Detection and classification for apple fruit diseases using support vector machine and chain code

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Abstract:

Diseases in fruit are the reason of destroying and economic losses and agriculture field. A solution of this problem for the detection and classification of apple fruit diseases is considered and experimentally validated. The image processing based considered approach consists of the following three steps, in the first step rgb to gray conversion, median filtering, edge detection, and morphological operations are used for the image segmentation. In the second step shape approximation technique are used for feature extraction, histogram of chain code and density of pixel widely used for feature extraction from the segmented image, both feature extraction technique are compared and in the third steps images are classified classes by using a different kernel in Multi-class Support Vector Machine. Comparison of all kernels is done and better results are indicated. Our experimental results express that support vector machine with radial basis kernel achieves best classification accuracy of 98%.

Keyword- Image segmentation, feature extraction, support vector machine, chain code, energy density

1. Introduction

We have taken in this paper disease classification problem in fruits. This can cause big losses in yield. A solution of this problem is prior detection and classification for apple fruit disease. In this paper, automatic detection and classification of apple fruit disease is needs to automatic detect the signs of disease as soon as they appear on the growing fruits. What control factors to know, then take action for next year avoid losses.

Classification is used to classify pixels of apple image into classes. Three classes are used in this paper normal apple, Scrub apple and bitter rot. Many types of disease in apple fruit are dimple apple, bistel spot, and apple blotch but some common disease in apple fruit are apple scrub, apple bitter rot, in describe. Scrub apple are easily recognized by the light to olive colored spots. Apple rot infections produce as a small circular light brown spot.

We have used a data set of normal and diseased apple fruits. It comprises of normal apple (100 image samples), scrub apple (100 image samples), bitter rot (100 image samples).

Arif khan et al [4] used chain code and energy for shape variation based classification. A chain code is shape approximation technique and easily classifies image shape based techniques.

[13]Veggie-vision et al use texture colour density. The reported classification accuracy was around 93%. [5]Shape recognition and matching using chain code. [7] Evaluation and comparison on the technique of vertex chain codes. [12]A feature based chain code method for identifying printed Bengali characters. [11] English alphabet recognition using chain cod and Lcs. [9] Face recognition using chain code. [8] Digital image processing approach for fruit and leaf identification and recognition.[10] fruit and vegetables recognition.[1] Detection and classification for apple fruit disease using local binary patterns.[2] Adapted approach for fruit disease identification using image.

This paper is divided in 4 sections; section 2 gives proposed solution, section 3 gives experimental result, section 4 gives conclusions.

2. Proposed solution

The steps of proposed approach are shown in the Fig. 1. For the fruit disease classification problem, image segmentation is required in this approach rgb to gray conversion median filter, edge detector, and morphology operation are used for image segmentation is preferred to detect the region of interest which is the diseased part only. After segmentation, Feature is extracted from segmented image of fruit. Finally, training and classification are performed on a multi class SVM classifier. Each phase of the proposed method is described in this section.

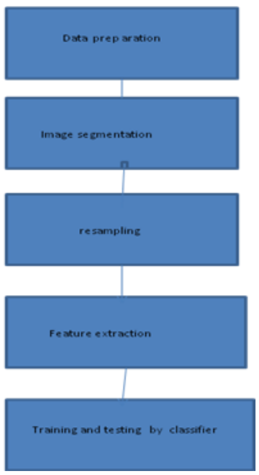


Fig.1 The basic procedure of the proposed approach

2.1 Image segmentation

Rgb to gray, median filter, edge detector, and morphology technique are used for image segmentation.

Step1. Convert rgb to gray image.
Step2. Median filter is used for remove noise.
Step3. Edge detector is used to identify the edge an image.
Step4. Morphology operation is used for image segmentation.

2.2 Feature extraction

In the proposed approach, we have used some state of the art color, shape and texture features to validate the accuracy and efficiency. The features used for the apple fruit disease classification problem are histogram of chain code and density of pixel.

2.2.1 Energy

Energy feature extraction scheme for recognizing apple fruit disease is proposed in the work. Energy is defined as the total energy present in each segment. We have done no. of segment of each apple disease and energy is obtained by counting the total number of 1s in each segment (i.e. total white pixels), thus, we have a feature vector for energy method as final database. This final database is fed to the support vector machine to perform the desired function i.e. training or classification

Let (v_1,v_2 and v_3.....v_n) is the intensity value of image corresponding the index value.

