Analysis of Color and Texture Feature Extraction for Food Image Classification

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Abstract—An imperative quality of fruits is its visual impact. Appearance not just impacts their market value, and the decision of the buyer, yet likewise, their inside quality to a specific degree. Texture, size, color, shape, as well the visual imperfections are generally reviewed to study the outside quality of food. In this manner, external quality control of fruits, computer vision systems have been widely utilized in the food business and have ended up to be a strongly appreciated apparatus for intensive work over years. The paper presents an automated system for classification of fruits. A dataset containing ten distinct fruits are constructed by downloading images from Google. Some extraction methods like Speeded Up Robust Features (SURF), Local Binary Pattern (LBP), Scale Invariant Feature Transform (SIFT),Gray Level Co-occurrence Matrix (GLCM),GABOR are discussed with the common features of fruits like color, size, shape and texture that gives the best accuracy. Indeed, chi- square distance is utilized to sort histograms according to the minimum distance & the one with minimum distance is retrieved as an output image. All the processing was completed in Matlab

Keywords—**:** LBP, SIFT, SURF, GABOR, GLCM

I. INTRODUCTION

The goal of this paper is to devise an efficient fusion of color and texture features for fruit recognition. Although for this purpose, there has been lot of work done already, but none holds 100% satisfaction to the users. Some systems do not succeed due to their hardware requirements, while others lack in providing comfort to such users. Striking advancements have been made in the use of food classification till now and specific improvement of such structures gives impaired shape detection. Yet at the same time, there stay various challenges to equal information access for the fruit classification. Agriculture is most important in human life. In India, 70% of people are suspended on agriculture because it is a backbone of Indian economy M. Bharti[1]. India is known to be a fruit basket of the world. After China, India has been considered as the second largest producer of fruits. Being the largest producer, it contributes only 1% of the global market of the fruit processing industry Aanchal Sharma[2]. A large variety of fruits are grown in India of which apple, banana, grape, mango, cherry are the major ones. Also, India is a large low cost producer of fruit and horticulture has huge export potential. According to fruit processing industry, fruits consist of vitamins, proteins, minerals and dietary fibers. Fruits are perishable in nature and in order to increase their storage or shelf-life there is a need to process fruits significantly.

Object recognition is a computer vision technique for identifying objects in images or videos. When any human glance at photograph or view a video, he can recognize people, object, scenes and visual details. The goal is to instruct a computer to do what comes naturally to humans: to gain a level of understanding of what image contains(A. Borji) [17].Likewise, in case cof fruit recognition technique known as CV will help us identify fruits along with its texture, color and features.

A complete goal of CV is to illustrate, reproduce and outperform the capacity of human vision using computer programming and equipment at different levels. One area where the use of this technology has spread quickly is in the investigation of food products (C. J.)[20] and specifically in the automatic inspection of fruits and vegetables. The quality of a piece of fruit or vegetable, fresh or processed, is characterized by a series of physicochemical characteristics that make it more or less attractive to buyers, such as its maturity, size, weight, presence of seeds, sugar content, etc.

II. LITERATURE SURVEY

A lot of work has been done for classification of color and texture of food images. The goal is to instruct a computer to do what comes naturally to humans: to gain a level of understanding of what image contains. There are many industries such as Indian agriculture industry consists of activities like quality inspection, sorting, assembly, painting, packaging are done manually whereas, by using Digital Image processing tasks done accessibly and easily. Using Digital image processing, one can complete tasks like object shape, size and color detection and other feature extraction etc. Various algorithms of shape detection are illustrate and conclusions are provided for best algorithm even merits and demerits of each algorithm or method are described like fractal dimension technique, Edge Detection and Boundary Tracing, Fourier Transform of Boundary, Scale Space fruit, chain code method, Fourier Transform of Boundary etc.. From above methods Circular Hough Transform (CHT) and Edge Detection and Boundary Tracing also provide better results Amit Chaudhari[1]However, in chain code method provides better results but in chain code comparison is difficult. Paras Patel et al.[2]

In order to utilize computers to analyze images has numerous potential applications for automated agricultural tasks was proposed in R.Newlin Shebiah et al.[3]. Consequently,paper presents a review of the main publications over the most recent ten years concerning new innovations and to the wide application of Computer Vision System in Food Processing Hilal A Makroo et al.[4].Survey on enhanced classification of Indian vegetables using combined color and texture features eas given in Ajit Danti[5] . A Novel Feature Descriptor was given in Avirup Bhattacharyya et al.[6] for Image Retrieval by Combining Modified Color Histogram and Diagonally Symmetric Co-occurrence Texture Pattern. In this, texture descriptor is named Diagonally Symmetric Local Binary Co-occurrence Pattern since it successfully captures the co- occurrence relationship between the symmetric neighbor pairs about the left and right diagonals of an image. The color descriptor centers around capturing the inter-channel relationship between the H and S channels of the HSV color space by quantizing the H channel into bins and voting with Saturation value and replicating the procedure for the S channel.

