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Article · March 2019

DOI: 10.26438/ijcse/v7si5.131135

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IJCSE International Journal of Computer Sciences and Engineering Open Access

Research Paper Vol.-7, Special Issue, 5, March 2019 E-ISSN: 2347-2693

Fruits Classification Using Image Processing Techniques

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DOI: https://doi.org/10.26438/ijcse/v7si5.131135 | Available online at: www.ijcseonline.org

Abstract— A new method for classifying fruits using image processing technique is proposed in this paper. The data set used had 70 apple images and 70 banana images for training and 25 images of apple and 25 images of bananas for testing. RGB image was first converted to HSI image. Then by using Otsu's thresholding method region of interest was segmented by taking into account only the HUE component image of the HSI image. Later, after background subtraction, a total of 36 statistical and texture features were extracted with the help of the coefficients obtained by applying wavelet transformation on the segmented image using Haar filter. Extracted features were given as inputs to a SVM classifier to classify the test images as apples and bananas. As KNN classification method did not give 100% accuracy while classification SVM classification method was used. 140 sample images of apples and bananas were used for training and 25 images of banana and 25 images of apples were used for testing the proposed algorithm. The proposed algorithm gave 100% accuracy rate.

Keywords— RGB, HSI, Region of interest, Wavelet domain, Haar filter, SVM classification.

I. INTRODUCTION

Machine vision system for fruit identification and disease identification of fruit or vegetable is one among the current topic that is under research in the agriculture industry. As a part of this current research area, this fruits classification using image processing techniques was developed. This classification of fruits can be used to identify a fruit and generate its price automatically in a shop or supermarket. As an initial step in this proposed methodology classification of apples and bananas was done. Even agriculturist will be benefited if an automation machine vision exits to classify different variety of fruits and vegetables in the agriculture industry.

Rest of the paper is organized as follows, Section I contains the introduction of this research paper fruit classification using image processing techniques , Section II contain the existing works related to fruit classification systems, Section III contain some measures used in the proposed algorithm and their explanations, also it explains the architecture and essential steps of the proposed fruit classification system, Section IV explain about the results obtained by implementing the proposed algorithm using MATLAB software , also it discusses about the features and advantages of the proposed algorithm, and finally Section V concludes with suggestion for future enhancement of this research work.

II. RELATED WORK

D Sahu, et al., proposed a method to identify and classify mango fruits using image processing techniques [1]. K Tarale ,et al., have introduced a fruit detection using morphological image processing technique [2]. K Tarale , et al., have proposed a new method for fruits recognition system[3]. W C Seng ,et al., have proposed a survey paper on image processing methods for fruit classification [4]. S P Deevan ,et al., introduced an automatic fruit classification method using random forest algorithm[5]. H M Zawbaa, et al., have proposed an algorithm for classification of citrus fruit using image processing – GLCM parameters[6]. H M Zawbaa, et al., have discussed about an automatic fruit image recognition system based on shape and colour features[7]. A robust approach for fruit and vegetable classification was proposed by S R Dubey , et al.,[8]. Apple fruit size estimation using a 3D machine vision system was introduced by A Gongal ,et al.,[9]. Another method was found by W Wang, et al., to find the mechanical damage caused by fruit-to-fruit impact of litchis[10]. Using geometry based mass, grading of mango fruits using image processing techniques was proposed by M A Momin , et al.,[11]. The above listed research papers were surveyed in order to develop this proposed methodology.

III. METHODOLOGY

Image processing techniques like image reading, image colour space conversion , background subtraction , image segmentation , masking , dilation , region fill , wavelet transformation, feature extraction using GLCM ,etc., were used. In order to classify fruits commonly extracted features are related to the statistical, colour, intensity, shape and texture. For this experiment statistical and texture features were used.

3.1 Samples used

For experimentation a total of 140 images were taken for training and 50 images was taken for testing. Out of these 140 training images, 70 apple images [granny smith, fuji, red delicious variety and 70 banana images [yellow and green variety] were taken and out of 50 test images 25 apple images [granny smith, fuji and red delicious variety] and 25 banana [yellow and green] images were taken.

