Section A-Research paper

Fruit Classify: A Mobile Application for Accurate Fruit Classification using CNN on Android

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ABSTRACT

This research paper presents a mobile application developed using Android Studio for fruit classification, aiding farmers in efficiently categorizing fruits based on their visual features. The Android application is built on Android Studio 8.0.1, a powerful integrated development tool designed for the Android operating system. The primary objective of the mobile application is to facilitate the classification of fruits as fresh, ripe, or rotten. To achieve accurate classification, a customized Convolutional Neural Network (CNN) model is integrated within the application. The CNN model is trained on a dataset containing various fruit images, enabling it to recognize The application allows farmers to capture images of fruits using their device's camera or select images from the gallery. The captured images are then processed through the integrated CNN model, providing real-time classification results to users.

This technology-driven solution empowers farmers to make informed decisions about the quality of their produce, thereby optimizing agricultural management and minimizing waste. The user-friendly interface ensures seamless usability, making it accessible and beneficial for farmers in diverse settings. The paper delves into the application's development process, including its architecture and CNN model integration. Particular attention is given to optimizing performance across various Android devices, ensuring reliable functionality in practical scenarios. This research represents a significant step towards incorporating cutting-edge technology in agriculture, revolutionizing fruit classification processes for farmers. The application's effectiveness and accuracy highlight its potential to enhance decision-making processes and overall agricultural productivity.

Keywords:

Mobile application, Fruit classification, Android Studio, Convolutional Neural Network, Agriculture, Decision-making, Machine Learning, Realtime classification, Technology-driven solutions

DOI: 10.48047/ecb/2022.11.12.108

Introduction

Smart phones have become an integral part of modern human life, serving various communication and utility needs. The ubiquitous presence of smart phones in contemporary society has revolutionized the way we communicate and interact with technology. The rapid growth of mobile applications has facilitated the fulfillment of various user needs, empowering individuals with accessible solutions at their fingertips. In parallel, fruits play a vital role in maintaining a healthy lifestyle, providing essential nutrients and vitamins to consumers worldwide. However, ensuring the quality of fruits, whether they are fresh, ripe, or spoiled, remains a significant challenge in the fruit supply chain. Earlier researchers have done the research on fruit disease detection and classification. For instance, Sulakshana A Gaekwad et al., **[1]** have found a solution for classification and detection of fruit diseases using Image processing techniques. K-Means clustering technique was used for image segmentation and features have been extracted from the segmented image. Using these features images have been classified using support vector machine. Similar kind of research has been done by Faizakhan et al., **[2]** where in they developed an application for the detection and classification of the diseases in maize crop using Deep Learning techniques. This application returns the segmented images of affected leaves and thereby identifies the disease spots on the leaves. They have used three different kinds of datasets for the purpose. Eventually, they proposed that, the developed application has shown superior performance with other existing models. Another kind of research with mobile application has been developed by Shrikanth et al.,**[3]** have used the CNN model for feature extraction and LSTM network was used to detect the class based on the features. The proposed system has been developed by an Android software to detect the quality of the disease of Pomgranate. Ahmad et al **[4]** have developed a system using CNN model for classifying 38 disease categories. They have developed a user interface of mobile application for capturing the photo of the infected plant leaves and finally they observed that the proposed CNN model has very good classification accuracy indicating the importance of the deep learning models in detecting the diseases of the plant leaves. Later Diksha Nigam et al., **[5]** have developed a portable and a scalable system for identifying and detecting plant diseases at an early stage using s CNN model. Sapna et al **[6]** have developed a mobile application as a user interface for capturing images and detected the plant disease by using Image Processing techniques of image segmentation and feature extraction for plant disease detection. Harold Costales et al., **[7]** have designed and developed a rice leaf disease detection system using a mobile application. They have developed a CNN model with transfer learning for disease detection and found that deep learning techniques have been useful for detecting the rice plant disease. This research endeavors to bridge this gap by developing an innovative mobile application that incorporates machine learning to accurately classify fruits based on their visual characteristics. The mobile application will empower users, especially farmers, vendors, and distributors, with an efficient and semi-automatic means of fruit classification. By harnessing the

power of technology, this solution aims to optimize fruit inspection processes, save valuable time, and enhance resource utilization throughout the distribution chain.