$[(x_1\ y_1),(x_2\ y_2),......(x_n\ y_n)]$

The energy of the segment

$E=1/n^2\ \sum_{i=1}^{n}\ \sum_{j=1}^{n} |v_{ij}|^2$........... *(1)*

V_{ij}=1or0

So that

$|v_{ij}|$=1or0

$=v_{ij}$

$|v_{ij}|2$=1or0=v_{ij}

So that

$E=1/n^2\ \sum_{i=1}^{n} \sum_{j=1}^{n} v_{ij}$

For the identification as feature vector is F = [E_1.....E_m]. When image is segment to m segment. E1 to Em is energy of each segment in apple disease. We are working 4 segment of the image and energy is found from each segment. And total of 4 feature vector is found.

2.2.2 Chain code

Chain code is based on the idea that we follow the outer edge of the object and store the direction in which we are travelling.

The direction is calculated as: four direction chain code or eight direction chain code. The chain code is calculated histogram of pixels

Shape approximation technique in feature extraction stage, particularly chain code has been widely used to encode the boundary line because of its simplicity and low storage requirement. Chain code (cc) representation gives the boundary of apple image where the codes represent the direction of where is the location of the next pixel from current point.

A digital boundary of an image is superimposed with a grid. The boundary points are approximate to the nearest grid point. Then a sampled image is obtained from a selecting from selecting starting point. A chain code can be generated by using a four directional chain code and eight directional a chain code.

Disadvantage; chain of code is too long even slightly disturbed code would not reconstruct original image.

Solution; resampling the boundary by selecting larger grid spacing. Different grid can be generating different chain code. Normalization.

Shape number: shape num is first difference of smallest magnitude. The num of digit in shape num is called the order.

Table1. First difference of chain code

Chain code	First difference
0→1	1
0→ 2	2
2→ 3	1
2→0	2
2→3	3

The algorithm for generating the chain code is given below.

1. Find the boundary of pre processed numeral image.
2. Search the image from top left until a first pixel belonging to the region is found.
3. Search the neighborhood of the current pixel for another pixel of the boundary in clockwise direction.
4. The detected inner border is represented by direction code,
   Process how chain code is calculated

.

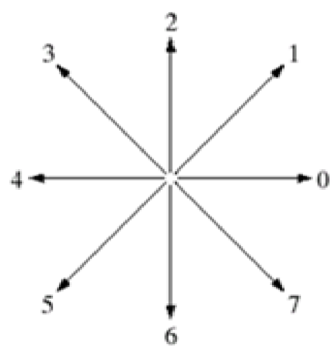


Fig.2 Eight directional chain code

In mixed from both, the energy and the chain code are combining to produce the result.

3. Training and classification

In this proposed approach, an approach is presented in that can combine many features and classifier. The author approaches the multi class classification problem as a set of binary classification problem. Some binary classification problems do not have a simple hyperplane as a useful separating criterion

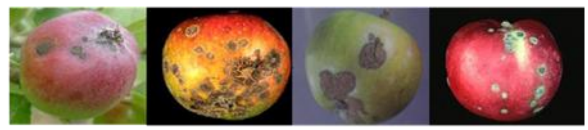
Their approach can be understood by a simple three class problem. Let three classes are 1, 2, and 3. One classifier will be used as base learners; classifier will be trained with training images. Classifier will be tested with testing images. Each class will receive a unique ID.

This paper uses multi class support vector machines for the training and classification.

4. Experimental result

4.1 Data set preparation

(a) Normal apple



(b) scab apple

(c) bitter rot apple

Fig.3 sample images from the data set of type (a) normal apple (b) scrub apple (c) bitter rot apple

4.2 Result Discussion

In the quest for finding the best categorization procedure and feature to apple disease classification, this paper analyzes some color, shape and texture based image descriptors derived from rgb to gray stored images considering multi class support vector machine classifier. If we use N images per class for training then remaining images are used for testing. The accuracy of the proposed approach is defined as,

$$\text{accuracy}\,(\%) = \frac{\text{total num of images correctly classified} * 100}{\text{total num of used for testing}}$$

We tested multiclass SVM using histogram of chain code and density of pixel feature; we choose the linear kernel, polynomial kernel, quadratic kernel, and Radial basis function kernel. Table2.Show the classification accuracy 300 images of fruit for different kernel function. Classification accuracies of quadratic are 69%. Polynomial kernel is 72% accuracies, linear kernel is 79% accuracies RBF kernel is 98% accuracies. Therefore, the best results are achieved using the RBF kernel with classification accuracy of 99%. Table.2. show the average accuracy 300 of fruit for different kernel function.

