AUTOMATIC APPLE FRUIT CLASSIFICATION USING SOFT COMPUTING MODELS

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***Abstract*—** This research paper presents the Automatic Apple Fruit Classification using Soft Computing Models. Fruit classification remains a challenge because of the similarities involved by a large quantity of types of fruits. With the point of perceiving natural products precisely and effectively, this paper offered a technique for Apple fruit-classification. Classification of the fruits by their biometric features is commonly performed task of trained botanist and taxonomist. To perform this task, they need to perform various set of operations. Because of this the task of classification of Apple fruit manually is time consuming. There are many biometric features of apple fruits for classification. Here various soft computing models like CNN, SVM etc are used to classify the various Apple fruit verities.

***Keywords*—** Apple fruit recognition, Convolutional Neural network (CNN), SVM, image acquisition, image segmentation, Feature extraction, Apple classification.

I. INTRODUCTION

FRUIT industry contributes a noteworthy part in country's development, however there has been a less production of very good quality fruits [1], because of improper cultivation, absence of upkeep, extremely high post-reap misfortunes in taking care of and preparing, manual investigation, absence of information of protection and snappy quality assessment systems. Likewise, rising work costs, lack of gifted laborers, and the need to improve creation procedures have all put pressure on makers and processors for the interest of a quick, monetary, steady and non-destructive assessment strategy [2]. In such a situation, automation can decrease the expenses by advancing creation proficiency. Automatic fruit grading and arranging requires the execution of computer vision systems.

The use of Computer Vision Systems in agriculture has expanded significantly as of late, since it gives considerable data about the nature and properties of the produce, decreases costs, ensures the support of value benchmarks and gives helpful data progressively. Computer Vision is a novel innovation for gaining and analyzing a picture of a genuine scene by PCs to control machines or to process it. It incorporates catching, preparing and investigating pictures to encourage the goal and non-destructive assessment of visual quality attributes in agricultural and nourishment items. The strategies utilized in picture examination incorporate picture securing, picture pre-preparing and picture translation, prompting measurement and order of image and objects of interest inside pictures [3]. The general appearance of fruit item is a mix of its chromatic attributes (color) and its geometric properties, with the nearness of defects that can reduce the outer quality [4].

The essential model for automatic apple classification primarily comprises of four stages: Firstly, a database of the apple to be arranged is made at image acquisition step. From there on different image processing systems are applied to improve picture quality. At that point highlights are extracted and diminished (whenever required) to encourage as contribution to the model. At long last, classification is performed utilizing a classifier.

Soft computing models like CNN, SVM etc are the chief soft computing models for developing computer aided Automatic Apple Fruit Classification system. A Convolutional Neural Network (CNN) is an amazing AI strategy from the field of deep learning. ResNet-50 pretrained CNN has been utilized in this proposal work. CNNs are prepared utilizing huge accumulations of different pictures. From these huge accumulations, CNNs can learn rich feature portrayals or representations for a wide scope of pictures. These component portrayals regularly outflank hand-crafted highlights, for example, HOG, LBP, or SURF. A simple method to use the

intensity of CNNs, without putting time and exertion into preparing or training, is to utilize a pretrained CNN as a feature or component extractor.

II. REVIEW LITERATURE

Unay et al. proposed a strategy for Apple Defect Detection and Quality Classification with MLP-Neural Networks. Here the initial examination of a quality classification framework for, "Jonagold and Golden Delicious" apples were appeared. Afterward, Color, surface and wavelet highlights are removed from the apple pictures. Essential components investigation was connected on the extricated highlights and some primer exhibition tests were finished with single and multilayer perceptron. The best outcomes were 89.9 and 83.7 percent for by and large and surrendered pixels of 6 abandoned pictures [5].

Rao et al. created six distinct strategies to decide the size of this classification of apples by applying the referred to geometrical models, for example, circle strategy, parabola technique, oval technique, main pivot technique, radius and area zone signature technique and coefficient of variety technique [6].

Kavdir et al. used Fuzzy logic (FL) as a basic leadership support to review apple grades. Quality highlights, for example, the shading, size and deformities of apples were estimated through various hardware. Evaluating results acquired from FL framework indicated 89% general concurrence with the outcomes from the human master [7].

Making a strong picture order framework relies upon having enough information with which one can satisfactorily train and validate the model. On the off chance that there isn't sufficient accessible information, this presumption may not hold and would result in a classifier that displays terrible showing, hence bringing down its adequacy. Woodford et al. offered an answer for the issue of preparing and testing a neuro-fluffy framework with the end goal of picture acknowledgment when there are a predetermined number of pictures. Highlights of intrigue were divided from each picture and after that used to prepare a neural-fluffy framework. This expanded the quantity of information models used to prepare the framework. The framework was then tried on the whole informational index of full pictures. This framework was connected to recognize bug harm on pictures of apples [8].

Unay et al. presented a PC vision-based system to consequently sort apple natural products. Artificial neural system was utilized to fragment the absconded districts on organic product by pixel-wise handling. Fluffy closest neighbor, ada boost, support vector machines, closest neighbor, Linear Discriminant classifiers were tried for organic product reviewing, where the last two are found to perform best with 90 % acknowledgment [9].