Resende Cui, Juan[7] in their paper "Health & Medical Informatics A Survey on Automated Food Monitoring and Dietary Management Systems" reviewed a wide variety of techniques in computer vision and artificial intelligence specifically designed for automated food recognition and dietary intervention. The progression of digital Image processing technology in the field of farming. Some image processing approaches used in the field of agriculture and fruit classification is depicted in paper Parth Dhameliya et al.[8]. In paper we done shape and texture extraction methods review in above session. Here some methods are presented like Fractal Dimension Technique, Hough Transform, Edge based detection etc. from this all technique fractal dimension and axis ratio shape detection (fuzzy logic) provide better outcome. Chain code additionally gives best outcome yet in chain code comparison is troublesome

III. IMAGE EVALUATION FEATURES

Color is an important feature for image representation and the most straight-forward feature that humans perceive when viewing an image(S. Kodituwakku)[34]. Next step in fruit classification is feature extraction Feature extraction is a low-level picture preparing application(T. Of)[31]. For a picture, the interesting part is features. After image segmentation, the next step is to remove image features which help in the description fruits. Different kind of features can be extracted from the image: shape, size, color, texture. There are some neighborhood detector and visual descriptor, which are utilized for object recognition and classification. Some of them are Speeded up Robust Features (SURF), SIFT (Scale Invariant Feature Transform), Gabor filter (edge-detector), GLCM (Gray-level co-occurrence matrix), and Local Binary Pattern (LBP) are demonstrate in next section.

LBP (Local binary pattern):- It is a basic and very efficient texture operator which is utilized for naming each pixels and considering the result as a binary number. The main objectives of LBP are to expand the exactness and acknowledgment time. LBP has turned into a prevalent approach in different certifiable applications such as pedestrian detection and face recognition(S. Naik)[24]. It is an important operator for real-world applications is its power and calculation effortlessness. LBP is used for describing the texture and model of an image. Thus, LBP is used in this work to improve the accuracy of fruit classification.

SIFT (Scale Invariant Feature Transform):- SIFT (Scale Invariant Feature Transform):- It is a computer vision algorithm utilized for identification ,an illustration of local features in images.and to distinguish locations and scales that can be assigned under various perspectives of the same object. Moreover,it also detect and describe local features in images. (L. Juan)[14] Notwithstanding, SIFT has ended up to be very efficient in object recognition applications, it requires a vast computational complexity which is a major disadvantages especially for real-time applications [3, 4]. ***SURF (Speed up Robust Features) :-*** SURF is an advance version of Scale invariant feature transform descriptor. It is more robust and quicker than SIFT. Speed up Robust Feature (SURF) technique, which is an approximation of SIFT, performs quicker than SIFT without diminishing the quality of the recognized points [14]. It is depends on multi-scale space hypothesis and the feature detector is based on Hessian matrix. Since Hessian matrix has great execution and precision. It was introduced by Bay, H., Tuytelaars, T. and Van Gool, L in 2006 [16]. Both SIFT and SURF are thus based on a descriptor and a detector. [9].(Ebrahim Karami).

GLCM (Gray-level Co-occurrence Matrix):-Gray level co-occurrence matrix transforms an image into a matrix which corresponds to the relationship of pixels in the original image. It calculates the mutual occurrence of pixel pairs for a specific distance and in a particular direction(P. Mohanaiah)[13]. An example of GLCM calculation is shown in Fig. 3. In Fig. 3, first matrix is image matrix and second matrix is the gray level co-occurrence matrix. Pixel pair of (2, 2) with distance '1' and angle 0 is denoted by red arrow in the first matrix and this pixel pair is occurring three times in the original matrix, and accordingly in the GLCM at position (2, 2) a number '3' is occurring. Similarly, for other pixel pairs, GLCM is calculated as:

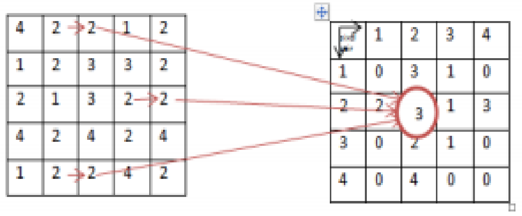
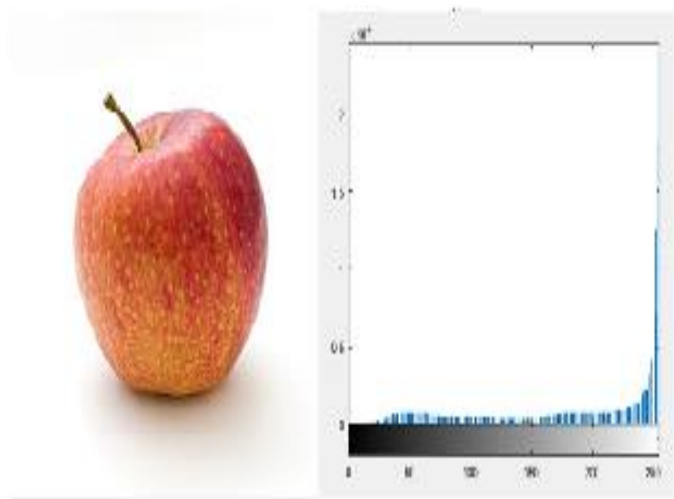


Figure1: Gray level co-occurrence matrix

***Gabor Filter (also known as Edge Detector)*:-** Gabor filter are broadly and effectively utilized universally, such as in many computer vision tasks, such as in texture segmentation, face detection and recognition, and iris recognition. In a feature construction, it's filters are utilized via multi-resolution structure and tuned to several different frequencies and introductions. The study of existing and advancement of new improvements which can be applied to filter parameter selection, filter construction, and feature computation. They are combined to provide a complete framework for optimally efficient computation of Gabor features. However, the main shortcomings of Gabor filter based features, the computational heaviness, has received any attention even though it may prevent the use of proposed methods in real applications. J. (Ilonen) [15] proposed a procedure where scale and rotation invariance were proficient by figuring distinctive scale energies of the Gabor filtered image. The basic hindrance of this method is the requirement to perform various matches in the scale measurement.

