A Review on Automatic Detection Techniques of Infected Fruits

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Abstract— In this paper we have discuss recognition techniques of automatic detection of normal and infected fruits. Nowadays computer science is getting more and more involved in agricultural and food science. Plenty fruits and vegetables are imported from the other nations such as oranges, apples etc. Manual identification of defected fruit is very time consuming, here work presents defect segmentation of fruits based on color features. In this paper we discussed the reviews of image processing and the general framework of image processing using different methods for automatic detection of fruits.

Index Terms— Artificial Neural Networks, Computer vision, Feature selection, Image Processing, Image segmentation.

I. INTRODUCTION

In today’s world for economic growth of nation, fruit industry contributes a major part, but because of lack of proper cultivation and maintenance, lack of knowledge of preservation and quick quality evaluation techniques, manual inspection, there has been a decrease in production of good quality fruits and very high post harvest losses in handling and processing. In such case there is the demand of a rapid, economic, consistent and non-destructive inspection method to get rid of problems like rising labour costs, shortage of skilled workers. [1]. As we know fruits exist everywhere we live. As diseases of the fruits are inevitable, detecting disease plays an important role in the field of Agriculture and fruit industry. As it reduces quantity and degrades quality of the agricultural products, this require careful diagnosis and detection, for this we require automation which can reduce the costs by promoting production efficiency. Automatic fruit grading and sorting requires the implementation of computer vision systems[2]. In this paper we are going through an overview of detection of different fruits using different techniques.

II. HISTORY

For classifying and detecting apple diseases using machine vision there are many researchers who made considerable efforts. And Several approaches like monochrome-colored near infrared imaging, and local-global methods have been tried[3]. It include computerized method from magnetic resonance images by threshold technique. The algorithm was only able to discriminate between all-bruised and non-bruised apples and was not applicable to on-line detection[3],[39].Other work used a thinning algorithm to discriminate between stem and body of the apples on monochromatic images. However the task of classifying the calyx and defected parts real-time was missing.[3],[40]. another work presented the ‘flooding’ algorithm for initial segmentation and ‘snakes’ algorithm for refining the boundary of the blemishes on the monochromatic images of apples. They applied both median and gaussian filters to remove impulsive noise and smooth small features.[3],[41]. the recent work included color (red, green, and blue) grading of apples by neural network using reflectance characteristics and concluded that multi-layer back propagation (MLBP) method gave the best recognition rates[3],[42]. next researchers used a pixel-wise comparison method between the chromatic (rgb) values of the related pixel and the color reference model. The local and global approaches of comparison were effective, but further research was needed.researchers then introduced automated rule-based system by near-infrared images to classify ‘Red Delicious’ apples as defected or not. Detection techniques are also used to separate anthracnose affected lesion areas from normal area and graded based on percentage of affected area in many fruits[6]. One of the method is using ANN which has been a successful tool in predicting food properties of dairy products, fruits, vegetables and meat products[7]. further introduced a system where three different sensors (a vision system, a near-infrared spectrophotometer and an electronic nose system) are combined by using ANN for non-destructive detection quality [8].

III. METHODS USED FOR DETECTION OF INFECTED FRUIT

A. Automated machine vision

The inspection and evaluation tasks are done manually in earlier it results in subjective, inconsistent, unreliable and also differs from experts to experts. The primary and major disadvantage of manual sorting are much manpower required, excessive labour power and strength, low production, standard of grading is challenging to carry out and grading precision insecure, hence machine vision based system has been introduced. Machine vision refers to visual data that can be processed by a computer, including imaging in Gamma ray, imaging in X-ray, imaging in UV band, imaging in visible band and IR band, imaging in Microwave band and imaging

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in Radio band, line or spot perception of brightness and colour, time-varying optical signals.[18] Machine vision includes several processes. Images are acquired with a physical image sensor and computing hardware and software are used to analyse the images with the objective of performing a predefined visual task[26]. Based on image processing and analysis, machine vision is a novel approach for recognizing objects and extracting quantitative information from digital images[28].