Table.2. classification accuracy of different kernel

Kernel function	Accuracy in percentage
RBF	98%
Linear	79%
Polynomial	72%
Quadratic	69%

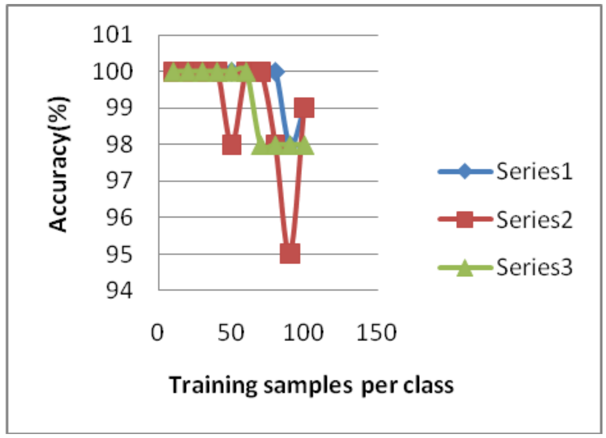


Fig.4. Training example per class for "RBF" kernel using chain code

Table.3. Effect of number training samples per class for 'RBF' kernel using chain code

Normal	Scrub	Bitter rot	Normal	Scrub	Bitter rot
10	10	10	100	100	100
20	20	20	100	100	100
30	30	30	100	100	100
40	40	40	100	100	100
50	50	50	100	98	100
60	60	60	100	100	100
70	70	70	100	100	98
80	80	80	100	98	98
90	90	90	98	95	98
100	100	100	99	99	98

Table.4. Effect of number testing samples per class for 'RBF' kernel using histogram of chain code

Apple fruit image			Accuracy of fruits in percentage		
Normal	Scrub	Bitter	Normal	Scrub	Bitter
10	10	10	70	90	100
20	20	20	75	95	80
30	30	30	86	80	93
40	40	40	92	95	95
50	50	50	64	86	90
60	60	60	71	76	96
70	70	70	71	70	88
80	80	80	73	23	95
90	90	90	41	70	94
100	100	100	74	72	89

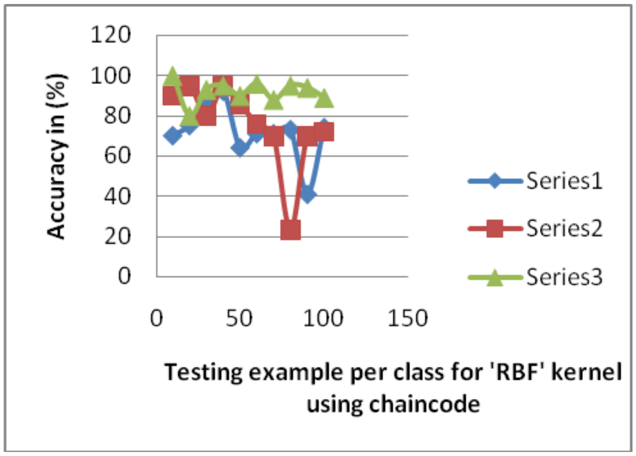


Figure.5. Effect of number testing samples per class for 'RBF' kernel using chain code

Table.5. Effect of number training samples per class for 'RBF' kernel using density of pixels

Apple fruit image			Accuracy of fruits in percentage		
Normal	Scrub	Bitter	Normal	Scrub	Bitter
10	10	10	90	100	60
20	20	20	100	65	80
30	30	30	100	83	96
40	40	40	95	97	65
50	50	50	92	92	62
60	60	60	96	81	61
70	70	70	92	78	64
80	80	80	86	91	48
90	90	90	100	82	42
100	100	100	95	85	43

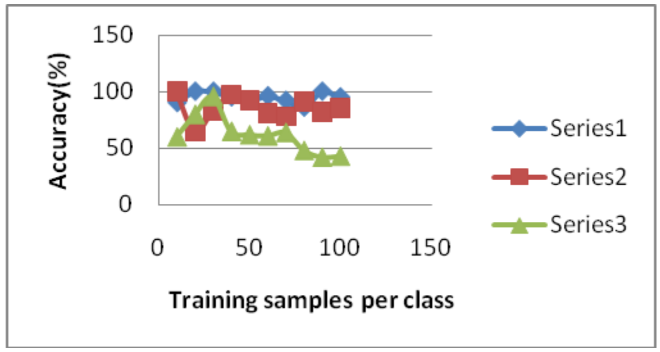


Fig.6. training example per class for the "RBF" using density of pixels

Table.6. Effect of number testing samples per class for 'RBF 'kernel using density o pixels.