IV. PROPOSED METHODOLOGY

The methodology is the method or type of algorithm that being used to develop a system. This section outlines the methodology and data that are used to develop the Fruit classification System. For Fruits classification System, two new techniques LBP (Quantized Color based LBP) & GLCM are proposed based on hybrid features of SIFT, SURF& Gabor. LBP is acquired into our system due to its computational viability, re-silence towards light changes & strongest & due to its state-of-art execution in different issues. Gabor filter having a constant nature, is fitted into our systems. Color of each image is extricated utilizing HSV & after it undergoes distinctive quantization levels. This division of colors is appealing on the fact that color picture preparing performs openly on the color channels like HSV & does not present false colors. We demonstrate the execution of proposed structures alongside their correlation with each other based on several parameters, via figures and graphs. Assistive advancements for food classification are demonstrating a snappy improvement, giving profitable gadgets to support every day exercises and to upgrade social consideration. Keypoint matching is basic feature of Computer vision object recognition& is utilized with the goal of food classification.



(a) (b)

Figure2: (a) an object,(b) its corresponding HSV Histogram

A. Proposed Flowchart

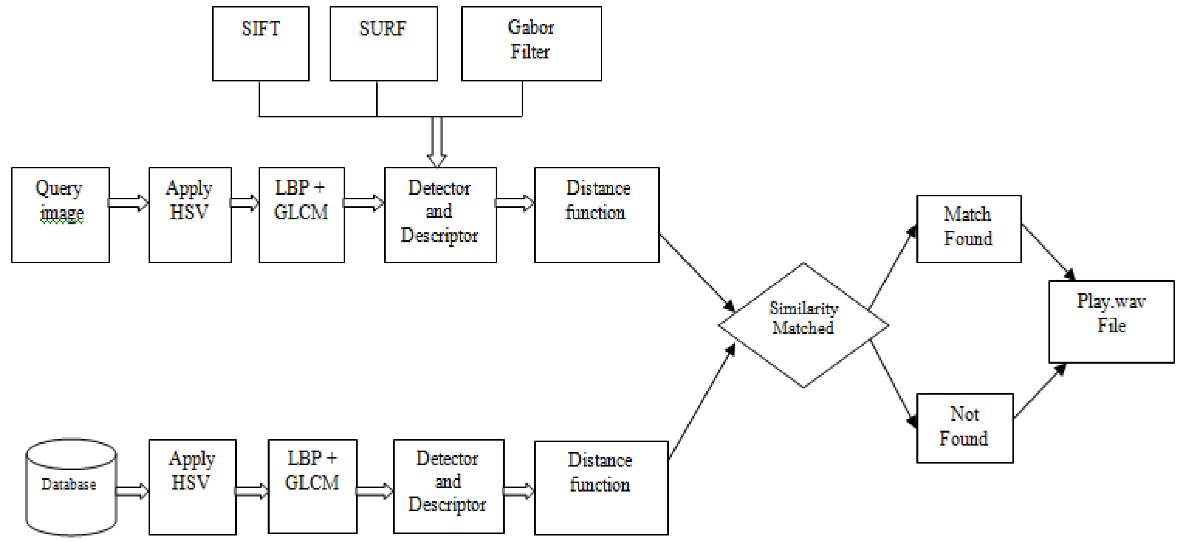


Figure3: Flowchart represents the working of proposed system

The figure shows the flowchart feature extraction of images and also the examination of input image and the database is presented. A sound is received by the user on finding the matched image. The user usually receive information through the speakers .In the Flowchart, a user generates an input image forming an image of an object, then the conversion is done from the coloured image of an object to HSV. Later, LBP and GLCM methods are applied along with the descriptor combination of SIFT, SURF and Gabor (as per cases shown in Figure 4) is also applied over each component and its histogram is generated.Furthermost, similar steps are run over the existing images in the database and generation of corresponding histograms happen .Leading to the output obtained from the histograms based on chi-square and the final output image is dependent upon the matched object having nearest distance.

CASE No.	Option (SIFT)	Option1 (SURF)	Option2 (GABOR)	LBP	GLCM
Case1	0	0	0	1	1
Case2	0	0	1	1	1
Case3	0	1	0	1	1
Case4	0	1	1	1	1
Case5	1	0	0	1	1
Case6	1	0	1	1	1
Case7	1	1	0	1	1
Case8	1	1	1	1	1

Figure4: Combination of SIFT,SURF ,Gabor, LBP and GLCM

Results will be obtained by the above eight cases .LBP/GLCM value be '1' that it is applicable in all cases. CASE1-CASE8 will be applied on the database on images, corresponding results will be obtained. In it, feature extraction methods are applied and result will be formed basis of it. However, at a time 2-5 methods will be applicable on the whole database .The value of option='1' that means particular method is applicable if value of option='0' then method is not applicable. To illustrate this, as shown in CASE1 option represents SIFT method and option1 and option2 represents SURF and Gabor respectively and their value='0' that means LBP + GLCM is applicable while, in CASE 5 option='1', option1and option2='0'that means SIFT+LBP+GLCM is applicable. Similarlily, in CASE 8 their value='1'that means SIFT+SURF+GABOR+LBP+GLCM is applicable.

B. *Proposed Algorithm*

Algorithm in the form of steps:

- A user generates an input image forming an image of an object, being sourced from the database.
- A conversion is done from the colored image of an object to HSV and separation of its three segments are termed as H (Color), S (saturation) & V (light).
- At this stage, eight cases will be formed as shown in above figure .In it, feature extraction method is applied and result will be formed basis of it. However, at a time 2-5 methods will be applicable on the whole database.
- LBP and GLCM methods are applied along with the descriptor combination of SIFT, SURF and Gabor (as per cases shown in Figure4) is also applied over each component & a Histogram is generated.
- Arriving this stage, chi-square formula to measure the distance is applied in order to sort histograms and least distance being the final output image.

$$x_{x,y}=\sqrt{\sum_{j=1}^{j}\frac{i}{c_j}(x_j-y_j)^2}$$

Where x & y are profiles of images or sites

- To check the similarity, image obtained as an output is examined with the input image. The output image is identical to the minimum distance of the input image, which has been sourced from the database.
- Audio recordings are heard as an output result to the user.

