Classification of Fruits and Vegetables using ResNet Model

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Abstract — **Agriculture is one of the important parts of Indian economy. Agricultural field has more contribution towards growth and stability of the nation. Therefore, a current technologies and innovations can help in order to experiment new techniques and methods in the agricultural field. At Present Artificial Intelligence (AI) is one of the main, effective, and widely used technology. Especially, Deep Learning (DL) has numerous functions due to its capability to learn robust interpretations from images. Convolutional Neural Networks (CNN) is the major Deep Learning architecture for image classification. This paper is mainly focus on the deep learning techniques to classify Fruits and Vegetables, the model creation and implementation to identify Fruits and Vegetables on the fruit360 dataset. The models created are Support Vector Machine (SVM), K Nearest Neighbor (KNN), Decision Tree (DT), ResNet Pretrained Model, Convolutional Neural Network (CNN), Multilayer Perceptron (MLP). Among the different models ResNet pretrained Model performed the best with an accuracy of 95.83%.**

Keywords — **Convolutional Neural Networks; Deep Learning; Classification; Multilayer Perceptron Model; Support Vector Machine; K Nearest Neighbor; Decision Tree; ResNet Model; Deep Neural Networks.**

1. INTRODUCTION

India is a country of villages. Agriculture is one of the essential components of the nation. Agriculture provides economic stability and economic growth to the country. In India, the livelihood of most people depends on agriculture. Fruits and vegetables are one of the cultivations in India. According to statistics, fruits and vegetables reported for over 3.7 trillion Indian rupees in the Indian economy in the year 2018. This area contributed about 28 percent to the GVA of crops that same year, an growth from 24 percent in the year 2012. Fruits and vegetables were the main contributors among crops.

Classification of fruits and vegetables is one of the key challenges in the agricultural field. It consumes a lot of money, time and needs more manpower. Time is one of the factors which affects classification. The fruits or vegetables may get spoil due to the time consumption. Therefore, an automated system to classify fruits and vegetables is required. With the help of Artificial Intelligence (AI) and Machine Learning (ML), this research can develop an automatic fruit classification system with an information dataset of each fruit.

2. METHODOLOGY

Proposed different architecture or algorithms are used to solve the fruit/veg classification problem. First, a dataset is presented, then different machine learning and deep learning algorithms are used. Methodologies followed to classify fruits and vegetables:

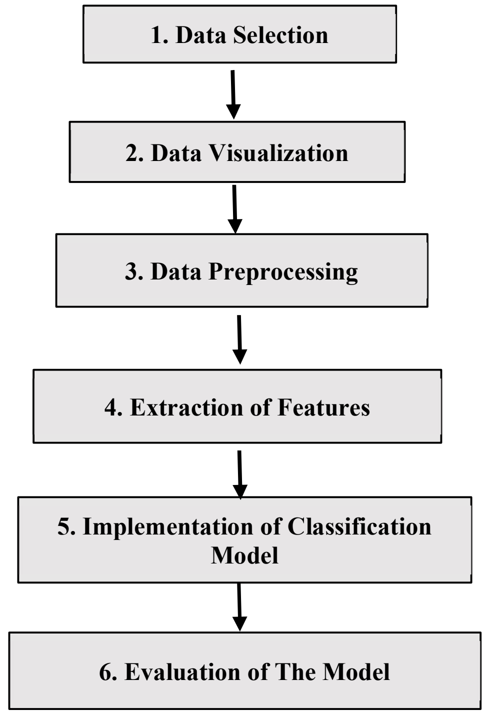

Fig 1. Workflow Diagram

2.1 Data Source

Data is an important part of Deep Learning. Therefore, it is essential to choose the appropriate input data agreeing to the objectives. For fruit/veg classification, I have used dataset called Fruits360. The dataset includes 90483 different fruits pictures of 131 categories. Filename format: imageindex100.jpg (e.g 32100.jpg) or rimageindex100.jpg. Various types of the same fruit (Banana for example) are collected as fit in to separate classes.

2.2 Data Visualization

Visualization is done to identify the patterns in the data. Some performed EDA are:

- Sample images on the dataset
- Data information
- Fruit/Veg and it's counts.
- Number of samples in each class of training data using Count plot.
- Top 10 classes in training and testing data (highest number of samples) using Bar plot.
- Bottom 10 classes in training and testing data (lowest number of samples) using Bar plot.