3.2 Image Acquisition

RBG colour images can be acquired using a Digital camera using an illumination chamber. All secondary images used for this research work were of sizes 800 x 800 pixels.

3.3 Proposed Method

The proposed method uses the following steps which have been depicted using a flowchart below. This proposed algorithm was coded and was executed using MATLAB 2017a software. As the first step region of Interest was extracted from the extracted apple's / banana's image. After identifying the region of interest, the segmented image's background was subtracted and the holes were filled using morphological procedures. Then wavelet transformation using Haar filter was applied on the ROI image. A total of 36 statistical and texture features using the diagonal, vertical and horizontal coefficient values of the wavelet domain were extracted. Using the extracted features of apple/banana images were well classified using SVM classifier as images of apple and bananas. The following flowchart depicts the proposed algorithm.

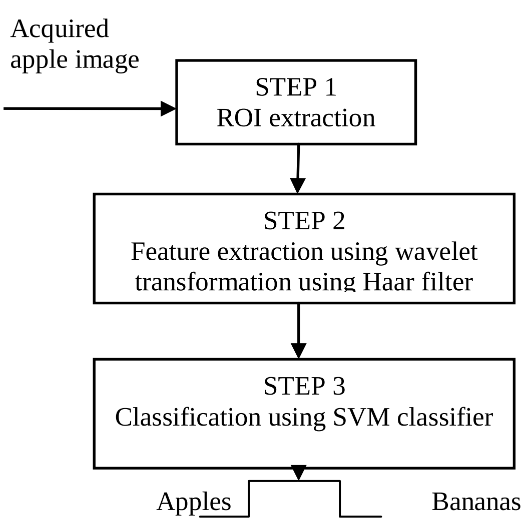


Figure 1. Diagrammatic representation of the proposed method

3.4 Proposed Algorithm

The steps involved in the proposed method are depicted in the algorithm given below.

Algorithm :

1 : Load RGB image
2 : Convert RGB image to HSI image
3 : Taking the Hue component image and subtract its background
4 : Obtain 'T' threshold using OTSU's method
5 : Extract the ROI using the same and fill the holes.
6 : Image with ROI alone is loaded
7 : Features like statistical and textural features were extracted using Wavelet Transformation using Haar filter for all Vertical, horizontal and diagonal coefficient values
8 : Extracted features from both training and testing samples were given as input to SVM classification procedure.
9 : Apple images and banana images were classified.

3.5 Region of Interest extraction

In this work the apple/banana image area was the Region Of Interest. To extract the ROI, the acquired RGB image was converted into HSI colour space. Hue component image was taken into account for further study. After conversion the background of the image was subtracted. Then 'Th' value was obtained using Otsu's method. Here gri(x,y) was the background subtracted image.

$$S(x,y) = \begin{cases} 1\ if\ \ gri(x,y) > Th \\ 0\ if\ gri(x,y) \geq Th \end{cases} \quad (1)$$

Image holes may be there in the segmented image therefore these image holes were filled using some morphological procedures to get the final ROI image.

3.6 Feature extraction

This subsection discusses about the features that were extracted to classify the apple and banana samples using the proposed algorithm.

3.6.1 Wavelet transformation

Images in general are not always clearly defined in special domain. This in turn will not help in accurate classification. So, DWT (Discrete Wavelet Transformation) coefficients of diagonal, vertical and horizontal pixel values were obtained. Further statistical and texture features were calculated using these level one coefficient values and level two coefficients. Haar filter was used to decompose the images.

3.6.2 Statistical features

For first and second level decomposition of the segmented image, statistical features like mean and standard deviation were calculated. A total of 12 features [Mean value for CH , CV , CD and Standard Deviation for CH , CV , CD] for each image was calculated.

$$\text{Mean} = \mu = \sum_{i=1\ to\ M}\sum_{j=1\ to\ N} Im\ (i,j) \quad (2)$$

$$\text{Standard Deviation} = \quad \sigma = \frac{\sqrt{(Im\ (i,j) - \mu)2}}{M\ x\ N} \quad (3)$$

3.6.3 Texture features

Texture features like Energy , Homogeneity , Contrast and correlation for CH , CV , CD at first and second level decomposition of DWT was calculated. And a total of 24 features were obtained.

