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A REVIEW ON IMAGE SEGMENTATION ALGORITHMS FOR DISEASE DETECTION IN LEAVES AND FRUITS

S. Kavitha[1], Dr. K. Sarojini[2]
Research Scholar, Assistant Professor & Head of the Department
Department of Computer Science
L.R.G. Government Arts College for Women
Tirupur, Tamilnadu, India

Abstract - The image segmentation is the process applied in order to fetch the significant objects from the given input image which in turn is used for further analysis. Image segmentation can also be coined as the technique of separating an image into different segments. Basically the segmentation is based on features such as pixel intensity value, gray scale, color, depth, brightness, texture, etc. Based on these there exists several image segmentation techniques. In this paper we present the review of the image segmentation methods.

Index Terms: - segmentation, clustering

I. INTRODUCTION

Image processing has an immense application in agriculture area. Detection of diseases at its earlier stage is much essential to avoid the huge loss. This can also help the farmers to safeguard them from the economical loss caused to them.

Studying the image understanding it and then extracting information from the image to accomplish an activity is considered as an important task and it is process of image segmentation. There is no need to process the entire image and only the required area of the image needs to be processed for further analysis. Segmentation is a process which is used for identification of such areas of interest. The image is made up of set of different pixels. The pixels which have related attributes are grouped together using image segmentation techniques. Pixels are grouped on the basis of the properties they have such as gray level, color, texture, motion, etc.,[1].

The segmentation focuses to limit the objects among all other and separating the image into significant illustrations. Apart from playing an important role in image processing the segmentation process forms the basis for feature extraction and image recognition. Based on certain criteria the given image is divided into number of segments. Many applications needs to process different areas of plants like leaves, fruits, vegetables etc., in order to identify the disease, identify the matured fruits and so on.
The main focus of this article is to update the researchers about the current segmentation techniques applied in the areas of disease detection in plants.

II. CLASSIFICATION OF IMAGE SEGMENTATION TECHNIQUES

Image segmentation methods are of two types based on properties of image.

1. Discontinuity based approach

   In this method image is segmented based on discontinuity or sudden changes. This technique searches for any sudden discontinuities in its pixel values which in turn indicate the edges that define a region. The most common segmentation methods which falls in this category is edge detection based segmentation [1].

2. Similarity based approach
   In this method image segmentation is carried out on the basis of similarities in the regions of an image. Some of the techniques based on this method are thresholding, region growing and clustering.

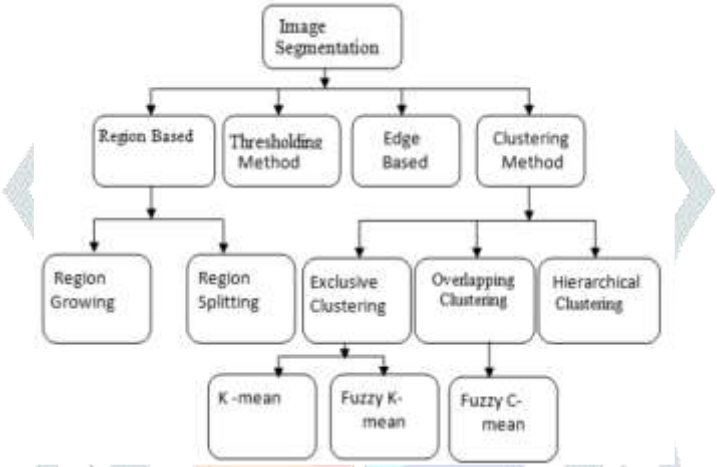

Fig. 1. Different Types of Image Segmentation Techniques [23]

Primary types of image segmentation techniques:

1. Thresholding Segmentation
2. Edge-Based Segmentation
3. Region-Based Segmentation
4. Clustering-Based Segmentation
5. Watershed Segmentation
6. Neural Networks for Segmentation

1. Thresholding Segmentation

The most effective method of segmentation which partitions the image into foreground and back- ground with a specific value. It is of two types bi-level and multilevel. If a single threshold value is used to differentiate the object from its background then its single level and if several different segments and multiple threshold values are used then its multilevel thresholding.

The most frequently used threshold segmentation algorithm is Otsu's method. The other methods are there minimum error method, Mean method ,entropy-based threshold segmentation, probability relaxation method, P-tile method, co-occurrence matrix, simple statistical method, fuzzy set, moment preserving method, Histogram dependent technique, , Edge Maximization technique etc.,

The calculation is simple and the also fast enough in case of the threshold method. The accuracy problem occurs in case of images with gray scale unevenness and also sensitive to noise [22].