C. Similarity Measure:

In content based image retrieval for retrieving and classifying images beside color and texture feature computation, similarity measure is of same significance. The distance between the query image feature vector and feature of each image from the database in the feature space is given by the similarity measure which is performed after feature calculation. Indexing is then done in view of this measure and sorting of the set of retrieved images is done based on the images with lower indices measures. Calculation of similarity matching is finished utilizing chi-square distance measure and accuracy is matched using following various distance measures.

- Chi-square Distance

$$x_{x,y} = \sqrt{\sum_{j=1}^{J} \frac{1}{c_j} (x_j - y_j)^2}$$

- Euclidean distance

$$d_{rs}^2 = (x_r - x_s)\,(x_r - x_s)'$$

- Standardized Euclidean distance

$$d_{rs}^2 = (x_r - x_s) D^{-1} (x_r - x_s)'$$

- Minkowski metric

$$d_{rs} = \left\{ \sum_{j=1}^{n} \left| x_{rj} - x_{sj} \right|^p \right\}^{\frac{1}{p}}$$

- City Block metric

$$d_{rs} = \sum_{j=1}^{n} \left| x_{rj} - x_{sj} \right|$$

- Cosine distance

$$d_{rs} = (1 - x_r x'_s / x'_r x_r)^{\frac{1}{2}} (x'_s x_s)^{\frac{1}{2}}$$

Correlationdistance

$$d_{rs} = 1 - \frac{(x_r - \bar{x}_r)(x_s - \bar{x}_s)'}{[(x_r - \bar{x}_r)(x_r - \bar{x}_r)']^{\frac{1}{2}} \, [(x_s - \bar{x}_s)(x_s - \bar{x}_s)']^{\frac{1}{2}}}$$

$$\bar{x}_r = \frac{1}{n} \sum_j x_{rj} \quad \text{and} \quad \bar{x}_s = \frac{1}{n} \sum_j x_{sj}$$

- Hamming distance

$$d_{rs} = (\#(x_{rj} \neq x_{sj})/n)$$

- Jaccard distance

$$d_{rs} = \frac{\#[(x_{rj} \neq x_{sj}) \wedge ((x_{rj} \neq 0) \vee (x_{sj} \neq 0))]}{\#[(x_{rj} \neq 0) \vee (x_{sj} \neq 0)]}$$

V. EXPERIMENTAL RESULTS & COMPARATIVE ANALYSIS

A. Dataset

A new database was established as a result of unavailability of any open operatable dataset. The dataset contains images of distinct fruits namely apple, Grapes, mango, banana and Orange.

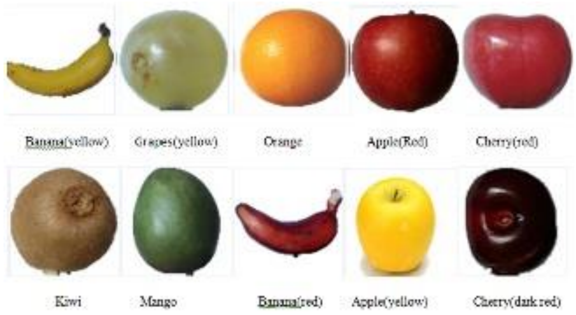
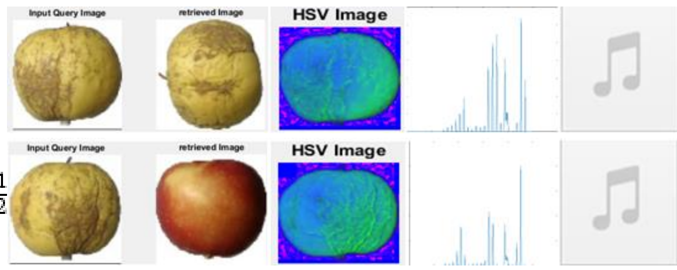


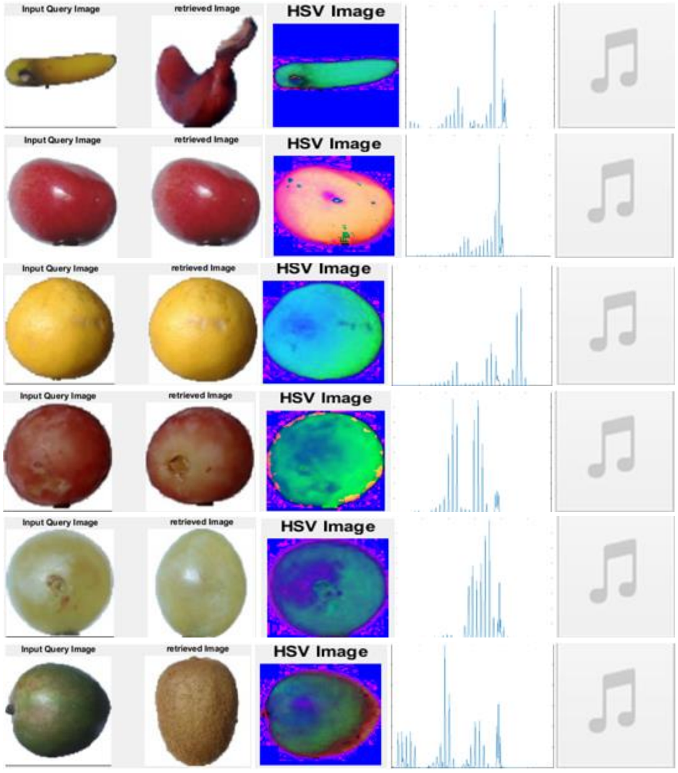
Figure5: Database Fruit Samples

Our database is prepared by downloading image from google. There are 10 objects & 15-20 sample images for each object. Few sample images from our database are shown in Figure5.