$$\text{Energy} = \sqrt{\sum_{i}\sum_{j}(Im\ (i,j)^2} \quad (4)$$

Energy give us the sum of squared elements.

$$\text{Homogeneity} = \sum_i \sum_j \frac{Im\ (i,j)}{1+(i-j)2} \quad (5)$$

This measures the closeness of the distribution of elements in the GLCM

$$\text{Contrast} = \sum_i \sum_j [(i-j)^2\ (Im\ (i,j))] \quad (6)$$

The local variations in the gray-level co-occurrence matrix was given by Contrast measures

$$\text{Correlation} = \sum_{i,j=1}^{N} Im\ (i,j)\frac{(i-\mu)(j-\mu)}{\sigma^2} \quad (7)$$

The joint probability occurrence of the specified pixel pairs was given by the Correlation measures
In formulae 2 thru 7 ‘Im’ was the segmented image, M x N was the size of the image with M rows and N columns. Where i vary from 1 to M, and j vary from 1 to N.

3.6.4 SVM Classification

Support Vector Machines are based on the concept of decision planes that define decision boundaries.

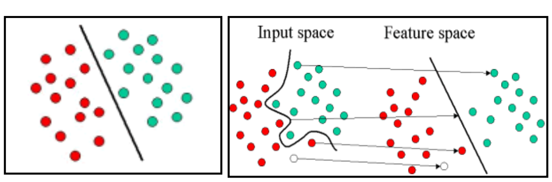


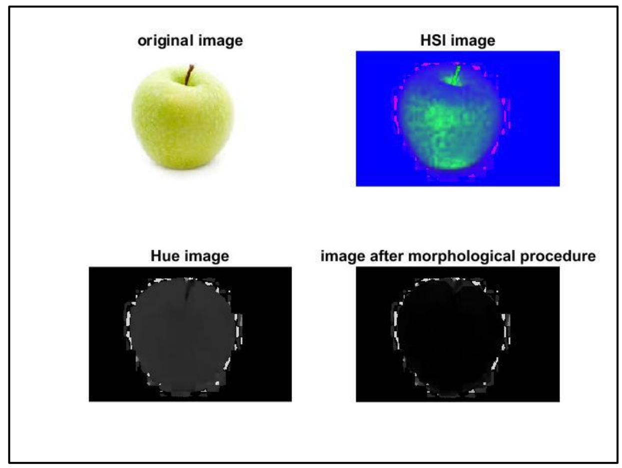
Figure 2. SVM Classifier illustration diagram

Figure 2 illustrates a SVM classifier diagrammatically. SVM classifier separates a set of objects into their respective groups here the objects are green and red colours with a line that correctly classifies new objects called test cases on the basis of the examples that are available as train cases. In the proposed methodology, SVM classification was used to classify the apples and bananas under two headers and was stored in two separate folders.

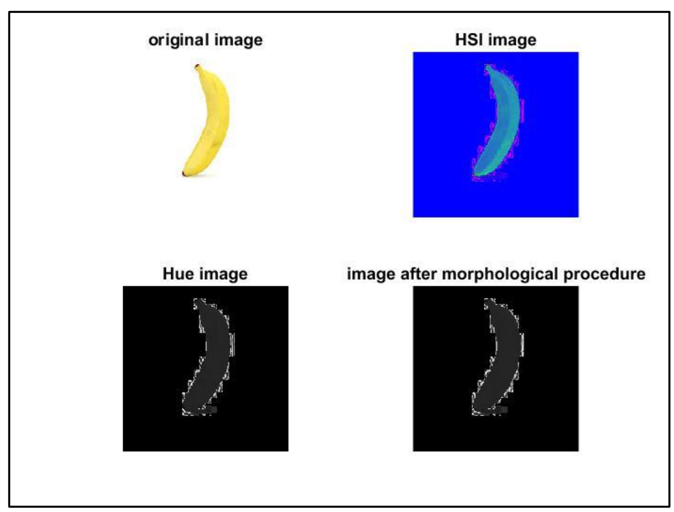
IV. RESULTS AND DISCUSSION

4.1 Results

Out of 50 test images used for testing 12 test image samples results are taken for discussion in this section. After STEP 1 phase of the proposed methodology the following output was obtained.



