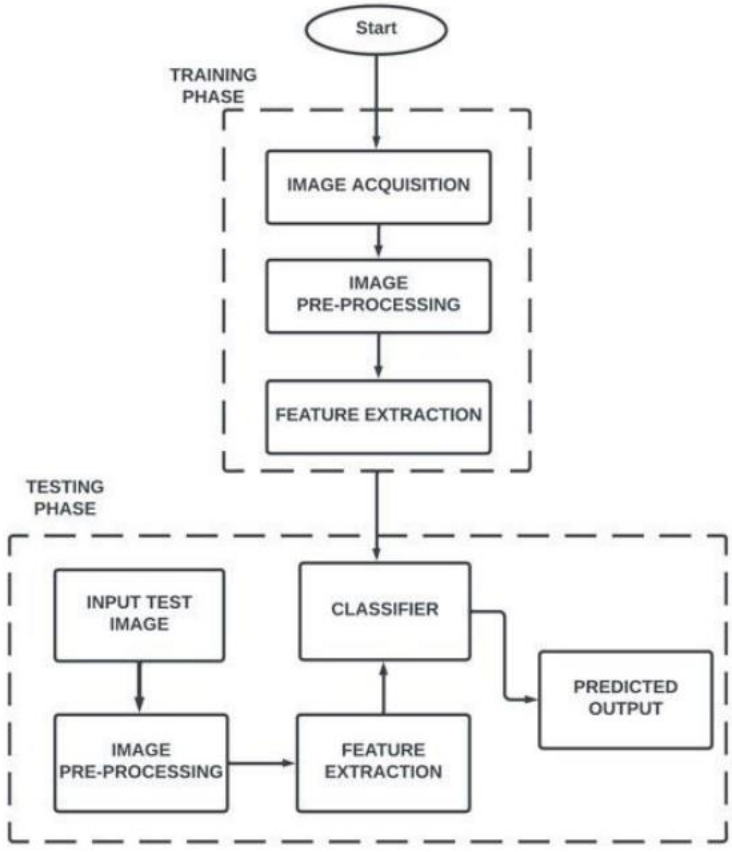

Figure 2: Workflow of the CNN Model

This quality analysis will consist of two phases: Model Training Phase and Model Testing Phase.

i. **Model Training Phrase:** For the training phase, the images of the dataset consist of fresh and stale classes of every fruit and vegetable.

ii. **Model Testing Phrase:** The CNN model runs through the data many times, these are called epochs. As the number of epochs increases, the more the model improves to a certain extent [20]. The below figure will show the training, validation accuracy, and training and validation loss of the model.

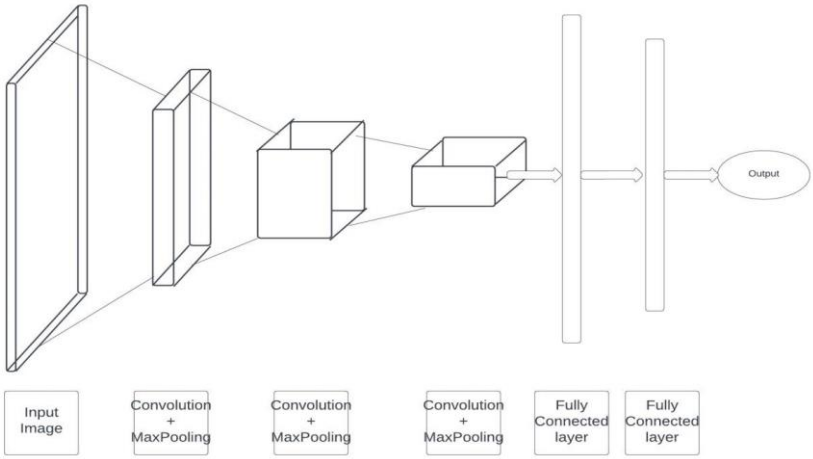

Figure 3: CNN Architecture

Tensor-Flow-Lite Model: The tensorflow-lite model is created using the tensor-flow-lite-maker, an extension of Keras which simplifies the testing of a new image. This tensor-flow-lite model maker converts the CNN model into a 'tflite' model which is an optimized version of the CNN model and can be deployed on mobile or embedded devices.

Android Application Development

This android application development will consist of three steps: Configuration of the android studio, Development of the Application, and Deploying the android application on mobile. This android application can be used in fast processing the given process steps.

Results

The result of this project is divided into two parts: one is the result obtained from the quality analysis process and the other is the result obtained from the Android application.

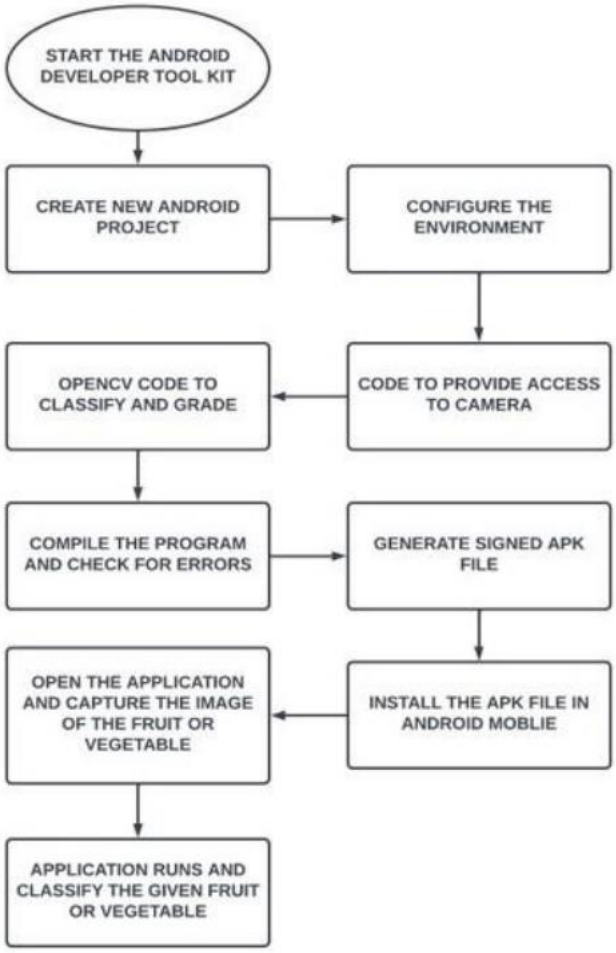

Figure 4: Flow Chart of Android Application

Future Work

The accuracy and efficiency of the system are founded on two aspects which are feature extraction algorithms and the database used. The proposed system can be installed in a hardware device and run using cloud computation which will be helpful in fast processing and in gaining higher accuracy. Even checking the products in large number. This system can be installed in a robot for checking the quality of

the fruits and vegetables in the markets. This application system can be used as an information system between customers and shops such as markets, where the products can be graded and uploaded to the database from where the customer can get the required product within the shortest time.