B. Output

First query image is selected from database ,at that point, HSV and other techniques such as LBP/ GLCM /SIFT/ GABOR are applied over it, then outputs retrieved image base on minimum chi-square distance s formed ,along with it corresponding histograms are formed .Likewise, on having least distance with query image comes as output or retrieved image. The entire process is shown in figure .It could be seen that in current algorithms such as combination of LBP,GLCM is applied on each cases .Moreover ,SIFT/SURF/GABOR are also applied and according to it outputs are obtained as shown in figure





(a) (b) (c) (d) (e)

Figure 6:(a)Depicts the input image(query),(b)output retrieved image base on minimum chi-square,(c)represents colored HSV image,(d) depicts correlated Histograms,(e)plays sound for each output

C. Evaluation Parameters

There must be certain parameters, based on which the obtained results are assessed & performance of the framework is measured. These parameters are important to know how well the system meets the objectives that it was determined to be. Here is a description of parameters utilized as part of our framework. These are as

True Positive (TP)*:* no. of correct yields received i.e. it detects the condition & that condition is actually present.

False Positive (FP)*:* no. of wrong yields recognized i.e. it detects the condition, when that condition is actually not present.

Sensitivity (sens)*:* measures the degree of positives that are accurately distinguished or capable of testing true positivity.

sens = TP/ (TP+FN)

Where TN=FP & FN=TP.

Specificity (spec)*:* measures the degree of negatives that are effectively recognized i.e. correctly distinguishes negatives.

spec = TN/ (FP+TN)

Positive predictive value (ppv)*:* is the probability that an output image is same as the query image or it is the degree of positives that identify with the condition's presence.

ppv = TP/(TP+FP)

Negative predictive value (npv)*:* It is the probability when an output image is not similar to the query image i.e. degree of correctly detecting negatives.

npv = TN/(FN+TN)

Recognition rate (RR)*:* it is an act of correctly perceiving correct object i.e. similar to ppv.

Accuracy*:* it is a condition of being correct i.e. correct outputs *100

D. Results

First, an input image is converted from the colored image of an object to HSV, Later, LBP and GLCM methods are applied along with the descriptor combination of SIFT, SURF and Gabor (as per cases shown in Figure 4) is also applied over each component and its histogram is generated. Furthermost, similar steps are run over the existing images in the database and generation of corresponding histograms happen .Leading to the output obtained from the histograms based on chi-square and the final output image is dependent upon the matched object having nearest distance However, it is clearly notable that HSV is completely overruled by the mixture of SIFT,SURF,Gabor i.e. for our system to detect similar objects, need not have to be of same color.

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Objects	Apple (red)	Apple (yellow)	Banana (yellow)	Banana (red)	Cherry	Grapes (green)	Grapes (red)	Orange	Kiwi	Mango
Images no.	20	20	20	20	12	10	10	10	18	20
TP	9	9	5	5	4	8	8	6	9	4
sensitivity	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000
specificity	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000
Ppv	0.9000	0.9000	0.8333	0.8333	1	0.9000	0.9000	0.9000	0.9000	1
Nnv	0.1000	0.1000	0.1667	0.1667	0	0.1000	0.1000	0.1000	0.1000	0
RR	0.9000	0.9000	0.8333	0.8333	1	0.9000	0.9000	0.9000	0.9000	1
Accuracy	90%	90%	83.333%	83.333%	100%	90%	90%	90%	90%	100%

Table 1: Table showing LBP+GLCM technique based on several parameter

Objects	Apple (red)	Apple (yellow)	Banana (yellow)	Banana (red)	Cherry	Grapes (green)	Grapes (red)	Orange	Kiwi	Mango
Images no.	20	20	20	20	12	10	10	10	10	10

TP	7	7	4	4	4	10	10	10	4	4
sensitivity	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000
specificity	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000
Ppv	1	1	0.6667	0.6667	1	1	1	1	1	1
Nnv	0	0	0.333	0.333	0	0	0	0	0	0
RR	1	1	0.6667	0.6667	1	1	1	1	1	1
Accuracy	100%	100%	67.66%	67.66%	100%	100%	100%	100%	100%	100%

Table 2: Table showing GABOR + LBP+GLCM technique based on several parameters

Objects	Apple (red)	Apple (yellow)	Banana (yellow)	Banana (red)	Cherry	Grapes (green)	Grapes (red)	Orange	Kiwi	Mango
Images no	20	20	20	20	12	10	10	10	10	10
TP	4	4	5	5	4	7	7	7	4	4
sensitivity	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000
specificity	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000
Ppv	0.5714	0.5714	0.8333	0.8333	1	0.7000	0.7000	0.7000	1	1
Nnv	0.4286	0.4286	0.1667	0.1667	0	0.3000	0.3000	0.3000	0	0
RR	0.9000	0.9000	0.8333	0.8333	1	0.7000	0.7000	0.7000	1	1
Accuracy	57.129%	57.129%	83.333%	83.333%	100%	70%	70%	70%	100%	100%