(a)



(b)

Figure 3. a) RGB image original image , converted HSI image , Hue component image and image after morphological procedure of an apple sample. b) RGB image original image, converted HSI image, Hue component image and image after morphological procedure of a banana sample.

From the above figures a and b it was evident that the Hue component image of an apple/banana image gave a clear picture of the ROI. Also, figures a and b also shows images that were obtained after the background subtraction procedure and the image that was obtained after the application of Otsu's thresholding algorithm.

The following tables from one through 4 are the 36 feature values extracted after applying wavelet transformation on the segmented image using Haar filter. Statistical and texture features found out using horizontal , vertical and diagonal coefficients are tabulated in the following tables.

Table 1. Texture features at level one

	WAVELET DECOMPOSITION USING HAAR FILTER STATISTICAL FEATURES - AT LEVEL ONE											
	CH				CV				CD			
	Contrast	correlation	energy	homogi	Contrast	correlation	energy	homogineity	Contrast	correlation	energy	homogineity
Sample1	0.0829	0.4599	0.9710	0.9916	0.2683	0.0664	0.9538	0.9842	0.0634	0.0436	0.9789	0.9931
Sample2	0.3634	0.3763	0.9187	0.9739	1.1358	0.1121	0.8574	0.9490	0.2977	0.1358	0.9295	0.9759
Sample3	1.1527	0.3198	0.8111	0.9353	1.5268	0.1164	0.7864	0.9229	0.8473	0.1451	0.8456	0.9442
Sample4	0.4455	0.4542	0.9065	0.9713	0.8538	0.0230	0.8830	0.9574	0.3239	0.0266	0.9269	0.9741
Sample5	0.7212	0.3418	0.8644	0.9540	1.5753	0.0896	0.8255	0.9337	0.4832	0.0525	0.9002	0.9635
Sample6	0.2478	0.6262	0.9039	0.9739	0.5592	0.1012	0.8826	0.9612	0.1692	0.1072	0.9375	0.9799
Sample7	0.0594	0.0590	0.9822	0.9944	0.1492	0.0087	0.9707	0.9898	0.0387	0.0656	0.9847	0.9953
Sample8	0.1566	0.4626	0.9441	0.9848	0.1612	0.0358	0.9495	0.9838	0.0904	0.0104	0.9600	0.9872
Sample9	0.3807	0.3730	0.9178	0.9736	1.1229	0.0132	0.8770	0.9543	0.2498	0.0323	0.9345	0.9773
Sample10	0.0684	0.2918	0.9817	0.9945	0.2229	0.0487	0.9731	0.9904	0.0441	0.0766	0.9877	0.9958
Sample11	0.0957	0.4810	0.9637	0.9898	0.1142	0.0313	0.9679	0.9894	0.0560	0.0464	0.9781	0.9928
Sample12	0.0595	0.7699	0.9754	0.9945	0.0812	-0.0004	0.9866	0.9954	0.0217	0.0597	0.9910	0.9971

Table 2. Statistical features at level one

	MEAN			STANDARD DEVIATION		
	CH	CV	CD	CH	CV	CD
Sample1	0.0000	0.0019	0.0005	0.0563	0.0658	0.0373
Sample2	-0.0038	0.0099	-0.0004	0.1291	0.1478	0.0927
Sample3	-0.0008	0.0105	0.0019	0.2024	0.1798	0.1473
Sample4	0.0017	0.0038	0.0021	0.1260	0.1271	0.0816
Sample5	0.0046	0.0152	-0.0012	0.1549	0.1672	0.1159
Sample6	0.0018	0.0033	-0.0003	0.1160	0.1054	0.0684
Sample7	-0.0003	-0.0007	0.0000	0.0400	0.0559	0.0304
Sample8	-0.0010	0.0005	0.0003	0.0854	0.0585	0.0461
Sample9	-0.0015	0.0027	0.0003	0.1234	0.1492	0.0789
Sample10	0.0004	0.0007	0.0003	0.0429	0.0607	0.0301
Sample11	0.0006	0.0001	0.0001	0.0580	0.0495	0.0371
Sample12	0.0002	0.0004	0.0001	0.0731	0.0354	0.0236