2. Edge-Based Segmentation

The boundary between two pixels with different brightness values such as texture changes, gray value of the mutation, color mutation is an edge. The edge represents physical boundary between two objects which have

different intensities. The edge- based segmentation basically detecting edges first, then eliminates the irrelevant edges and then forms a group. The discontinuity is identified using derivatives which are calculated by differential operators. The commonly used differential operators are Prewitt operator, Sobel operator, Roberts's operator, Laplacian and Wallis operator.
If there is an image with many edges then the performance of this technique slows down and also it is sensitive to noise. The common algorithms in this category is Canny detector, Sobel graidient etc,.

3. Region based methods

The regions are a set of pixels and the algorithm finds these sets by locating a seed point. The point might be a small section or a large section. In the second step the algorithm will either add pixels or shrink the seed points. Computational cost is high in this approach.

3.1. Region Growing

In this approach it selects a random seed pixel in the image then compares that pixel with all the neighboring pixels and then start merging the region once it finds the matches to the seed point. If the selected region can't find matches then the algorithm will select the seed pixel which does not belong to any existing region.

3.2. Region splitting and merging methods

This approach focuses on the entire part of the image. Divide and conquer methodology is followed here. It first divides the image into many different sections and then matches them according to its predetermined values. Markov random field, graph cut image partitioning, pulse-coupled neural network, graph-based segmentation algorithm

4. Clustering based Segmentation

The Common and most widely image segmentation technique is K-means based clustering algorithm. The process of K-means is expressed: 1) it initially selects the centers randomly 2). Calculation of distance between the selected cluster and every sample is done 3).The center of new cluster is then taken as the mean and then all these above mentioned steps proceeded repeatedly. The most widely used algorithms in this category are Fuzzy c-means algorithm, multi objective optimization algorithm, spatial fuzzy genetic algorithm, multi-level low-rank approximation-based spectral clustering. These methods are easy to implement and also very fast. This method cannot find number of clusters initially.

5. Watershed Segmentation

The Watershed Segmentation is based on the concept of topological analysis. The brightness of a pixel is taken as height and fetches all the lines that run along the top of those ridges. It also defines the basins which are opposite of the ridges. It then floods the basins with markers until they meet the watershed lines going through the ridges. This algorithm play's an important role in medical image segmentation.

6. Neural Networks for Segmentation

In this method many elements are interconnected by links with variable weights to perform some tasks. Artificial neural networks are mostly used for pattern recognition. It consists of three layers the input layer, hidden layer and the output layer. These networks are trained with the image and then that image is processed with the already trained neural network. Here the color of each pixel is matched with the color of the winning neuron [22, 23].
Convolutional Neural Networks, ANN classifier are most widely known for image segmentation as they can identify and process image data much quickly and efficiently. The speed and accuracy is notably high when compared with other methods. Self-organizing maps (SOMs), discrete wavelet transform (DWT), methods on ensemble of self-organizing maps are best examples for this approach. These networks must be trained every time an input image is given.

III. COMPARISON OF VARIOUS SEGMENTATION METHODOLOGIES

Wolffang D et al., 2020, proposed Otsu's algorithm, which used threshold value t for each class that minimized the variance. The selected value t was in between peaks of intensity level. The process of binarization distinguished the object clearly from its background. Image was converted to binary type format when the optimal binarization threshold value was found and then the separation from the background was carried out. The background scene was eliminated by applying the AND operation between the original and the binarized image. MLP, KNN algorithm was used for classification and for clustering K-Means was applied. The performance was evaluated based sensitivity, accuracy, specificity metrics and precision. With the accuracy of above 90% KNN with MLP was proved as best [1].

Saifali Tamakuwala et al., 2018, proposed segmentation based on K means, conversion of RGB to HIS etc. Infected area of tomato was found using spot detection method. For classification k- means clustering algorithm was applied. The accuracy of 95 % was achieved by SVM [2].

Xuebing Bai et al., 2017, proposed FCM algorithm. Based on HIS Space the portion of the leaf was extracted by marked – watershed algorithm following the gray and weighted characters. During iteration the calculation of distance between the pixels and the clusters was done and center head was changed repeatedly. Then a two dimensional vector was created with the mean gray value calculated from the neighborhood pixels. When compared with three algorithms FLICM, FCM and SAFCM, the SAFCM dints separate the spots from background due to noise. FCM was also affected by noise. Comparatively FLICM was resistant to noise and segments were separated quickly. The performance was evaluated based on average number of iterations, running time [3].