Table3: Table showing SURF+ LBP+GLCM technique based on several parameters

Objects	Apple (red)	Apple (yellow)	Banana (yellow)	Banana (red)	Cherry	Grapes (green)	Grapes (red)	Orange	Kiwi	Mango
Images no	20	20	20	20	12	12	12	12	10	10
TP	7	7	4	4	4	10	10	10	9	9
sensitivity	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000
specificity	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000
Ppv	1	1	0.6667	0.6667	1	1	1	1	0.9000	0.9000
Nnv	0	0	0.333	0.333	0	0	0	0	0.1000	0.1000
RR	1	1	0.6667	0.6667	1	1	1	1	0.9000	0.9000
Accuracy	100%	100%	67.66%	67.66%	100%	100%	100%	100%	90%	90%

Table4: Table showing SURF+GABOR+ LBP+GLCM technique based on several parameter

Objects	Apple (red)	Apple (yellow)	Banana (yellow)	Banana (red)	Cherry	Grapes (green)	Grapes (red)	Orange	Kiwi	Mango
Images no	20	20	20	20	12	10	10	10	18	20
TP	6	6	3	3	4	8	8	6	9	4
Sensitivity	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000
Specificity	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000
Ppv	0.8571	0.8571	0.5000	0.5000	1	0.9000	0.9000	0.9000	0.9000	1
Nnv	0.1429	0.1429	0.5000	0.5000	0	0.1000	0.1000	0.1000	0.1000	0
RR	0.8571	0.8571	0.5000	0.5000	1	0.9000	0.9000	0.9000	0.9000	1
Accuracy	85.71%	85.71%	50%	50%	100%	90%	90%	90%	90%	100%

Table5: Table showing SIFT+ LBP+GLCM technique based on several parameters

Objects	Apple (red)	Apple (yellow)	Banana (yellow)	Banana (red)	Cherry	Grapes (green)	Grapes (red)	Orange	Kiwi	Mango
Images no	20	20	20	20	12	10	10	10	10	10
TP	7	7	4	4	4	10	10	10	9	9
sensitivity	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000
specificity	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000
Ppv	1	1	0.6667	0.6667	1	0.8000	0.8000	0.6000	0.9000	0.9000
Nnv	0	0	0.333	0.333	0	0.2000	0.2000	0.4000	0.1000	0.1000
RR	1	1	0.6667	0.6667	1	0.8000	0.8000	0.6000	0.9000	0.9000
Accuracy	100%	100%	67.66%	67.66%	100%	100%	100%	100%	90%	90%

Table 6: Table showing SIFT+GABOR+ LBP+GLCM technique based on several parameters

Objects	Apple (red)	Apple (yellow)	Banana (yellow)	Banana (red)	Cherry	Grapes (green)	Grapes (red)	Orange	Kiwi	Mango
Images no	20	20	20	20	12	10	10	10	10	10
TP	4	4	5	5	4	8	8	8	4	4

Sensitivity	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000
Specificity	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000
Ppv	0.5714	0.5714	0.8333	0.8333	1	0.8000	0.8000	0.8000	1	1
Nnv	0.4286	0.4286	0.1667	0.1667	0	0.2000	0.2000	0.2000	0	0
RR	0.5714	0.5714	0.8333	0.8333	1	0.8000	0.8000	0.8000	1	1
Accuracy	57.14%	57.14%	83.33%	83.33%	100%	80%	80%	80%	100%	100%

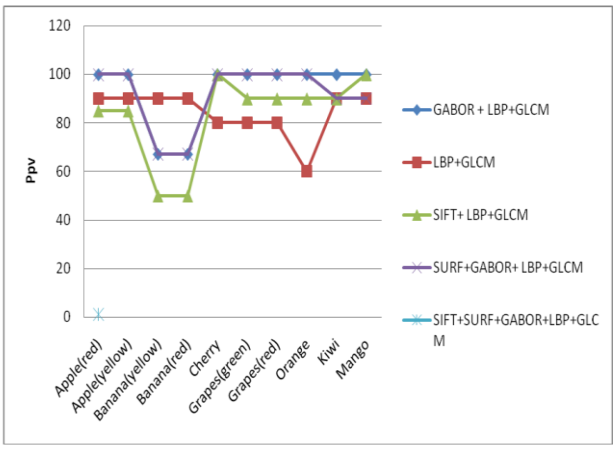
Table 7: Table showing SIFT+SURF+ LBP+GLCM technique based on several parameters

Objects	Apple (red)	Apple (yellow)	Banana (yellow)	Banana (red)	Cherry	Grapes (green)	Grapes (red)	Orange	Kiwi	Mango
Images no	20	20	20	20	10	10	10	10	10	10
TP	7	7	4	4	4	10	10	10	4	4
Sensitivity	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000
Specificity	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000
Ppv	1	1	0.6667	0.9000	1	1	1	1	1	1
Nnv	0	0	0.3333	0.1000	0	0	0	0	0	0
RR	1	1	0.6667	0.9000	1	1	1	1	1	1
Accuracy	100%	100%	66.66%	66.66%	100%	100%	100%	100%	100%	100%