Fig 2. Sample images from data

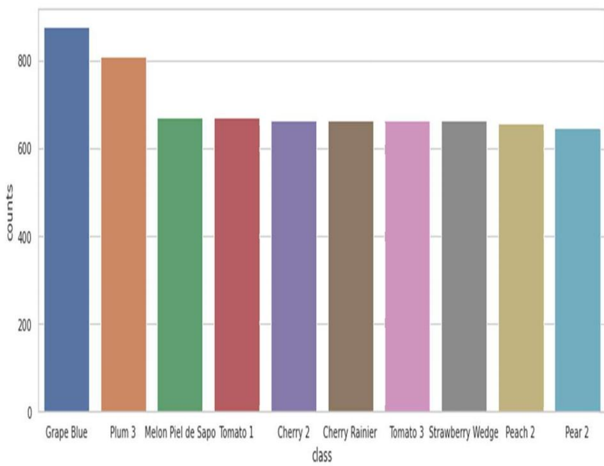

Fig 3. Top 10 classes in training data

2.3 Data Pre-processing

Data preprocessing is achieved in two steps, one is for Machine Learning Algorithms (ML), and another is for Deep Learning Algorithms (DL).

Data preprocessing for Machine Learning Models:

Data preprocessing for Machine Learning Models are achieved by converting images into numpy array. This converted images has been flattened and then scaled.

Data preprocessing for Deep Learning Models:

- Create a lists namely, trainLables, trainImages, testLables, testImages load the data into particular list using cv2
- Convert the loader array as numpy
- Scale these values to a range of 0 to 1 before feeding them to model.
- Shuffle the data
- Converted the labels into categorical output.

Data Augmentation:

Pre-processing the input image data to transform it into significant floating-point tensors for feeding into Convolutional Neural Networks (CNN) using and inbuilt function called Keras ImageDataGenerator

Algorithm:

- Read the picture files (stored in data folder).
- Decrypt the JPEG content to RGB grids of pixels with channels.
- Transform these into floating-point tensors for input to NeuralNets.
- Rescale the pixel standards (between 0 and 255) to the [0, 1] period (as training Neural Networks with this range gets efficient).

2.4 Feature Extraction and Selection

Feature extraction is performed based on different physical characteristics of fruits/vegetables. Characteristics of each fruit/vegetable are different from each other. Features can be identified based on their external appearances like color, shape, and size, etc. There are some similarities between some fruit/vegetable, between apple and tomato, various kinds of coconut or pineapple have only slight differences in attributes.

2.5 Model Selection

Many factors, such as longitudinal resolution of the remotely perceived data, various resources of data, a classification system, and accessibility of classification software system must be taken into account when selecting a classification method for use. For the classification and grading of fruits and vegetables different types of classifiers are used. Mainly used classifiers are, K-nearest Neighbor (KNN), Support Vector Machine (SVM), Decision Tree (DT), Multilayer Perceptron (MLP), Convolutional Neural Networks (CNN).

Support Vector Machine (SVM):

A Support Vector Machine could be a Supervised Machine Learning model that utilizes classification algorithms for 2 group classification challenges. Later providing an SVM model sets of labelled training data for every class they are capable to classify new text. It supported these transformations since it uses a way called the kernel trick to remodel the information. Amongst the possible outputs it discovers an ideal boundary.

K-nearest Neighbor (KNN):

K-Nearest Neighbors belongs to the supervised learning domain and might be widely applied for classification and regression challenges. When KNN is employed for regression problems the prediction relies on the Mean or the Median of the K most similar occurrences. The abbreviated form of K-Nearest Neighbors Algorithm is shortened K-NN, is a method to data classification that approximates how likely an information point is to be a member of 1 group or the opposite gambling on what group the information goals are closest to that.

Principal Component Analysis (PCA):

Principal Component Analysis is used for Dimensionality Reduction in Machine Learning. It is also an Unsupervised Learning Algorithm. It is a method of transforming the correlated characteristics into a set of linearly uncorrelated characteristics with the benefit of orthogonal transformation. It is a method to obtain robust designs from the given dataset by lowering the differences.

Decision Tree (DT):

A Decision Tree is a Supervised Machine Learning algorithm, which is applied for both classification and regression algorithms. The Decision Tree is similar to a tree with nodes. The branches depend on several factors. It divides data into branches like these till it achieves a threshold value. A decision tree involves of the root nodes, child nodes, and leaf nodes.

Multilayer Perceptron (MLP):

The perceptron is extremely helpful for classifying data sets that are linearly detachable. They confront major constraints with data sets that do not adapt to this model as detected with the XOR problem. The XOR problem indicates that for any classification of four points that there occurs a set that are not linearly distinguishable. The Multilayer Perceptron (MLPs) stops this limitation and classifies datasets which are not linearly distinguishable. They do this by applying a additional strong and complicated design to learn regression and classification models for challenging datasets.