Bennedsen et al. utilized artificial neural systems and main parts to recognize surface deformities on apples in close infrared pictures. Neural systems were prepared and tried on sets of important apparatuses, got from sections of pixels from pictures of apples procured at two wavelengths (740 nm and 950 nm). In an iterative procedure, various methods for pre-processing pictures before preparing the systems were endeavoured. Best outcomes were gotten by evacuating the foundation and applying a Wiener channel to the pictures with a general deformity discovery rate of 79% was acquired [10].

III. METHODS AND MATERIALS

The proposed apple fruit classification model will work in two phases

In the first phase the images will be acquired and preprocessed, followed by segmentation, feature extraction and feature selection. While in the second phase the classification will be performed for grading and maturity.

Proposed model for automatic apple fruit classification is:

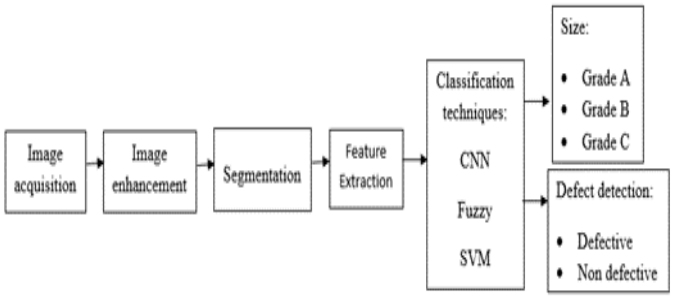

Fig.1. Proposed model for automatic apple fruit classification.

A. DATA COLLECTION

Apple fruit dataset has been collected from the Kaggle, which is a place to do data science projects. Kaggle is an organisation which has been working on collection of large number of datasets that is presently being used for large number of science projects and research works. Fruit 360 dataset is a dataset with 33 fruits categories and 20701 images. Out of 33 fruit categories I have used only apple fruit categories for my thesis work. This database is very attractive since at least 492 images of the same category are present, which is essential for a good recognition at a large scale.

B. IMAGE ACQUISITION

image acquisition can be defined in image processing as the activity of recovering a picture from any source, for the most part a hardware-based source, so it tends to be gone through whatever procedures need to happen a while later. In image

processing an image acquisition remains dependably the initial phase in the work process grouping because, without a picture, no processing is conceivable.

C. IMAGE ENHANCEMENT

It is a process of adjusting digital pictures so that the outputs are more suitable for display and further image analysis. For instance, RGB to Gray, Histogram, Histogram Equalization, Contrast Stretching etc.

D. IMAGE SEGMENTATION

Usually image segmentation is done only at single level that is to segment the area of interest from the background. However, fruit segmentation can be applied at 3 levels. Background subtraction and feature extraction. Segmentation at background level is performed to separate out fruit region from the background.

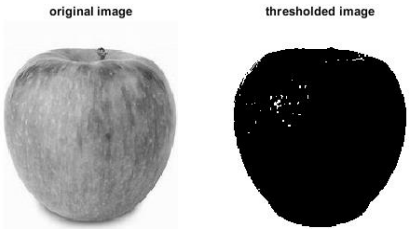

Fig.1. Grey level thresholding.

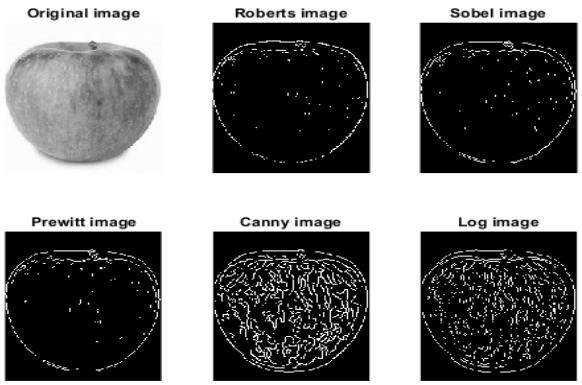

Fig.2. Edge detection

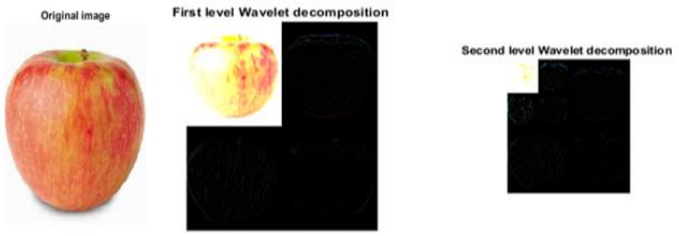

Fig.3. Discrete Wavelet Transformation.

E. FEATURE EXTRACTION

Feature extraction is the procedure by which certain highlights of interest inside a picture are distinguished and spoke to for further processing [11]. The subsequent representation can be therefore utilized as a contribution to various pattern recognition and classification systems which will at that point mark, arrange or recognize the semantic substance of the picture or its articles. The feature extraction of a picture should be possible by determining various things from a picture like [12]:

AREA: Area represents number of pixels in the apple region. Binary type of our apple picture has black background and white apple. In this picture, number of white pixels shows the area of the apple.