The significance of this research lies in its potential to revolutionize fruit classification, transcending traditional manual methods to embrace data-driven decision-making. The proposed mobile application will provide real-time insights into the quality of fruits, offering consumers high-quality produce and minimizing waste. Moreover, the automation of fruit classification will empower farmers to make informed decisions, ensuring optimal produce distribution and reducing economic losses.

To achieve accurate fruit classification, the research will delve into investigating various features and techniques, including color, texture, and shape analysis, to design a robust machine learning model. This model will be trained on a comprehensive dataset of fruit images, encompassing a diverse range of fresh and rotten fruits. The model's performance will be rigorously evaluated and compared with state-of-the-art architectures to validate its effectiveness.

The ultimate goal of this research is to develop a mobile application that serves as a comprehensive solution for fruit classification. This application will streamline the fruit supply chain, enabling stakeholders to make data-driven decisions, from farmers to end consumers. By providing an efficient and accurate fruit classification tool, we aspire to contribute to sustainable agricultural practices, supporting a healthier lifestyle and fostering economic growth. Through this research, we endeavor to pave the way for a technology-driven transformation in fruit classification, benefitting the entire fruit industry and society at large.

.**Methodology**

The methodology for fruit classification involves two main components: The development of the Android application and the integration of a Convolutional Neural Network model (CNN).

1. Android Application Development: The Android application is developed using Android Studio, an integrated development environment (IDE) designed specifically for Android app development. This user-friendly mobile application will allow users to capture images of fruits using their device's camera or select images from the gallery. The captured images will serve as inputs for the CNN model to perform fruit classification.

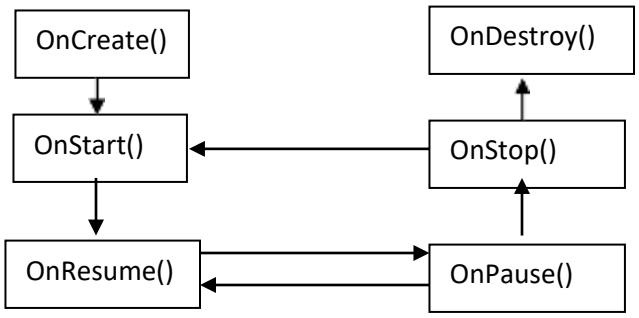
2. Convolutional Neural Network (CNN) Model: The CNN model forms the core of the fruit classification methodology. It is trained on a comprehensive dataset of fruit images, including various categories of fresh and rotten fruits. The CNN's architecture comprises multiple layers, including convolutional layers, pooling layers, and fully connected layers, designed to automatically learn and extract intricate features from the input images. Elaborative work on this component has already been done in **[8]**.

Component-1

The application discussed in this paper is a mobile application for fruit disease detection and which acts as an interface to capture the image of the fruit. This application was built on Android Studio 8.0.1. Initially, we have downloaded the Andriod studio with its Android SDK and its virtual device. We need to install the studio and its environment, setting will be done for Application Programming Interface level. A new project need to be created and application name need to be entered. This data will be used to create a package name and this includes all the data that is required to develop the android and is said to be android package file and finally needs to be uploaded into the googles play store. Later, we need to set a path for saving the file of the application.

Android activity life cycle can be monitored using seven methods. They are OnCreate(), OnStart(), OnResume(), OnPause(), OnStop(), OnRestart(), OnDestroy(). OnCreate is used when activity is first created, OnStart() will be used when the activity is becoming visible to the user, OnResume() is used when the activity starts interacting with the user, OnPause() is used when the activity is not visible to the user, OnStop() will be used when the activity is no longer visible to the user, OnRestart() will be used when the activity is stopped prior to start, OnDestroy() will be used before the activity is destroyed.