Components of machine vision
Charge-coupled-device (CCD) camera
Computer disk/ tape drives
Computer hardware and software
Cables and software
Video monitor

![Block diagram of general fruit detection methodology](image)

**Fig. 1. Block diagram of general fruit detection methodology**

**B. Image Processing**

Image pre-processing is the name for operations on images at the lowest level of abstraction whose aim is an improvement of the image data that suppress undesired distortions or enhances some image features important for further processing and analysis task. It does not increase image information content. Neighboring pixels corresponding to one real object have the same or similar brightness value. In many systems image pre-processing methods are applied to the captured image which are stored in image database[9].Brendon J. Woodford , Nikola K. Kasabov and C.Howard Wearing in paper named “Fruit Image Analysis using Wavelets”[19] proposed wavelet based image processing technique and neural network .Fast wavelet transform with special set of Doubeniches wavelet was used to extract the important features. To retrieve the related images, the search used two steps. The first step matches the images by comparing the standard deviations for the three color components. In the second step, a weighted version of the Euclidean distance between the feature coefficients of an image selected in the first step and those of the querying image is calculated and the images with the smallest distances are selected and sorted as matching images to the query. Principal component transform (PC) and minimum noise fraction transform (MNF) are two commonly used techniques for extracting useful features from hyperspectral images. Both techniques are intended to maximize image features with a minimal number of independent components through orthogonal transformation of the original image data[11]. In general fruit length obtained with image analysis was significantly greater than that recorded with a stereomicroscopic. Advantages of image processing are the high amount of fruit parameters obtained with one single measurement, the minimization of human errors ,the reduction of time needed to obtain large data sets concerning fruit trait variability [19].

**C. Image Segmentation**

Image segmentation algorithms development has drawn extensive and consistent attention, relatively A research has been done on segmentation evaluation. As we know most evaluation methods are either subjective,or tied to specific applications and Some objective evaluation methods. In supervised objective evaluation method a manually-segmented reference image is used while in unsupervised objective evaluation the quality score is based solely on the segmented image[14]. We can say segmentation of the image is nothing but pixel classification. Image segmentation is important to separate the object and background clear regardless the image has blur boundary. The proposed improved bacterial foraging algorithm is implemented on the input image[22].It has an importance in image analysis and pattern recognition. It has applications in many fields like Analysis of Remotely Sensed Image, Medical Science, Traffic System Monitoring, and Fingerprint Recognition and so on. Image segmentation methods are based on two fundamental properties of the intensity values of image pixels: 1.similarity in which the concept is to partition the image into several different regions such that the image pixels belonging to a region are similar according to a set of predefined criteria and 2.discontinuity in this category, the concept of partition an image on the basis of abrupt changes in the intensity values is used. An example of this category is Edge detection which is similar to the boundary extraction. Researchers have been introduced many segmentation methods which can be broadly classified into six categories[5]:

* a. Histogram based Method

Computationally this is very efficient when compared to other image segmentation techniques as it usually require only a single pass through the image pixels. In this technique, a histogram is calculated from all of the image pixels, and the peaks and valleys are detected in the histogram. Now the image pixels between two consecutive peaks can be considered to a single cluster. Disadvantages of this method are it is not able to categorize when the image has no clear gray level histogram peak. and the continuity of the segmented image regions cannot be ensured.

* b. Edge Detection

![Fig. 2 Processing the fruit image (a) original image, (b) gray scale image (c) diversion image (d) tracking edge](image)

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It is very widely used technique in the image segmentation problems. It based on the detection of points considering abrupt changes at gray levels. The above figure shows the edge detection of mango fruit[17]. A disadvantage of this method is that it doesn’t work well when there are many edges in the image because in that case the segmentation technique produces an over segmented output, and it cannot easily identify a boundary or closed curve. For improving efficiency of this approach, it should identify the global edges and these edges have to be continuous.

c. Neural Network based segmentation methods

This method relies on processing small regions of an image using a neural networker a set of different artificial neural networks. After this, the decision-making method marks the regions of an image on the basis of the category recognized by the artificial neural network. Kohonen self organizing map is a type of network designed especially for such type of problems. To detect tomatoes, research analyzed the roundness and detected deformed tomatoes by applying the variation of fruit’s diameter, and Genetic Algorithm (GA) trained artificial neural network[23].

