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A Novel Approach of Detection and Classification of Apple Fruit Based on Complete Local Binary Patterns

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Abstract: ***The manual identification of detected things from the given data which is very time consuming. We propose an approach which uses neural network to identify the defects in the apple. The features are extracted from the images using Color Invariant, Color histogram and Local Binary pattern algorithm. The features are extracted for the input image and all the images in the database. The extracted feature values are passed into the neural network classifier. The neural network classifies the image into normal or defected. If defect is identified means the defected region is segmented. The color image is converted L*a*b* Color Space. Then K-means clustering is applied to classify the images. Then finally the defected item is identified by identifying the defected cluster. The extracted test image features and the train image features are then passed into the Multi SVM classifier in order to find the type of defects in the cluster.***

Keywords: K-Means Clustering, Local Binary Pattern, Support Vector Machine, Color histogram, Neural Network, Median Filter, Color Invariant, Classification, Segmentation, Gaussian Filter.

I. INTRODUCTION

Image processing is a method to convert an image into digital form and perform some operations on it, in order to get an enhanced image or to extract some useful information from it. It is a type of signal dispensation in which input is image, like video frame or photograph and output may be image or characteristics associated with that image. Usually Image Processing system includes treating images as two dimensional signals while applying already set signal processing methods to them. It is among rapidly growing technologies today, with its applications in various aspects of a business. Image Processing forms core research area within engineering and computer science disciplines too.

Image processing basically includes the following three steps. The first step is importing the image with optical scanner or by digital photography. The second step is analyzing and manipulating the image which includes data compression and image enhancement and spotting patterns that are not to human eyes like satellite photographs. The third step is output is the last stage in which result can be altered image or report that is based on image analysis.

PREPROCESSING:

In preprocessing unnecessary noises in the image were eliminated. An unnecessary noise refers to the unwanted pixels in the frames. Pre-processing methods use a small neighborhood of a pixel in an input image to get a new brightness value in output image. Such pre-processing operations are also called filtration. Local pre-processing methods can be divided into the two groups according to the goal of the processing. Smoothing suppresses noise or other small fluctuations in the image equivalent to the suppression of high frequencies in the frequency domain. Unfortunately, smoothing also blurs all sharp edges that bear important information about the image.

Gradient operators are based on local derivatives of the image function. Derivatives are bigger at locations of the image where the image function undergoes rapid changes. The aim of gradient operators is to indicate such locations in the image. Gradient operators suppress low frequencies in the frequency domain (i.e. they act as high-pass filters). Noise is often high frequency in nature; unfortunately, if a gradient operator is applied to an image the noise level increases simultaneously.

Filters are used in the preprocessing techniques. Filterfunction is used to remove noises from multidimensional array. The input can be logical or a nonsparse numeric array of any class and dimension. The resulting array has the same size and class as the input. The computation is performed using double precision floating point numbers.

FEATURE EXTRACTION:

- To extract the features from the image Color Histogram features, Color Coherence vector features and Local Binary Pattern features are extracted from the image.
- The color channels of the images are separated and histogram is applied to each color channels. The values are saved as features.
- The Color Coherence Vector is calculated for the image and the values are stored as features.
- Then finally LBP features are obtained by the comparison of the pixels with the neighboring pixels and the values are saved as features.

II. K-MEANS CLUSTERING

K-means clustering is a method of vector quantization originally from signal processing that is popular for cluster analysis in image processing. *K-means* clustering aims to partition *n* observations into *k* clusters in which each observation belongs to the cluster with the nearest mean, serving as a prototype of the cluster. However, the pure *k*-means algorithm is not very flexible, and as such of limited use. In particular, the parameter *k* is known to be hard to choose (as discussed below) when not given by external constraints. In contrast to other algorithms, *k*-means can also not be used with arbitrary distance functions or be use on non-numerical data. For these use cases, many other algorithms have been developed since. Then, the regions are grouped into a set of classes using k-means clustering algorithm. Finally, a pixel wise segmentation is applied to those pixels which were not segmented in the first stage. By using this two-step process, it is possible to reduce the computational cost significantly, since only a small number of pixels need to be segmented in the second stage, avoiding the feature calculation for every pixel in the image. Furthermore, the parameters computed from the regions present in the image during the first stage are used to refine the segmentation process in the second stage. The initial segmentation partitions the input image into square blocks with m×m pixels, and then applies a wavelet transform to each block to extract features to compose a feature vector. The k-means clustering algorithm is then used to group the feature vectors into a set of classes.