Kai Tian et al., 2019, proposed an adaptive segmentation method and identified the diseased tomato leaves. K-Means clustering algorithm was applied. The initial clusters were determined by using the white paper image. Then by applying Manhattan distance for distance calculation the second clusters were determined. The proposed method was compared with DBSCAN, fixed threshold algorithm, Mean Shift algorithm, traditional K-means clustering and was proved that proposed method was accurate in segmentation of diseased leaves.
To determine the performance F1-measure and Entropy measures was used as parameters. The average values for F1 (0.982) and Entropy (0.118) values of the proposed methods [4].

Table.1. Comparison of Various Segmentation Methodologies

Article	**Objective**	**Segmentation Technique**	**No of Samples used**	**Results and performance**	**Future Scope**
Tomato classification according to organoleptic maturity (coloration) using machine learning algorithms K-NN, MLP, and K-Means Clustering [1]. Author : Wolffang D Journal : 2019, IEEE	Analyze the maturation stage of the fruits	Otsu segmentation technique	450	Greater than 90 % accuracies	Getting needs of farmers and working with automated system to allow the determination of physical characters
Quality identification of tomato using image processing techniques [2]. Author: Saifali Tamakuwala Journal : 2018, International Journal of Electrical, Electronics and Data Communication	Quality detection of tomatoes	Using spot detection	200	SVM - 95% accuracy ANN -73% accuracy.	To formulate a hybrid classification technique using SVM-ANN

A fuzzy clustering segmentation method based on neighborhood grayscale information for defining cucumber leaf spot disease images [3]. Author : Xuebing Bai Journal : 2017, Elsevier	extraction of cucumber leaf disease spot images	fuzzy C-means	129	Average segmentation error was only 0.12%.	reducing the running time while improving the efficiency and effectiveness of the algorithm.
Segmentation of tomato leaf images based on adaptive clustering number of K-means algorithm [4]. Author : Kai Tian Journal : 2019, Elsevier	To successfully segment the tomato leaf images more precisely and efficiently based on kmeans	Adaptive	800	Comparatively the proposed method was accurate and robust for tomato disease images segmentation average F1(0.982), Entropy(0.118) values	fully deploy the proposed algorithm in large-scale image-processing applications and mainly concerns the segmentation of images containing similarly colored objects.
Automatic image segmentation of oil palm fruits by applying the contourbased approach [5]. Author : Anindita Septiarini Journal : 2019, Elsevier.	separate the oil palm fruit from various kinds of background	Canny algorithm	160	The performance of the proposed method achieves Sc, FPe, and FNe of 90.13%, 2.92%, and 5.20%, respectively. Incorrect segmentation occurs more frequently in the images containing the multi-colored oil palm fruit, complex background, and non-uniform of illumination condition	the ripeness grading of the fruit area which detected correctly is still possible to be recognized
Segmentation of Different Fruits Using Image Processing Based on Fuzzy C-means Method [6]. Author : Yogesh Journal : 2018, IEEE	This method is used to segment a fruit image using color based segmentation on HSV image.	HSV – Fuzzy C-Means Method.		HFCM method provides excellent result in segmenting and recognizing almost every type of objects having various shapes, sizes and features even under natural Illumination.	HFCM method could reliably be employed in vision-based application such as fruit grading system and fruit analysis.
Superpixel-Based Fast Fuzzy C-Means Clustering for Color Image Segmentation [7]. Author : Tao Lei Journal : 2019, IEEE.	Colour image segmentation with a very low computational cost	superpixel-based fast FCM clustering algorithm SFFCM	two synthetic color images	very fast for color image segmentation, is insensitive to the change of parameters because the superpixel image obtained by MMGR-WT isconvergent.	explore fast clustering algorithms that automatically estimate the number of clusters
Image segmentation based on adaptive K-means algorithm [8]. Author : Xin Zheng Journal : 2018, Springer.	To overcome the existing difficulty in clustering	Adaptive K-means segmentation	--	is of high accuracy,	reduce the number of pixels and speed up the algorithm,