Table 3. Texture features at level two

	WAVELET DECOMPOSITION USING HAAR FILTER STATISTICAL FEATURES - AT LEVEL TWO											
	CH				CV				CD			
	Contrast	correlation	energy	homogi	Contrast	correlation	energy	homogineity	Contrast	correlation	energy	homogineity
Sample1	0.3669	0.3499	0.9157	0.9737	0.2683	0.0664	0.9538	0.9842	0.1396	0.1366	0.9382	0.9811
Sample2	1.6483	0.3978	0.7464	0.9171	1.1358	0.1121	0.8574	0.9490	0.8501	0.0319	0.8016	0.9347
Sample3	2.4808	0.4720	0.5951	0.8619	1.5268	0.1164	0.7864	0.9229	1.3257	0.0191	0.6307	0.8709
Sample4	1.2876	0.3889	0.7820	0.9285	0.8538	0.0230	0.8830	0.9574	0.7588	0.0409	0.8003	0.9335
Sample5	1.9898	0.3539	0.6841	0.8931	1.5753	0.0896	0.8255	0.9337	1.3227	0.0029	0.7273	0.9072
Sample6	1.0596	0.5641	0.7475	0.9172	0.5592	0.1012	0.8826	0.9612	0.4722	-0.0079	0.8173	0.9420
Sample7	0.1830	0.1876	0.9500	0.9837	0.1492	0.0087	0.9707	0.9898	0.1084	0.0608	0.9543	0.9858
Sample8	0.6357	0.3911	0.8756	0.9606	0.1612	0.0358	0.9495	0.9838	0.2980	0.0455	0.8754	0.9617
Sample9	1.3559	0.4955	0.7618	0.9233	1.1229	0.0132	0.8770	0.9543	0.7500	0.0167	0.7916	0.9317
Sample10	0.2935	0.3944	0.9341	0.9810	0.2229	0.0487	0.9731	0.9904	0.0422	0.0871	0.9559	0.9883
Sample11	0.4086	0.4747	0.9187	0.9752	0.1142	0.0313	0.9679	0.9894	0.1630	0.0466	0.9409	0.9806
Sample12	0.2679	0.5808	0.9570	0.9887	0.0812	-0.0004	0.9866	0.9954	0.0639	0.2557	0.9778	0.9934

Table 4. Statistical features at level two.

	MEAN			STANDARD DEVIATION		
	CH	CV	CD	CH	CV	CD
Sample1	0.0004	0.0000	-0.0001	0.1136	0.1599	0.0651
Sample2	0.0066	0.0068	-0.0011	0.2972	0.3060	0.1424
Sample3	-0.0092	-0.0347	-0.0135	0.4052	0.3664	0.2197
Sample4	-0.0007	-0.0015	0.0008	0.2299	0.2928	0.1368
Sample5	-0.0020	0.0044	-0.0047	0.3079	0.3566	0.1844
Sample6	0.0092	-0.0023	-0.0002	0.2143	0.1895	0.1057
Sample7	0.0003	0.0013	-0.0007	0.0688	0.1032	0.0584
Sample8	-0.0044	0.0005	-0.0012	0.1655	0.1176	0.0941
Sample9	0.0057	0.0002	0.0002	0.2886	0.3070	0.1333
Sample10	0.0033	-0.0008	-0.0011	0.0968	0.1165	0.0465
Sample11	0.0038	-0.0006	0.0003	0.1086	0.0898	0.0614
Sample12	-0.0039	-0.0010	0.0006	0.1495	0.0632	0.0401

For these 12 test sample images the output obtained after applying SVM classification method the graph got plotted as follows:

