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Automated Process of Fruit Recognition Using Computer Vision

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Abstract: The capability of a machine in order to identify the quality of fruit is an essential part in the food industry. This has resulted due to the fact of people being conscious of the health factors and the quality of fruits they intake. However, there are multiple types and categories of fruits available in the market and identifying each category of them is a tedious task. Therefore, it is necessary to comprehend the forms of fruits and classify them so that they don't deteriorate over time. This is the primary reason for the contribution of the author of the proposed research to identify the respective domain and classify the accordance of fruits with respect to its existential quality. For the above-mentioned reasons; the author uses a detections method that is responsible to detect the texture of the fruit along with its color and shape and further use techniques of image processing to recognize the respective fruit. In addition to this, the author also uses techniques of computer vision wherein various process of image segmentation is carried out using MATLAB as the implementation portal. The research is further capable to classify and implement the project in real time wherein the process of image segmentation is carried out using feature extraction and recognition techniques. However, the implementation of the research occurs in stages wherein the raw image is initially converted from RGB to greyscale and further processing image illumination is carried out. Finally, the algorithms of support vector machine (SVM) and KNN is used as the classifier to detect and recognize the respective fruit.

Keywords: Recognition, detection, image processing, SVM, KNN

Introduction

Identifying and recognizing various kinds of fruits is one of a tedious task in the agricultural and the food industry. This process is however necessary in order to identify fruits and further classify them into their existing categories so that the fruit vendors can determine their right prices. For this to occur, the usage of barcodes is commonly utilized wherein the fruit is placed on the machine and further categorized and recognized to be a specific kind of fruit. The usage of barcodes further enables the customer to use and pick the fruit of their choice and weigh them accordingly. In addition to this, the recognition of fruits is also done in order to verify and determine the cost of the respective fruit using barcodes; since the process would have either become tedious; had the cost been known using a manual process of verifying it from a list. This entire process would therefore become a tedious and a time-consuming task. Hence, this demands the usage of moder technology that could conduct the process using machine learning, image processing and computer vision techniques. Identifying fruits and further recognizing them using computer vision becomes a very easy to do job by the machine wherein techniques and algorithms of converting a raw image to a greyscale image is performed using lines of codes. Various forms and types of fruits are thereby identified using this process. In addition to

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recognition of fruits, the detection of their quality can also be done using the same technique and algorithms. This not only saves the time but also makes the entire process of recognition a hassle-free task. The detection of the quality of fruits is majorly done by identifying the shape, size and color of the fruit [1].

Hence, the implementation of the proposed research work utilizes the concepts of computer vision and image processing techniques; along with executional implementation of algorithms such as SVM and KNN that are capable to recognize the category of fruit based on the color, shape and size of the same. The usage of SVM and KNN enables the precision score and accuracy of the research and also helps to reduce the overall time required to perform the same. Based on the recognition theory of identifying the respective fruits; the usage of SVM and KNN helps to attain high levels of accuracy so that an optimized system model could be achieved. In addition to this; the implementation of the respective algorithms are used to be executed on a large sample dataset thus obtained. This usage also enables and tends to overcome the issues of overfitting.

Since the primary aim is to recognize the type and category of a respective fruit; the raw image is initially obtained from a repository and pre-processed for image segmentation. The images are then converted from RGB to greyscale so that issues of over-fitting and overlapping is resolved.

The presented research paper also tends to conduct a thorough literature survey and presents a review on the same. The review mentions the work presented by different authors who have contributed their work in the same field. However; the process of implementation of the proposed research involves the collection of sample dataset from Kggle repository which comprises of 562 instances of fruit images. The repository comprises of two files namely as; test and train wherein they presented in a csv format. The images from the repository are initially obtained under natural condition of color and illuminations. In the next stage; the textural features of the fruits along with its color and shape are extracted. In the final stage; the recognition and the identification of the fruit is done using respective machine learning algorithms thus chosen. For the purpose of implementation of the proposed research paper; SVM and KNN are used to detect the same. Hence, in this manner; the respective fruits are recognized and identified based on their color, shape and texture.

Hence, in the entire process of recognizing fruits; the usage of image processing, computer vision and machine learning techniques are widely used which not only helps to recognize the type of fruit; but also helps to identify the quality of the respective fruit. Therefore, the authors of the proposed research paper; tends to contribute their work in the respective domain by identifying and recognizing fruits using the techniques and algorithms thus mentioned.