Activity Life Cycle can be depicted in the following diagram.



The following process needs to be followed to build a mobile application using Android software.

Step 1: Download Android Studio and setup environment

Step 2: First create a project

Step 3: Connect to a device

Step 4: Write the code for the application

Step 5: Debug and test the code

Step 6: Deployment

The User side of the mobile application will act as an interface to capture the image of the fruit. After capturing the image, The features are extracted from the image and will be sent as input to the CNN model which is the core part of the application. The CNN model will determine finally whether the fruit will be classified as rotten or fresh. Feature extraction is done internally by the CNN model which is deployed in the mobile application.

Component-2

During the training phase, The CNN model learns to recognize patterns and distinctive visual features specific to fresh and rotten fruits. This process involves optimizing the model's weights and biases to minimize the classification error. After the training is completed, the model is capable of predicting the class label (fresh or rotten) when provided with unseen fruit image.

Algorithm

To classify fresh and rotten fruits in this project, a customized Convolutional Neural Network (CNN) model is trained on a fruit image dataset. This dataset is taken from Kaggle and is divided into a training and validation set. The custom model includes multiple convolutional and max pooling layers and dropout layers for regularization. To optimize the model, the Adam optimizer and categorical cross-entropy loss function are used for the purpose. The model is then compared against two well-known CNN architectures, LeNet-5 and AlexNet by evaluating accuracy and loss on the validation set.

1. The process of building the model starts by loading the dataset and setting parameters like batch size, image size, and validation split.

2. Then, the data is preprocessed by normalizing the pixel values and one-hot encoding the labels. The custom CNN architecture is built using the Keras Sequential API, with multiple convolutional layers, max pooling layers, batch normalization layers, dropout layers, and dense layers.

3. Finally, the model is compiled with the Adam optimizer and categorical cross-entropy loss function and trained on the training set for 20 epochs, with the results being evaluated on the validation set.