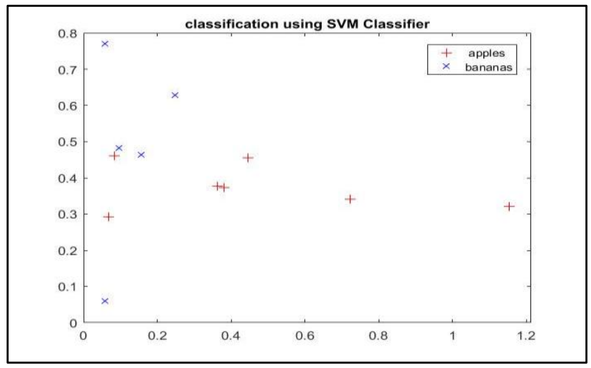
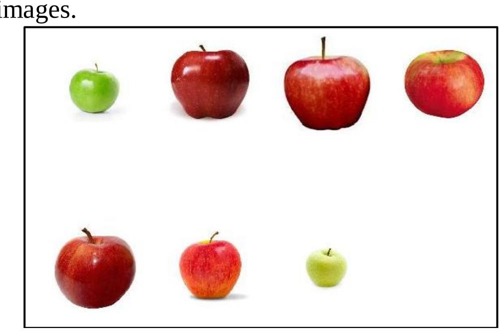
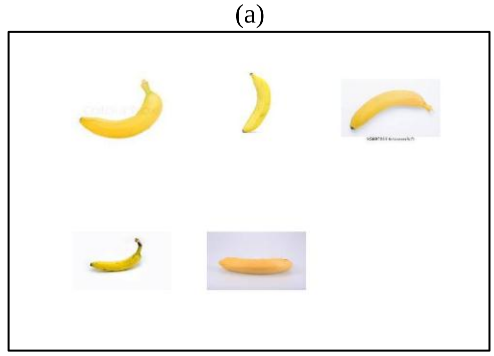


Figure 4. Scatter diagram of SVM classification output

In the above scatter diagram 'x' represents a banana image and '+' represents an apple image. Out of the 12 test sample images 5 images were banana images and 7 images were apple images.



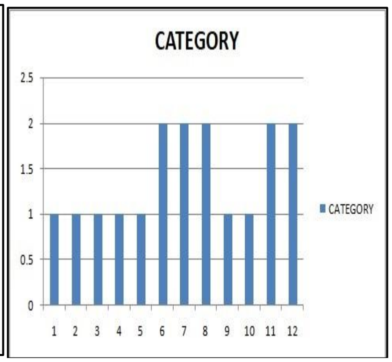
(a)



(b)

Figure 5. (a) Apple test images (b) Banana test images

SVM CLASSIFICATION	
SAMPLE	CATEGORY
1	1
2	1
3	1
4	1
5	1
6	2
7	2
8	2
9	1
10	1
11	2
12	2



(a) (b)

Figure 6. (a) SVM Classification table '1' – apple , '2' – banana
(b) Bar chart for SVM output

The above figure 6 gives the SVM classification table and its equivalent bar chart representation.

4.2 Discussion

The above listed results were obtained using 12 test samples taken out from the actual no. of 140 and 50 images used for training and testing. The above algorithm was coded and tested using MATLAB software. Different apple varieties and banana varieties that had different backgrounds were taken for training and testing. SVM gave 100% accuracy when compared to KNN classifier. Though there are so many methods that are there in this field , this paper exposes a different methodology wherein the given RGB when converted to Hue gives 100% accuracy rate if SVM is used. Apart from the existing methods of extracting colour features , this methodology uses texture features and statistical feature for all the coefficients obtained from wavelet transformation using Haar filter at both level one and level two. Only the Hue component image was considered for experimentation from the HSI image as it alone gave 100% classification accuracy Colour features were not used to classify the image that was one among the unique feature of this proposed system.

IV. CONCLUSION AND FUTURE SCOPE

Sample images of apples and bananas were alone taken for experimentation, in future few more fruits or vegetables can be taken as samples for experimentation.
Images having white background alone can only be considered for testing this algorithm using KNN classifier. Sample images should be acquired at 360 degrees in order to obtain 100% accuracy in real time classification of any fruit or vegetable in the agriculture industry. Thus a machine vision system for segregating/ classifying apple fruit and banana fruit was developed and tested for 100% accuracy and the same was obtained

Also this research work can be extended to help the agriculturist to classify different varieties of apples and bananas.

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