Literature Survey

In a research paper by authors [2] they used the methods and concepts of image processing techniques in order to recognize and further classify various types of mango fruits. For this purpose; they used the techniques and stages of processing a raw image using the binarization process wherein the obtained image form the repository underwent the process of greyscale conversion. The image size and the resolution was calculated and used for processing using various phases of feature extraction. The dataset was initially obtained from the Kaggle repository which comprised of two csv files namely; test and train. A total of 894 mango images were collected from the database and

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three machine learning algorithms were implemented on the same. On system execution it was observed that the implementation of SVM generated high levels of accuracy by producing a precision factor of 89 percent.

In another research work by authors in [3] they introduced the concept of detecting images of fruits which were initially morphed. The technique used to recognize the same followed the concepts of computer vision wherein the obtained citrus fruits underwent the stages of image processing based on the GLCM parameters. In addition to this; various other parameters such as the shape and the color of the fruit were also taken in to consideration. However; the entire implementation of the proposed system occurred in the stages of dividing the dataset sample into the ration of 70 and 30 wherein 70 percent of the dataset was used for training purpose and 30 percent of the dataset was used for testing purpose. The final implementation of the same occurred on three machine learning based algorithms namely; logistic regression, decision trees and a stacking algorithm. The stacking algorithm was however built using a hybrid approach wherein two classifiers were combined together and used as the implementation of one. The combined usage of algorithm enabled to increase the overall performance of the system model and thereby reduce the overall executional and time complexity. Hence, on implementation it was observed that the execution of the hybrid model with AdaBoost as the Meta classifier and the logistic regression as the base classifier generated high levels of accuracy in comparison to the other algorithms.

A research work in [4]; the authors conducted a thorough literature survey on the existing methods for detection and recognition of apple as a fruit. For this purpose they used the concepts of computer vision and image processing techniques wherein the image of the apple fruit was initially obtained from the Kaggle repository. The dataset sample used in the same comprised on 723 image instances of apple which were further used for training and testing purpose. The overall implementation also included a cross validation process wherein the sample dataset underwent 10-fold cross validation. In addition to this, the GLCM parameters were also taken in to consideration and the obtained images were further converted from RGB to greyscale. A histogram was thus created to fulfil the purpose of data visualization and the images were further split for training and testing purpose. The final implementation of the same occurred by performing a comparative analysis; utilizing three machine learning algorithms namely; logistic regression, decision trees and AdaBoost. On implementation it was observed that the execution of AdaBoost resulted into generation of highest accuracy.

Research work in [5], the authors conducted a conducted a comparative analysis wherein they performed a literature review of various methods of recognizing fruits. The methods included the limitations and the advantages of the existing systems along with its techniques and algorithms. It was observed that the usage of image processing enhanced the overall performance of the system model and increased the accuracy and precision factors of the same. On comparison, a conclusion on the accuracies thus obtained was also made and certain parameters such as the color, shape and the texture of the fruit was also taken in to consideration. The overall accuracy was however calculated using the precision factor thus obtained by using the confusion matrix and finally evaluating it on the basis of accuracy percentage thus generated.

Methodology Used

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This section of the research paper focuses on the methodology used to recognize an apple fruit and a banana fruit which is obtained from the dataset.

For the purpose of implementation, techniques of image processing comprising of GLCM parameters, image augmentation, image segmentation, conversion of RGB image to greyscale and feature extraction were used. To fulfill the purpose of the research of recognizing apple and banana as a fruit; the common features that can be used to distinguish between the two were used and masking was performed on the same wherein the intensity, color and the shape of the fruit were taken in to consideration in order to classify it as either apple or banana.

A. Dataset Used

For the purpose of implementation; 190 images were obtained form the Kaggle repository and performed on the system model thus proposed. The dataset was however obtained from Kaggle repository and 140 images were used for the purpose of training followed by 50 images which were used for the purpose of testing. In all the 140 images used for training purpose; 70 instances were comprised of apple images and 70 instances comprised of banana images. The apple images were red in color and juicy in texture followed by the banana images which were yellow in color and luscious in texture. On the other hand; the 50 images which were used for testing purpose comprised of 25 apple images and 25 banana images.

B. Region of Interest

Once the dataset from the respective repository is obtained; the images from the sample dataset undergo the process of determining the region of interest wherein only a specific region with maximum features that might contribute into fruit recognition are used. For this purpose; the obtained raw image is converted into greyscale using HIS color space. This conversion leads to filling up the morphological space thus created by the conversion so performed. After the process of conversion; the segmentation of the image is thus filled and the final ROI of the image is acquired.

C. Feature Extraction

After the process of getting the ROI of the image instance; the process of extracting features takes place wherein the image from the sample dataset is used in order to determine and further categorize it as either apple or banana.

For the purpose of implementation of the proposed research paper; the conceptual working theory of wavelet transformation is used in order to extract respective features of the sample image. The spatial domain of the respective image is thus defined and coefficient values of diagonal, horizontal and vertical pixel values is calculated. Next, the process of image segmentation takes place wherein statistical features of the image is thus calculated using the mathematical operations of mean and median values. In the next stage, all the correlations of the respective features is obtained and the GLCM parameters are calculated using DWT function.