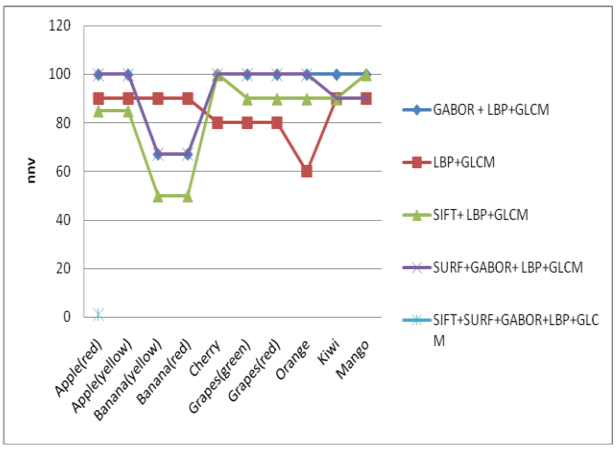
Table8: Table showing SIFT+SURF+GABOR+LBP+GLCM technique based on several parameters

Distance functions	Apple (red)	Apple (yellow)	Banana (yellow)	Banana (red)	Cherry	Grapes (green)	Grapes (red)	Orange	Kiwi	Mango
Chisquare	100%	100%	66%	66%	100%	100%	100%	100%	100%	100%
Euclidean	100%	100%	66%	66%	100%	100%	100%	100%	100%	100%
Seuclidean	57%	57%	50%	50%	100%	10%	10%	10%	100%	100%
Minkowski	100%	100%	66%	66%	100%	100%	100%	100%	100%	100%
Cityblock	100%	100%	66%	66%	100%	100%	100%	100%	100%	100%
Squaredeuclidean	100%	100%	66%	66%	100%	100%	100%	100%	100%	100%
Chebychev	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Cosine	85%	85%	66%	66%	100%	80%	80%	80%	100%	100%
Correlation	85%	85%	66%	66%	100%	80%	80%	80%	100%	100%
Spearman	70%	70%	50%	50%	100%	80%	80%	80%	100%	100%
Hamming	57%	57%	50%	50%	100%	30%	30%	30%	100%	100%
Jaccard	57%	57%	66%	66%	100%	20%	20%	20%	100%	100%

Table 9: Table showing Accuracy using several Distance functions



(a)



(b)

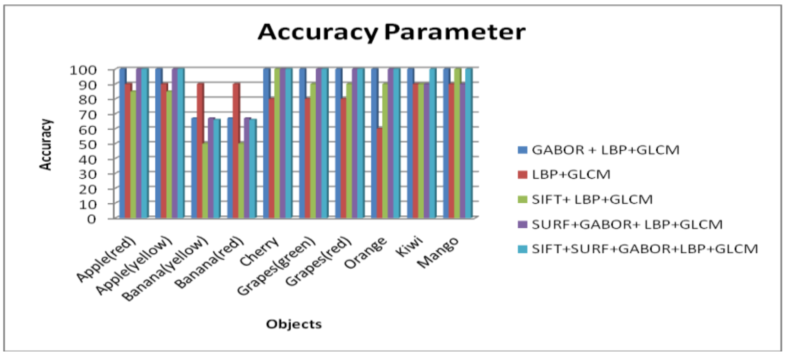


Figure7: Comparison of performance with existing techniques is depicted as,(a) Based on positive predictive value,(b) Based on Negative predictive value,(c) Based on Accuracy

VI. CONCLUSION

In this study, the hybridization of techniques has been carried out and implemented on variety of fruits and the observations observed are mentioned in the result table. From the above result, it has been concluded and analyzed that the fruit cherry has shown its excellency in each case ,whereas ,the fruits apple , grapes , orange , kiwi, mango has shown appreciable performance in cases2,4,6,8,while, the fruit apple has shown its least performance in cases3,7.Considering,the fruit banana has been analyzed that it has shown its moderate performance throughout except for cases 3,7.

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REFERENCES

[1] M. Bharti, N. Khatri, and A. Chaudhari, "Review on shape feature extraction and classification of fruit," vol. 3, no. 4, pp. 42–46, 2016.

[2] Aanchal Sharma, Neeraj Anand, Binod Kumar Singh "Fruit Processing Industry in India: A Short Review", 2016.

[3] D. Jasani, P. Patel, S. Patel, B. Ahir, K. Patel, and M. Dixit, "Review of Shape and Texture Feature Extraction Techniques for Fruits," vol. 6, no. 6, pp. 4851–4854, 2015.

[4] S. Arivazhagan, R. N. Shebiah, S. S. Nidhyanandhan, and L. Ganesan, "Fruit Recognition using Color and Texture Features," *Inf. Sci. (Ny).*, vol. 1, no. 2, pp. 90–94, 2010.

[5] A. Rafiq, H. A. Makroo, P. Sachdeva, and S. Sharma, "Application of Computer Vision System in Food Processing-A Review," *J. Eng. Res. Appl.*, vol. 3, no. 6, pp. 1197–1205, 2013.

[6] M. Madgi and A. Danti, "AN ENHANCED CLASSIFICATION OF INDIAN VEGETABLES USING International Journal of Computer Engineering and Applications , AN ENHANCED CLASSIFICATION OF INDIAN VEGETABLES," no. February, 2018.

[7] A. K. Bhunia, A. Bhattacharyya, P. Banerjee, P. P. Roy, and S. Murala, "A Novel Feature Descriptor for Image Retrieval by Combining Modified Color Histogram and Diagonally Symmetric Co-occurrence Texture Pattern," 2018.

[8] J. H. M. Informat, B. Vieira, R. Silva, and J. Cui, "Health & Medical Informatics A Survey on Automated Food Monitoring and Dietary Management Systems," vol. 8, no. 3, 2017.

[9] E. Karami, S. Prasad, and M. Shehata, "Image Matching Using SIFT , SURF , BRIEF and ORB : Performance Comparison for Distorted Images Image Matching Using SIFT , SURF , BRIEF and ORB : Performance Comparison for Distorted Images," no. February 2016, 2015.