COLOR HISTOGRAMS:

A color histogram is a representation of the distribution of colors in an image. For digital images, a color histogram represents the number of pixels that have colors in each of a fixed list of color ranges that span the image's color space, the set of all possible colors.

The color histogram can be built for any kind of color space, although the term is more often used for three-dimensional spaces like RGB or HSV. For monochromatic images, the term intensity histogram may be used instead. For multi-spectral images, where each pixel is represented by an arbitrary number of measurements (for example, beyond the three measurements in RGB), the color histogram is *N*-dimensional, with N being the number of measurements taken. Each measurement has its own wavelength range of the light spectrum, some of which may be outside the visible spectrum.

If the set of possible color values is sufficiently small, each of those colors may be placed on a range by itself; then the histogram is merely the count of pixels that have each possible color. Most often, the space is divided into an appropriate number of ranges, often arranged as a regular grid, each containing many similar color values. The color histogram may also be represented and displayed as a smooth function defined over the color space that approximates the pixel counts.

NEURAL NETWORK:

The area of Neural Networks probably belongs to the borderline between the Artificial Intelligence and Approximation Algorithms. Think of it as of algorithms for "smart approximation". The NNs are used in (to name few) universal approximation (mapping input to the output), tools capable of learning from their environment, tools for finding non-evident dependencies between data and so on.

The Neural Networking algorithms (at least some of them) are modeled after the brain (not necessarily - human brain) and how it processes the information. The brain is a very efficient tool. Having about 100,000 times solver response time than computer chips, it (so far) beats the computer in complex tasks, such as image and sound recognition, motion control and so on. It is also about 10,000,000,000 times more efficient than the computer chip in terms of energy consumption per operation.

The brain is a multi-layer structure (think 6-7 layers of neurons, if we are talking about human cortex) with 10^11 neurons, structure, that works as a parallel computer capable of learning from the "feedback" it receives from the world and changing its design (think of the computer hardware changing while performing the task) by growing new neural links between neurons or altering activities of existing ones. To make picture a bit more complete, let's also mention, that a typical neuron is connected to 50-100 of the other neurons, sometimes, to itself, too.

To put it simple, the brain is composed of neurons, interconnected.

SVM CLASSIFIER:

Support vector machines are supervised learning models with associated learning algorithms that analyze data and recognize patterns used for classification and regression analysis. The basic SVM takes a set of input data and predicts, for each given input, which of two possible classes forms the output, making it a non-probabilistic binary linear classifier. Classification accuracy is computed.

SVM maps input vectors to a higher dimensional vector space where an optimal hyper plane is constructed. Among the many hyper planes available, there is only one hyper plane that maximizes the distance between itself and the nearest data vectors of each category. This hyper plane which maximizes the margin is called the optimal separating hyper plane and the margin is defined as the sum of distances of the hyper plane to the closest training vectors of each category.

Expression for hyper plane

$w.x+b = 0$

x – Set of training vectors

w – Vectors perpendicular to the separating hyper plane

b – Offset parameter which allows the increase of the margin

III. CLASSIFICATION

Classification is done using SVM classifier.

In machine learning, support vector machines are supervised learning models with associated learning algorithms that analyze data and recognize patterns, used for classification and regression analysis. The basic SVM takes a set of input data and predicts, for each given input, which of two possible classes forms the output, making it a non-probabilistic binary linear classifier. Given a set of training examples, each marked as belonging to one of two categories, an SVM training algorithm builds a model that assigns new examples into one category or the other. An SVM model is a representation of the examples as points in space, mapped so that the examples of the separate categories are divided by a clear gap that is as wide as possible.

SEGMENTATION:

- If the images are classified as abnormal images the infected region is segmented.
- K-means algorithm is used to segment the images.
- The input color image of the fruit is transformed form RGB to L*a*b* Color Space.
- The defected regions are grouped into a single cluster.
- The image is segmented into clusters based on the pixel value changes in the image.