Apple fruit image			Accuracy of fruits in percentage		
Normal	Scrub	Bitter	Normal	Scrub	Bitter
10	10	10	50	70	50
20	20	20	55	50	30
30	30	30	66	53	40
40	40	40	72	67	42
50	50	50	50	94	36
60	60	60	81	73	36
70	70	70	78	75	34
80	80	80	65	68	25
90	90	90	55	63	48
100	100	100	76	72	36

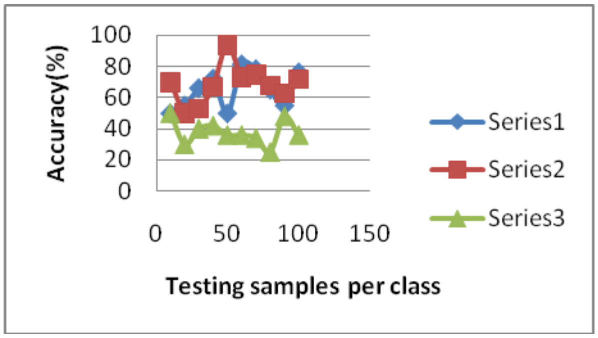


Fig.6. testing example per class for the "RBF" using density of pixels

Table,7 Average accuracy of all class training samples for 'Radial basis function' using histogram of Chain Code.

Apple fruit images	Total of accuracy in per
10- 10 images	100
20-20 images	100
30-30 images	100
40-40 images	100
50-50 images	99
60-60 images	100
70-70 images	99
80-80 images	99
90-90 images	97
100-100images	98

. Table.8 average accuracy of all class testing samples for 'Radial basis function' using chain code

Apple fruit images	Total of accuracy in per
10- 10 images	86
20-20 images	83
30-30 images	86
40-40 images	94
50-50 images	80
60-60 images	81
70-70 images	76
80-80 images	81
90-90 images	68
100-100images	65

Table.9. Average accuracy of all class training samples for 'Radial basis function' using density of pixel

Apples fruit images	Total of accuracy in per
10-10 images	83
20-20 images	81
30-30 images	93
40-40 images	85
50-50 images	82
60-60 images	80
70-70 images	80
80-80 images	78
90-90 images	69
100-100images	74

Table.10 Effect of num of testing samples of all class on accuracy for 'radial basis function' using density of pixel

Apples fruit images	Total of accuracy in per
10-10 images	56
20-20 images	45
30-30 images	53
40-40 images	60
50-50 images	60
60-60 images	63
70-70 images	62

80-80 images	61
90-90 images	54
100-100images	61
100-100images	61

We observe across the plot that histogram of chain code feature perform better result than density of pixel feature as shown in the fig.4 and Fig.6 Show the results for different feature respectively. The X- axis represents the number of images per class in the training set and the Y-axis represents the accuracy for the test images

For 100 training example per class and histogram of chain code, for instance, reported classification accuracy is 98% show in table.7 For 100 training example per class and density of pixel, for instance, reported classification accuracy is 74% show in table.9

For 100 testing example per class and histogram of chain Code, for instance, reported classification accuracy is 65%. For 100 testing example per class and density of pixel, for instance, reported classification accuracy is 43%. Result of training example is better testing example.
One important aspect when dealing with apple fruit disease classification is the accuracy per class. This information points out the classes that need more attention when solving the confusions. Fig.4 and fig.6 shows the accuracy for each one of three classes using histogram of chain code and density of pixel. Fig.4 and fig.6 Normal apples are very easily distinguishable with diseased apples and a very good classification result is achieved for the Normal apples in both features. Fig.4 shows that, the behavior of apple scrub is same bitter rot apple. Fig.6 shows that bitter rot is lowest accuracy as compared to scrub. For 100 training example per class and chain code, for instance, reported classification accuracy are 100%, 98%, and 98% for the normal apple, scrub apple and bitter rot apple, resulting average accuracy is 74%.
For 100 testing example per class and histogram of chain code, for instance, reported classification accuracy are 74%, 72%, and 89%. For the normal apple, scrub and rot apple. Resulting average accuracy is 65%.
For 100 testing example per class and density of pixel
For instance, reported classification accuracy is 76%, 72% and 36%. For the normal apple, scrub and rot apple. Resulting average accuracy is 61%.

5. Conclusion

An image processing based solution is proposed an evaluated for the detection and classification of apple fruit disease. The proposed is made of mostly three steps. In the first step image segmentation is performed using conversion rgb to gray, median filtering edge detector and morphology technique in the second step histogram of chain code and density of pixel are used for feature extracted. In the third step training and classification are performed on the multi class SVM kernel. We have used three types of apple disease namely: apple rot and apple scrub as a case study and evaluated our program.
Our experimental results indicate that the proposed solution can support automatic detection and classification of apple fruit disease. Based on our experiment, we have found that normal apples are easily distinguishable with the diseased with the diseased apples and density of pixel show result for classification of apple fruit diseased apples and achieve more than 74% and histogram of chain code is gives better result compare density of pixel. Histogram of chain code shows more accurate result for the classification of apple fruit diseases and achieved more than 98% classification accuracy. Further work includes consideration of fusion of more than one feature to improve the output of the proposed method.

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