Convolutional Neural Networks (CNN):

A Convolutional Neural Network (ConvNet/CNN) is a Deep Learning algorithm which can take in an input image, allocate significance to several characteristics in the image and be able to distinguish one from the other. The pre-processing needed in a ConvNet is much smaller as equated to other classification algorithms. While in basic techniques cleans are hand-engineered, with enough training, ConvNets can learn these attributes.

3. RESULTS AND DISCUSSIONS

Data visualization and Preprocessing:

From data visualization we can observe that there are 131 different kinds of fruits and vegetables in the dataset. Grape Blue is more in number and Ginger Root is less. Dataset id preprocessed using different scaling methods and data augmentation done using ImageDataGenerator function from Keras library.

SVM, KNN, and DT Classifiers:

In the beginning performed binary classification for the Dataset using SVM, KNN, and DT model. At the end of binary classification, the entire dataset will be classified. This taken little long time to execute the results. The Classes are: ['Orange', 'Banana', 'Strawberry', 'Apple Golden 1', 'Kiwi', 'Lemon', 'Cocos', 'Pineapple', 'Peach', 'Cherry 1', 'Cherry2', 'Mandarine'] From the classes we can observe that all the fruits are in different shape and size, hence it led to the better accuracy of the model. Model Evaluation for Multiclass Classification done based on Accuracy. The results obtained are, Accuracy with SVM: 99.36%, Accuracy with K-NN: 95.89%, Accuracy with Decision Tree: 87.13%. In the multi-class classification task SVM performed better (Table 1).

SVM, KNN, AND DT with PCA:

PCA with SVM and KNN works well for two classes having an entirely different shape, size, and color. To find the appropriate algorithm some evaluation methods are used, those are: Accuracy, Confusion Matrix, ROC Curve. The area under the ROC curve, performed plotting TPR and FPR is used as evaluation metrics for the different classifiers. SVM and KNN perform well with this classification with an AUC of 0.97, instead the DT is lowest with an AUC of 0.87.

MLP Model:

An MLP uses easy data vectors, with the x-values of every input image offered. Because the image is a 32x32 matrix, need to convert it to a flattened vector. Once the matrix is flattened, we can feed them into neural networks. Then compile the models using appropriate optimizers. Later fit the model to get the results. Here performed MLP for multiclass classification. MLP is better approach to image classification than Machine Learning models like SVM, KNN, etc. Once MLP model is created, fitted the model into train data and validated against test dataset. The loss and accuracy is as follows, loss: 0.1261; accuracy: 95.36% (Table 2).

CNN-RESNET Model:

Classification of fruit/veg using ResNet and Regularization techniques in PyTorch was done with the following steps:

- Libraries were imported. PyTorch, along with some functions like DataLoader, Dataset, ToTensor, etc. were loaded. Also, matplotlib for the data visualization was imported.
- Training and Test Dataset were generated
- Batch Sample: To show a batch of sample, a function "make_grid" was defined in order to show the sample batch in the dataset. This will help to verify if the data is randomized.
- Making Training Model: Before defining a model, some functions were defined that to calculate and show the training and validation loss, and the validation accuracy
- Finally, an accuracy of 95.83% was obtained for KNN classifiers (Table 2).

Table 1: Results of Machine Learning Models

Classifier model	Accuracy (%)
1. Support Vector Machine (SVM)	97.36
2. K- Nearest Neighbor (KNN)	95.89
3. Decision Tree (DT)	75.17

Table 2: Results of Deep Learning Models

Model	Accuracy (%)
1. Multilayer Perceptron (MLP)	95.36

2.	Convolutional Neural Network (CNN)	89.98
3.	ResNet Pretrained Model	95.83

4. CONCLUSION

Outer characteristics of fruits like colour, size, shape, and different flaws are very essential qualities of fruits for classification and grading. The following conclusions can be made:

- The data needs to be pre-processed prior to it can be used with a Machine Learning algorithm for the classification.
- The work reviews the difference between traditional and modern fruit/vegetable grading and sorting system. It also talks about the importance of grading and classification in real time scenario. Also clarifies the significance of Data Science in the same.
- Mainly this project evaluates the basic method flow of fruit and vegetable classification. Feature extraction methods for color, size, shape and texture are explained. Data augmentation and different procedures used for augmentation are explained. Finally, some machine learning approaches like K-NN, SVM, ANN and CNN are briefly discussed.
- From the experiment, all the algorithms identified are evaluated with the Performance Metrics and ROC curve, and the outcomes obtained are noted. The results of all the six machine learning models are compared and the better one is chosen from them which classifies the fruits/vegetable. Out of all classifiers tested ResNet Pretrained Model performed the best with the test accuracy of 95.83%.

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