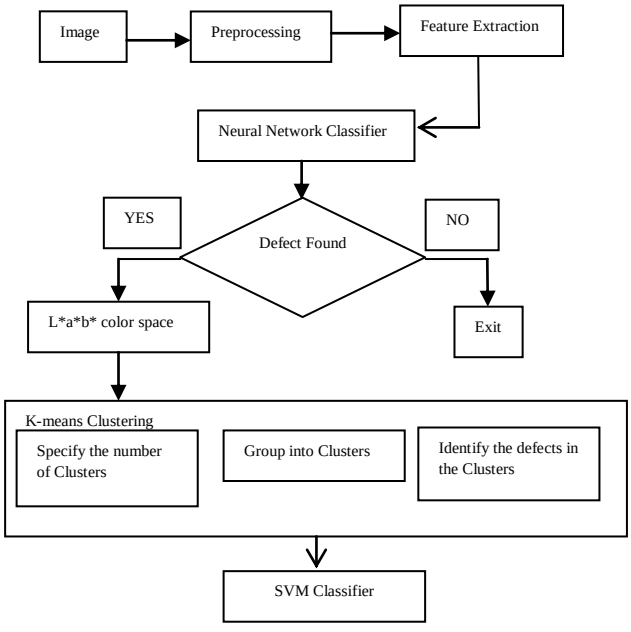
IV. PROPOSED METHOD

The Apple images are first preprocessed to remove the unwanted pixels from the image. The features are extracted from the images using Local Binary Pattern algorithm. The features are extracted for all the images in the database and saved as training image features. The features are extracted for the test image and they are saved as test image features. The Training image features and the test image features are passed into the classifier. The Neural Network Classifies the image into disease affected or normal image. If the given image is abnormal means the images are segmented using k-means segmentation algorithm. Then the type of the disease in the image is identified using Multi SVM Classifier. Finally the accuracy of the classifier is calculated. The accuracy of the classifier shows that the accuracy of the proposed method is compared to the previous algorithms used. The features extracted using Local Binary Pattern algorithms are more efficient and more reliable which helps the classifier to produce better results.

A. Methodology

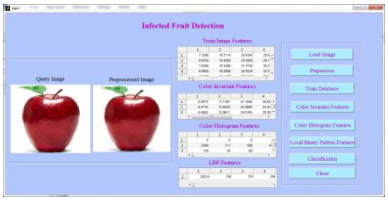
INITIAL CLASSIFICATION:

- The images are classified into normal or abnormal using neural network classifier.
- The NN receives inputs, which can be a pattern of some kind.
- After the neuron in the first layer received its input, it applies the Linear Combiner and the Activation Function to the inputs and produces the Output.

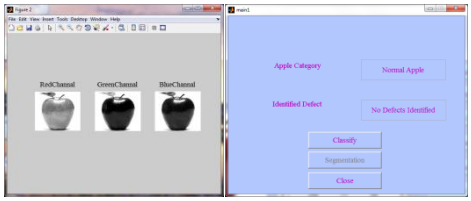


B. RESULT:

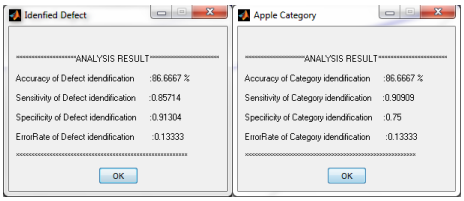
Not Afftected Apple image



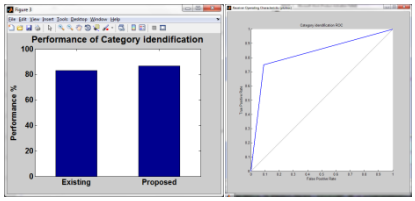
Classification of image



Accuracy of Result

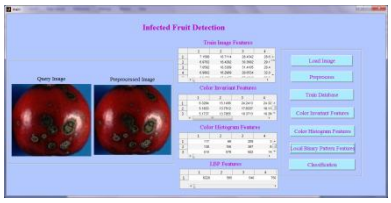


Performnce Chart Graph Representation

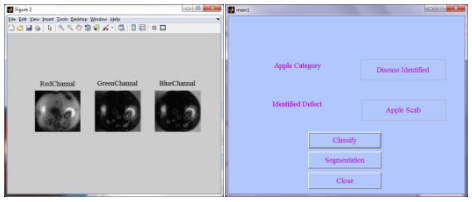


Algorithm:
Load the image as an input.
Convert the image in gray scale.
Remove the unwanted pixel using median filter.
Image's features extracted using LBP.
Image's features extracted in training image.
Image's features extracted in test image.
Image of training and test passed into classifier.
Neural Network classifies the image into disease affected or normal image.
Images are segmented using k-means cluster.
Type of the disease in the image is identified using Multi SVM Classifier.
Finally the accuracy of the classifier is calculated.