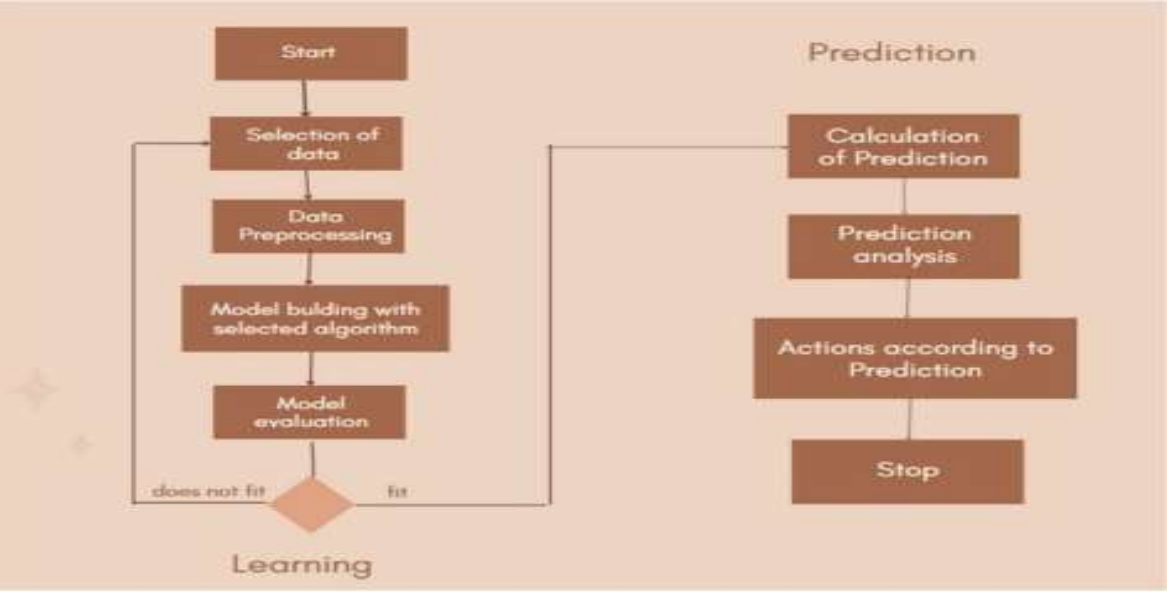


Fig1: The architecture of the CNN model

The opening application page (Front end) has been developed by the software FIGMA and the header indicates the application name and the body shows the eye/camera for the projecting the image on the screen and footer shows the name of the fruit which it has been seen or captured by the eye and gives the category of fruit like rotten or fresh in percentage. In the back end of the application, we have developed a CNN model. The details of the model have been given in [1]. The backend machine learning algorithm is integrated by a file Ts Float and Ts Quantize file.

Limitations:

1. Dataset Size: Since the mobile application is embedding the CNN model, The performance of the CNN model heavily depends on the size and diversity of the dataset used for training. Limited availability of high-quality fruit images may affect the model's accuracy and generalization capabilities and hence for the mobile application.

2. Device Compatibility: The mobile application's performance may vary across different Android devices due to variations in hardware specifications and camera quality, potentially impacting classification accuracy.

3. Real-World Variability: Fruits in real-world scenarios may exhibit variations in shape, size, and lighting conditions, which could challenge the model's ability to generalize effectively to all possible scenarios.

4. Overfitting: The CNN model might be prone to overfitting, especially when the dataset is small or imbalanced, leading to reduced performance on unseen fruit samples. Thereby, it reduces the performance ability of the mobile application as well

5. Limited Fruit Types: The model's performance might be constrained to the specific fruits present in the training dataset, limiting its applicability to a broader range of fruit types.

Discussion

This research aims to address this challenge by developing an innovative mobile application that incorporates a Convolutional Neural Network (CNN) as a machine learning methodology to accurately classify fruits based on their visual characteristics. The mobile application will empower users, particularly farmers, vendors, and distributors, with an efficient and semi-automatic means of fruit classification. By leveraging the power of technology, this solution seeks to optimize fruit inspection processes, save valuable time, and enhance resource utilization throughout the distribution chain. The importance of this research lies in its potential to revolutionize fruit classification, transcending traditional manual methods to embrace data-driven decision-making. The proposed Android-based mobile application will provide real-time insights into the quality of fruits, enabling consumers to access high-quality produce and minimizing wastage. Moreover, the automation of fruit classification will empower farmers to make informed decisions, ensuring optimal produce distribution and reducing economic losses.

Conclusion:

Through the development of an Android application integrated with a Convolutional Neural Network model, this research aims to transform fruit classification processes. This research has successfully developed a mobile application for fruit classification using Android Studio and a Convolutional Neural Network (CNN) model. The application exhibits promising potential for accurately distinguishing between fresh and rotten fruits, providing valuable insights for stakeholders in the fruit supply chain.

Despite limitations stemming from dataset size and device compatibility, the application represents a significant advancement in automating and streamlining fruit quality assessment processes. The application's real-time and accurate classification capabilities empower stakeholders in the fruit supply chain to make informed decisions, ultimately benefiting consumers with high-quality produce and optimizing resource utilization. Future research could focus on expanding the dataset's diversity and size, as well as exploring transfer learning techniques to enhance the CNN model's robustness.

By empowering farmers, vendors, and distributors with a data-driven decision-making tool, the application can optimize resource allocation and reduce economic losses in the fruit industry. As technology continues to evolve, this research sets the stage for more sophisticated applications in agriculture, enabling a smarter and more efficient fruit supply chain and contributing to a healthier and more sustainable future. Through this research, we aim to pave the way for a data-driven approach to fruit classification, contributing to the advancement of the fruit industry and society at large.

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