MAJOR AXIS: Major axis is meant as a line, which lies among apex and base of the apple.

MINOR AXIS: Minor axis of the circle that has indistinguishable standardized second central moments from the apple area.

PERIMETER: It is defined as the amount of space around the boundary of apple area.

CONVEX HULL: Convex hull shows the littlest convex polygon that encapsulates the apple area.

MINOR AXIS LENGTH RATIO OF MAJOR AXIS LENGTH: This component is meant as ratio of minor axis length to major axis length. It is opposite of the perspective ratio that is utilized in the writing.

ECCENTRICITY: A scalar regard which shows the eccentricity or unconventionality of the circle that has indistinct second-minutes from the area. The eccentricity or unconventionality is the extent of the division between the centralizations of the circle and its major axis length. The regard extends some place in the scope of 0 and 1.

ENTIRETY: Entirety of an apple is determined utilizing the accompanying recipe, (Convex area - Area) / Area.

EXTENT: Extent of an image is used to show the area of pixels in the region to pixels in the littlest rectangle shape containing the area.

EQUIVALENT DIAMETER: It is used to decide the width of an ellipse with a comparable domain as the area. An area's similar width, DE can be solved by utilizing the formula,

$$DE = \sqrt{(b \, X \, \text{Area}/\pi)}$$

Shape based features	Features		
			
1. Apple Name	Apple_Red_I	Golden_II	Granny_Smith
2. Area	6599	7620	6899
3. Perimeter	296.8	311	326.8
4. Major Axis	96.88	103.4	95.74
5. Minor Axis	87.27	94.3	92.26
6. Equivalent Diameter	91.66	98.5	93.72
7. Eccentricity	0.4341	0.4094	0.2671
8. Convex Area	6739	7720	7187
9. Extent	0.7662	0.8283	0.7581
10. Euler Number	-1	1	1

F. CLASSIFICATION

Different soft computing models have been used like CNN and SVM for classification of apple fruit verities.

Convolutional Neural Network, as neural systems, are comprised of neurons with learnable loads (weights) and biases [13]. Every neuron gets a few information sources, takes a weighted aggregate over them, go it through an activation function and reacts with an outcome. A CNN is an uncommon sort of ANN that has an input layer, an outcome layer and different hidden layers. A portion of these layers are convolutional, utilizing a mathematical model to pass on results to progressive layers [14]. It is a central case of deep learning. ResNet-50 is a popular pre trained CNN that has been used in this thesis work for classification of various Apple fruit verities.

Support Vector Machine (SVM) is machine learning algorithm that breaks down information for arrangement and relapse analysis [15]. SVM is a supervised learning strategy that first have a look at information and sorts it into one of two classes [16]. SVM produces a guide of the arranged information with the edges between the two as far separated as could be expected under the circumstances. SVMs are utilized in text categorization, picture classification, handwriting acknowledgment and is also used in sciences. SVM algorithm should not only place objects into classifications, however have the edges between them on a diagram as wide as would be possible.

IV. RESULTS AND DISCUSIONS

Classification involves two stages, training and testing using any classifier. In training phase, classifier is trained using feature values and its respective target values. This trained classifier is then used to classify test images.

In this work total 3936 apple fruit images of Kaggle Fruit 360 Dataset are used and which has been divided into 08 apple fruit categories out of which 492 images are Apple Red 1, 492 images are Apple Red 2, 492 images are Apple Red 3, 492 images are Apple Red Yellow, 492 images are Golden 1, 492 images are Golden 2, 492 images are Golden 3 and 492 images of Granny Smith apple verity. For training phase 20 images are Apple Red 1, 20 images are Apple Red 2, 20 images are Apple Red 3, 20 images are Apple Red Yellow, 20 images are Golden 1, 20 images are Golden 2, 20 images are Golden 3 and 20 images of Granny Smith apple verity images are used. For testing phase 10 images are Apple Red 1, 10 images are Apple Red 2, 10 images are Apple Red 3, 10 images are Apple Red Yellow, 10 images are Golden 1, 10 images are Golden 2, 10 images are Golden 3 and 10 images of Granny Smith apple verity images are used.

$$Accuracy(\%) = \frac{\text{Total number of images correctly classified} * 100}{\text{Total number of images used for testing}}$$

Here we use 80 images for testing and more than 77 images has been classified correctly so, the recognition rate or accuracy is 96.25%.

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VI. CONCLUSION

The aim of this thesis work was to create a new method called Automatic Apple Fruit Classification using Soft Computing Models which is capable to classify various types of Apple fruit images using Soft Computing models like CNN, SVM etc. ResNet-50 a pre trained CNN that has been used in our thesis work to identify the correct verities of apple fruit from different classes with the recognition rate of more than 96.25%. This thesis work will be utilized to distinguish between different types of apples by which farmers can sell different varieties of apples at their deserving quality price according to the qualities of apple classified using soft computing models.

In future research, we will attempt to collect the dataset of other Apple fruit verities and will classify them in order to make our system more advanced that will completely recognize all apple fruit verities.

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VIII. BIOGRAPHY

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