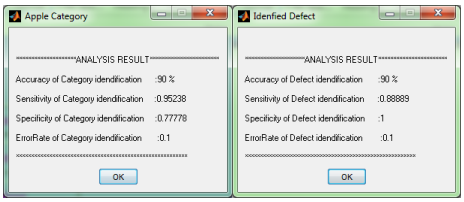
Affected Apple image



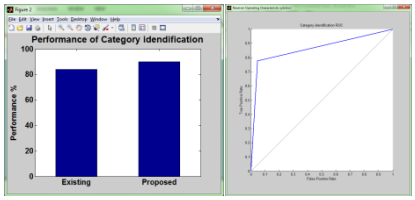
Classification of image



Accuracy of Result



Performnce Chart Graph Representation



Segmentation of image

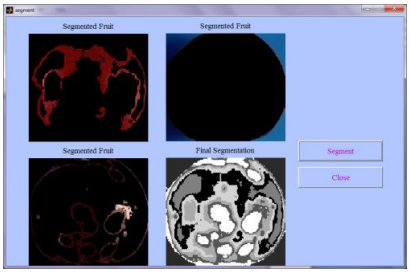


Table: Accuracy of Image

Apple Image	Type	Accuracy	Sensitivity	Specificity	Error Rate
1	Category	86.6667%	0.90909	0.75	0.13333
	Defect	86.6667%	0.85714	0.91304	0.13333
2	Category	90%	0.91304	0.85714	0.1
	Defect	93.3333%	0.88889	1	0.066667
3	Category	90%	0.95238	0.77778	0.1
	Defect	90%	1	0.95652	0.1
4	Category	90%	1	1	0
	Defect	93.3333%	1	0.95652	0.066667
5	Category	90%	0.91304	0.85714	0.1
	Defect	86.6667%	1	1	0.13333
6	Category	90%	1	0.72727	0.1
	Defect	86.6667%	0.77778	0.95238	0`13333
7	Category	96`6667%	0.95652	1	0.033333
	Defect	90%	1	1	0.1
8	Category	93.3333%	0.95455	0.875	0.066667
	Defect	90%	0.77778	0.95238	0.1
9	Category	100%	1	1	0
	Defect	93.3333%	1	0.95652	0.066667
10	Category	86.6667%	1	0.66667	0.13333
	Defect	93.3333%	1	1	0.066667
11	Category	93.3333%	0.95455	0.875	0.066667
	Defect	86.6667%	0.88889	1	0.133333
12	Category	93.3333%	0.95455	0.875	0.066667
	Defect	93.3333%	1	1	0.066667
13	Category	96.6667%	0.95652	1	0.033333
	Defect	93.3333%	0.8	1	0.066667
14	Category	90%	1	0.72727	0.1
	Defect	90%	0.8	1	0.1
15	Category	96.6667%	1	0.88889	0.033333
	Defect	93.3333%	1	1	0.066667
16	Category	93.3333%	1	0.8	0.066667
	Defect	86.6667%	0.72727	1	0.13333

17	Category	93.3333%	0.95455	0.875	0.066667
	Defect	93.3333%	1	0.95652	0.066667
18	Category	96.667%	1	0.88889	0.033333
	Defect	93.3333%	1	1	0.066667
19	Category	93.3333	1	0.8	0.066667
	Defect	90%	0.875	0.95455	0.1
20	Category	86.6667%	0.95	0.7	0.13333
	Defect	93.3333%	0.88889	1	0.066667

IV. CONCLUSION AND FUTURE ENHANCEMENT

We present an algorithm that segments the apple images to identify the defected region and classifies the given image using the features extracted. In the pre-processing stage the noise in the images are removed. The color channels of the images are separated and color histogram is applied to each color channels. The calculated histogram values are the extracted features. Then Color Invariant features are extracted and then Local Binary Pattern algorithms were used to extract the features. Then neural network finds that defect is present in the apple image or not. The apple images are converted into L*a*b color format. Using the extracted features and the true label the SVM classifier identified the defects in the apple such as apple scab, apple rot, apple Bloch.

As the accuracy of the classification is low since only Local Binary Pattern algorithm is used for classification, In the future, improve the accuracy of the classification through using newest algorithm or technology.

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