D. Proposed Workflow

Once the dataset is obtained and the sample is acquired from the respective repository, a conversion of RGB images to greyscale images takes place wherein the pixel and the resolution of the image is altered in accordance to the processing technique thus used to develop the system model.

The entire execution of the system model occurs on MATLAB as the software. After the respective conversion of images from RGB to greyscale; the image instances are further given for the process of feature extraction. Extracting respective features of

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the images thus obtained is done in order to distinguish an apple image from the banana. This process is termed as extracting the region of interest (ROI) wherein only specific features of the dataset are extracted and the rest of the features are discarded from the background. This process also involves filling up the morphological space using wavelet transformations. The usage and implementation of such wavelet transformations involves the process of extracting vertical and horizontal textural features and thereby obtaining coefficient values. Once the defined stages of image processing is completed; machine learning algorithms of SVM and KNN are used to determine and recognize the respective fruit. Following are the steps used in the implementation of the same:

1. Gather the dataset
2. Convert RGB images to its respective greyscale image and adjust the resolution of the same
3. Perform image segmentation and discard background noise
4. Extract features of ROI
5. Perform wavelet transformation and obtain coefficient values
6. Perform the stages of training, testing and cross validation
7. Implement the system model using machine learning algorithms of SVM and KNN
8. Classify the obtained images of fruits as apple or banana

The architectural diagram below depicts the workflow of the proposed methodology.

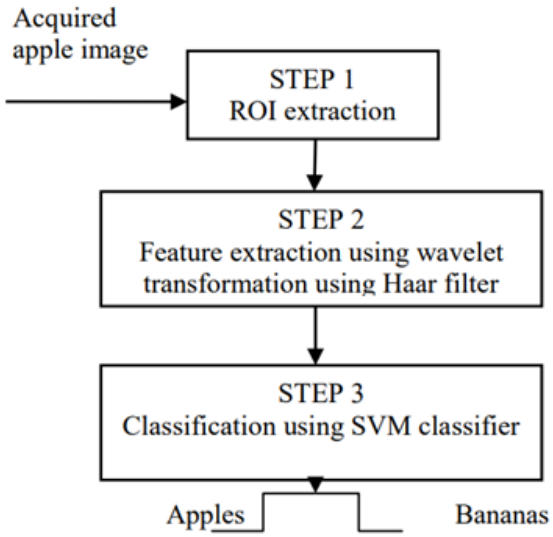

Figure 1: Workflow of the proposed methodology

Results

This section of the research paper briefs on the results thus obtained using the SVM and KNN classification.

The implementation of Support Vector Machine (SVM) is a commonly used algorithm of machine learning and is majorly used to classify system models. The primary aim of SVM is to establish a boundary which can be used in order to create an n-dimensional space in the hyperplane [6]. The hyperplane is used to further generate points and vectors. On the other hand, the implementation of K-Nearest Neighbor (KNN) is considered to be the unsupervised method of machine learning which is used for the purpose of classification of system models [7]. However, the primary aim of KNN is to cluster all the respective instances of a similar image class and to discover the final category of labelled dataset. The diagram below illustrates SVM and KNN as the classifier:

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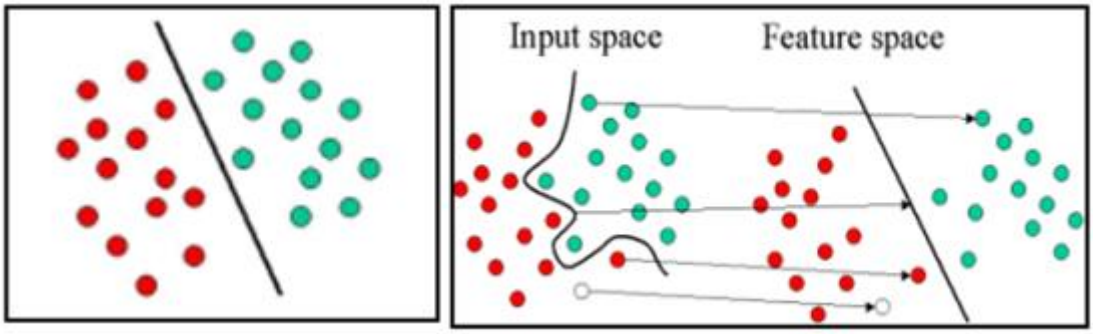

Figure 2: Schematic representation of the classifiers used

For the purpose of the proposed implementation; a total of 50 images were used. After the execution of step 1 as mentioned in the proposed methodology; following is the output hence achieved:

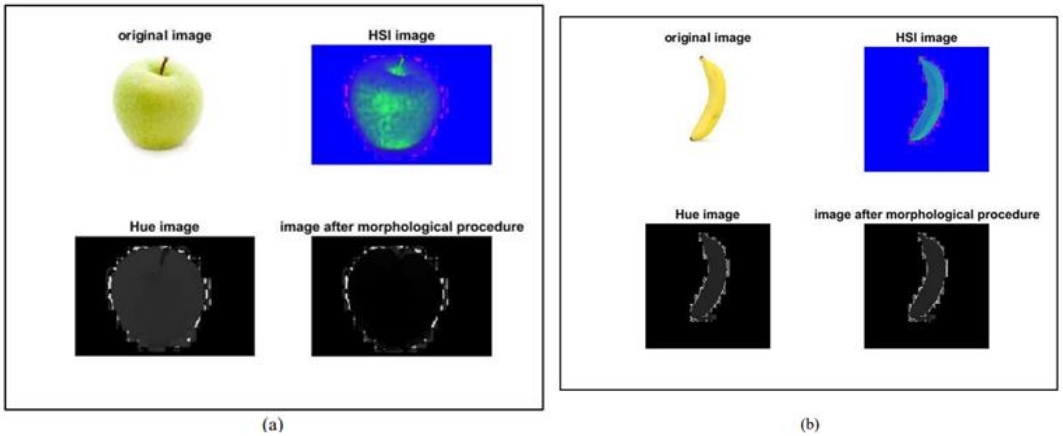

Figure 3: Schematic representation of the output obtained

From figure 3 above; it can be clearly witnessed that the conversion of RGB image to greyscale occurs through a pre-processing stage wherein the hue component of the image is taken into consideration followed by the process of feature extraction to get the ROI of the image. The result thus obtained also shows removal of the background noise by usage of wavelet transformation. However, for the purpose of calculation of mathematical operation of mean and median values; a total of 36 features are extracted and sent for the process of image segmentation. The respective values thus obtained through the calculation of the same is depicted in tables below:

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

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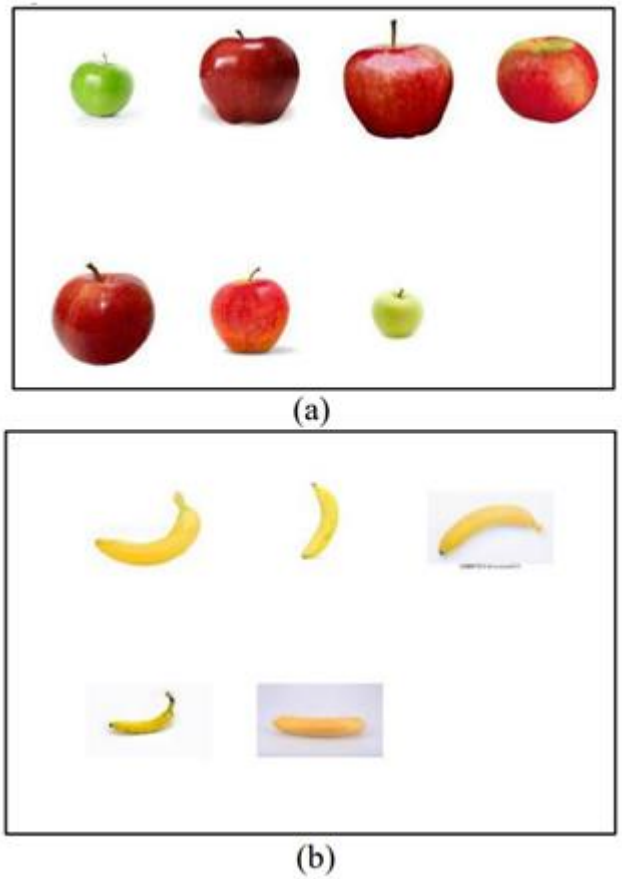

Figure 4: Sample Dataset

Conclusions

The primary aim of the research paper is to recognize fruit images given to the system model and further classify it as either apple or banana. For this reason; a dataset consisting of 140 sample images were taken from Kaggle repository and image processing techniques were applied on the same. The entire implementation however occurred through MATLAB wherein different varieties of apple and banana images were used with different texture. 70 percent of the dataset was used for training purpose and 30 percent of the dataset was used for testing purpose. On the other hand; SVM and KNN were used as machine learning classifiers and the initial RGB image was converted to greyscale using Hue compensation techniques and wavelet transformations. The methodology also used the color features of the sample image which contributed into detection of the HIS image. On implementation it was observed that the execution of SVM generated an accuracy of 89.23 percent and hence was declared as the optimized model.

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