[10] T. Meruliya, "Image Processing for Fruit Shape and Texture Feature Extraction - Review," *Int. J. Comput. Appl. (0975 – 8887)*, vol. 129, no. 8, pp. 30–33, 2015.

[11] S. H. Shirazi *et al.*, "Content-Based Image Retrieval Using Texture Color Shape and Region," *IJACSA) Int. J. Adv. Comput. Sci. Appl.*, vol. 7, no. 1, pp. 418–426, 2016.

[12] J. Moonrinta, S. Chaivivatrakul, M. N. Dailey, and M. Ekpanyapong, "Fruit Detection, Tracking, and 3D Reconstruction for Crop Mapping and Yield Estimation," *11th Int. Conf. Control. Autom. Robot. Vision, ICARCV 2010*, no. December, pp. 1181–1186, 2010.

[13] S. Sasano, X. H. Han, and Y. W. Chen, "Food recognition by combined bags of color features and texture features," *Proc. - 2016 9th Int. Congr. Image Signal Process. Biomed. Eng. Informatics, CISP-BMEI 2016*, pp. 815–819, 2017.

[14] L. Juan and O. Gwun, "A comparison of sift, pca-sift and surf," *Int. J. Image Process.*, vol. 3, no. 4, pp. 143–152, 2009.

[15] J. Ilonen, J.-K. Kämäräinen, and H. Kälviäinen, *Efficient computation of gabor features*. 2005.

[16] F. Firtha, "Computer vision for fruit and vegetable quality assessment," no. July, 2014.

[17] A. Borji and L. Itti, "Compuer vision vs. human vision: What can be learned?," *Comput. Vis. Pattern Recognit.*, p. 1, 2014.

[18] S. Gunasekaran, "Computer vision technology for food quality assurance," *Trends Food Sci. Technol.*,

vol. 7, no. 8, pp. 245–256, 1996.

[19] W. C. Seng and S. H. Mirisaee, "A new method for fruits recognition system," *Proc. 2009 Int. Conf. Electr. Eng. Informatics, ICEEI 2009*, pp. 130–134.

[20] C. J. Du and D. W. Sun, "Learning techniques used in computer vision for food quality evaluation: A review," *J. Food Eng.*, vol. 72, no. 1, pp. 39–55, 2006.

[21] A. Patel, P. Kadam, and S. Naik, "Color , Size and Shape Feature Extraction Techniques for Fruits : A Technical Review," *Int. J. Comput. Appl.*, vol. 130, no. 16, pp. 6–10, 2015.

[22] Madival, S. A., and S. Madole, "Recognition of Fruits in Fruits Salad Based on Color and Texture Features," *Int. J. Eng. Res. Technol.*, vol. 1, no. 7, pp. 1–6, 2012.

[23] Y. Zhang and L. Wu, "Classification of fruits using computer vision and a multiclass support vector machine," *Sensors (Switzerland)*, vol. 12, no. 9, pp. 12489–12505, 2012.

[24] S. Naik, "Machine Vision based Fruit Classification and Grading - A Review," vol. 170, no. 9, pp. 22–34, 2017.

[25] E. Saldaña, R. Siche, M. Luján, and R. Quevedo, "Review : computer vision applied to the inspection and quality control of fruits and vegetables. Revisão : visão computacional aplicada à inspeção e ao controle da qualidade de frutas e verduras," *Brazilian J. Food Technol. Campinas*, vol. 16, no. 4, pp. 254–272, 2013.

[26] M. Computing, "Content Based Image Retrieval using Color Feature Extraction with KNN Classification," vol. 3, no. 5, pp. 1274–1280, 2014.

[27] R. Mahendran, J. Gc, and K. Alagusundaram, "Application of Computer Vision Technique on Sorting and Grading of Fruits and Vegetables," *J. Food Process. Technol.*, vol. s1, pp. 1–7, 2015.

[28] N. Sharma , Aanchal;Singh, Binod Kumar;Anand, "Fruit Processing Industry in India: A Short Review," *Cold Chain Logist. Hortic. Agric.*, no. April, pp. 1–17, 2016.

[29] J. D. Pujari, R. Yakkundimath, and a S. Byadgi, "Reduced Color and Texture features based Identification and Classification of Affected and Normal fruits ' images," vol. 3, no. Ccm, pp. 119–127, 2013.

[30] W. B. Croft, "Color Feature Extraction," *Perspect. Content-Based Multimed. Syst.*, p. 49, 2000.

[31] T. Of and F. Extraction, "Texture Feature Extraction," no. I, pp. 83–107.

[32] M. A. Koslowski, F. G. Santos, G. B. Borba, and H. R. Gamba, "Fruits Classification Using MPEG-7 Descriptors from Image Patches."

[33] Y. Zhang, S. Wang, G. Ji, and P. Phillips, "Fruit classification using computer vision and feedforward neural network," *J. Food Eng.*, vol. 143, pp. 167–177, 2014.

[34] S. Kodituwakku and S. Selvarajah, "Comparison of color features for image retrieval," *Indian J. Comput. Sci. ...*, vol. 1, no. 3, pp. 207–211, 2004.

[35] H. N. Patel, R. K. Jain, and M. V Joshi, "Fruit Detection using Improved Multiple Features based Algorithm," *Int. J. Comput. Appl.*, vol. 13, no. 2, pp. 1–5, 2011.

[36] P. Mohanaiah, P. Sathyanarayana, and L. Gurukumar, "Image Texture Feature Extraction Using GLCM Approach," *Int. J. Sci. Res. Publ.*, vol. 3, no. 5, pp. 1–5, 2013.