The first step for determination of genetic algorithm scheme is when GA is applied, is the determination of a genetic encoding scheme, namely to denote each possible point in the problem’s search space as a characteristic string of defined length. This is in order to be sure that GA will not only optimize network configuration but, in the meantime, genetic training will proceed on weight values. In this paper, weight values between each layer of the multi-layer feed-forward neural network are simultaneously coded as one chromosome. Also Partial least squares(PLS) is a well-known linear algorithm was considered the best option in neural network as the PLS algorithm builds a model that describes the relationship between sensor signals and the fruit-quality parameter to be predicted. [24].

d. Physical Model based approach

The physical model based image segmentation technique assumes that for an image, individual regions follow a recurring form of geometrical structure. This type of segmentation methods uses texture feature.

e. Region based methods

This image segmentation method uses the similarity of pixels within a region in an image. Sometimes a hybrid method incorporating the region based and edge based methods have been proved to be very useful for some applications.

f. Clustering (Fuzzy C-means clustering and Kmeans clustering)

The segmentation method using clustering approaches encounters great difficulties when computing the number of clusters that are present in the feature space or extracting the appropriate feature. This type of image segmentation is widely used due to the simplicity of understanding and more accurate result. K-Means clustering works well if the boundaries are well defined[10]. Some researchers present work on K-means clustering technique based on color features from the images. Defect segmentation is carried out into two stages. At first, the pixels are clustered based on their color and spatial features, where the clustering process is accomplished. Then the clustered blocks are merged to a specific number of regions. Using this two step procedure, it is possible to increase the computational efficiency avoiding feature extraction for every pixel in the image of fruits[5]. Using K-Means Clustering

Step 1. Read the input image of defective fruit.
Step 2. In order to remove the image noise and reduce detail levels the Gaussian low-pass filter (GLPF) smoothing operator is applied.
Step 3. Transform the image from RGB to L*a*b* color space as all of the color information is present in the a* and b* layers only.
Step 4. Calculate the histograms of the image to decide the number of clusters.
Step 5. Classify colors using K-means clustering in a*b* space, with Euclidean distance to measure the distance between two colors.
Step 6. Label each pixel in the image from the results of K labeled with its cluster index.
Step 7. Generate different images for each cluster.
Fuzzy C-Means
Step 1. Read the input image of defective fruit.
Step 2. In order to remove the image noise and reduce detail levels the Gaussian low
(GLPF) low pass filter smoothing operator is applied.
Step 3. Calculate the histograms of the image to decide the number of clusters.
Step 4. Classify pixel intensities using FCM algorithm (initial
value of m=2 and $\delta = 0.01$) with number of clusters as
determined in Step 3.
Step 5. Generate image by allocating different intensity levels
for each subclass of the image.[37]

Fig.7. Fuzzy C-means defect segmentation of an apple with
scab. (a) Filtered Image (b) FCM Processed Image

D. Features Extraction
It is a method of capturing visual content of an image. A set of
features are extracted in order to allow a classifier to
 distinguish between defect and non defect pattern. The non
defect fruit can be identified on the basis of textural
appearance. Extracted features are used in neural classifier to
train it for the recognition of particular class either defect or
non defect[16]. As defined in [21], features are refer to
external quality factors. These features are texture, size, shape,
intensity and defects. It is interesting to perform background
subtraction and focus in the object’s description. As
Background subtraction is a commonly used for segmenting
out objects of interest in a scene. It is a simple technique of
subtracting the observed image from the estimated image and
thresholding the result to generate the objects of interest.
The best channel to perform the background subtraction is the S
channel of HSV-colored images as S channel is much less
sensitive to lighting variations than any of the RGB color
channels[25]. It consist of Classification which is the process of
reducing images to usable information[32].

a. Color
In many pattern-recognition and computer-vision
applications, color information can be used to enhance image
analysis and improve segmentation results as Color images
carry much more information than gray-level ones.[20].
The most commonly used color feature model in image processing
is based on the primary spectral components of red (R), green
(G) and blue (B), here much of the data that applied as
network input were obtained from different color spaces.
a. Separating matrices R, G and B for each picture and
calculation of matric mean in two dimensions.
b. Transferring to L*A*B* color space and calculation of L, A
and B values distinctly.
c. Transferring to HSV color space using function that was
existing for this purpose in MATLAB Image Processing
Toolbox and calculation mean of matrices H, S and V in two
dimensions.
d. Transferring to HSI color space using function that was
written in MATLAB M-File editor and calculation
mean of matrices H, S and I in two dimensions[12].

b. Size
The size is estimated by calculating the area covered by the
fruit image. To compute the area, first the fruit image is
binarized to separate the fruit image from its background. The
number of pixels that cover the fruit image is counted and
considered as an estimate of size. Fruits are categorized as big,
medium, and small using the average area and variance
relationship: $A \_ kr2$; where $A$ is the average of the
normalized area and $r^2$ is the variance obtained from the
training data set. If the normalized pixel count in a fruit image
is $A$, and $A < A \_ kr2$; where $k$ is has been experimentally
estimated to be 1.45, then the fruit is categorized as small. If
$A \_ kr2 < A < A \_ kr2$ then it is categorized as medium;
otherwise it is considered big[21].

c. Shape
The another feature used by farmers is shape irregularity as
a quality measure. Four shape features which are calculated
from an image are area, perimeter, major axis length and
minor axis length. Number of pixels in an image is used for
determining the area of the image[15]. Fruits having irregular
shapes are considered of better quality. It is estimated from
the outer profile of the fruit image. The estimation steps are
described below[21].

1. Using an edge tracking operator to estimate the outmost
dege points of the fruit image.
2. Link the outermost edge points to form the outermost
profile of the fruit image.
3. Compute the centroid $(x_g, y_g)$ of the profile.
4. Starting from the topmost and leftmost point of the
profile
and moving clockwise calculate the sequence
$$r(t) = \sqrt{(x_t - x_g)^2 + (y_t - y_g)^2},$$
for $t=1, 2, 3, \ldots, N$, were $x_t$ and $y_t$ are the Cartesian
coordinates of the profile at profile boundary time $t$,
and $N$ is the total number of points in the profile.
5. Compute the Fourier coefficients of $r(t)$
$$a_n = \sum_{t=1}^{N} \frac{r(t) \cos \frac{2\pi nt}{N}}{N}$$
The value of the first coefficient was used as the
irregularity measure.[21]

d. Intensity
Pixel intensities is a simple available feature useful for
pattern classification. Intensity features depends only on
individual pixel values. The intensity and its variation inside
the fruit images can be measured by features like: median,
mode, standard deviation and variance.[16]

e. Defects
These are determined from the color intensity. An estimate of
the average brightness and variations in intensity of the bird
flicked area were obtained. The average brightness was
thoroughly examined and the bird flicked area size was tracked and estimated. A pixel belongs to the bird flicked area if the brightness of a pixel lies in the interval \( I_b \_kr2 \_b \); where \( I_b \) is the average brightness of the pixels and \( r2b \) is the variance in the bird flicked area, and \( k \) is an experimentally determined constant. The bruises are estimated from the shape as they generally deform the shape by tearing the fruit. If observed finding an accurate estimate of bruises is an extremely difficult task[21].

CONCLUSION AND FUTURE SCOPE

This review paper shows the detection techniques for normal and defected fruits as well. Using artificial neural network is the best approach for quality analysis of fruits and it has a great scope in other food analysis field too.

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NOTE: COLOUR IMAGES ARE REQUIRED IN FIGURES WHERE SHOWN.

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