Automatic Segmentation of Plant Leaf Disease Using Improved Fast Fuzzy C Means Clustering And Adaptive Otsu Thresholding (Iffcm-Ao) Algorithm [9]. Author : M.Yogeshwari Journal : 2020, European Journal of Molecular & Clinical Medicine	To identify the leaf disease	Improved Fast Fuzzy C Means Clustering and Adaptive Otsu threshold (IFFCM-AO) algorithm	--	achieved a minimum average MSE of 0.892. Similarly, our framework achieved a good PSNR of 37.35	--
Early detection of decay on apples using hyperspectral reflectance imaging combining both principal component analysis and improved watershed segmentation method [10]. Author : Jiangbo Lia Journal : 2018, Elsevier	To identify the early decay of apples.	improved watershed segmentation method based on morphological filtering and morphological gradient reconstruction	440	99% detection accuracy	--
Tea leaf disease detection using multi-objective image segmentation [11]. Author : Somnath Mukhopadhyay, Journal : 2019, Springer	automatically detecting tea leaves diseases	Non-dominated Sorting Genetic Algorithm	312	type of disease persisting in tea leaves with an average accuracy of 83%	Hyperspectral plant images will be considered for remotely detecting diseases in tea leaves.
Image segmentation based on fuzzy clustering with cellular automata and features weighting [12]. Author : Chengfan Li Journal : 2019, Springer.	effectively segment common images and long-term sequence satellite remote sensing images	on fuzzy clustering with cellular automata (CA) and features weighting.	--	can effectively segment common images and long-term sequence satellite remote sensing images and has good applicability	find out the optimal feature combination, improve the segmentation speed and efficiency, and further apply to the satellite remote sensing image classification.
Sunflower leaf diseases detection using Image Segmentation based on Particle swarm optimization [13]. Vijai Singh, 2019, Elsiver.	Segmentation of Sunflower leaf images for disease classification	Particle swarm optimization	--	The average accuracy of classification of proposed algorithm is 98.0 % compared to 97.6 and 92.7 %	Combination/ hybridization of PSO with other methods like gradient search method may yield faster speed.
A Method of Apple Image Segmentation Based on Color-Texture Fusion Feature and Machine Learning [14]. Author : Chunlong Zhang Journal : 2020, Agronomy	To assess and optimize the suitability of color features, texture features for apple fruit image segmentation	Otsu based on R-B and boundary object removal could effectively segment part of apple and background	105	The classification algorithm based on Random Forest could effectively classify the apple fruit pixels, and the accuracy was 0.94.	deep learning network is complex, so it needs to run on the platform with rich computing resource
AN OTSU image segmentation based on fruitfly optimization algorithm [15]. Author : Chunyan Huang Journal : 2020, Elsiver.	FOA to quickly and stably optimize and select the optimal threshold for image	fruitfly optimization algorithm (FOA) FOA-OTSU	--	The results show that the segmentation time is reduced by about 50.0% more accurate segmentation results and	--

	segmentation			better restrain noise, but also has less running time and can segment images quickly and effectively	

Anindita Septiarini et al., 2019, proposed a segmentation method based on the edge detection method. Along with Gaussian smoothing, canny operation was also applied. To remove the noise from the image the morphology and reconstruction operations were applied. During the next phase the dilation operation was applied continuously until the images remains constant with the process of masking. The performance was evaluated using three indices false positive error, segmentation accuracy and false negative error. The results achieved were noted as 2.92%, 90.13%, and 5.20% respectively [5].

Yogesh et al., 2018, proposed a method based on HFCM which converted the RGB to HSV image and then segmentation process was carried out. The proposed method was compared with TsNKM method and it was proved that the proposed method proves best as the original image is converted to HSV then after that FCM method is applied. Analysis of various types of fruits was done efficiently in this proposed method. Better segmentation was carried out on various fruit images which had different pixel colors, intensity textures, noise content etc,. The performance was evaluated using the Similarity Index (S.I.) and Tanimoto Cofficient (T.C.) [6].

Tao Lei et al., 2019, proposed super pixel based fuzzy C- Means for color image segmentation. Compared with the neighboring window of fixed shape and size this method provides more number of irregular local spatial and also adaptive neighbors. The proposed method produced better pre segmentation and it was proved to be best compared with traditional methods like FGFCM, NWFCM, FCM_S, NDFCM and KWFLICM. The number of colors' in a super pixel images is smaller than compared to the original image and hence the computation of histogram was made easy. The proposed methods had limited execution time compared to the previous method. Execution time is the parameter for used for performance comparison [7].

Xin Zheng et al., 2018, proposed Adaptive K-means segmentation. The original image was first converted to LAB color space. Then for segmentation K- means methods was used. Morphological processing has been applied to reduce noise. The resultant image was then used to extract the connected domain from which match for the original image was obtained. To extract the edges the canny operator was applied. The performance was evaluated using the rate of error parameter [8].

M.Yogeshwari et al., 2020**,** proposed 2D Adaptive Anisotropic Diffusion for noise removal. Adaptive Mean Adjustment technique is used for enhancement. Then Fast Fuzzy C Means clustering algorithm was applied. Here image histogram was used instead of raw image pixels. The pixel values are then compared with the threshold value. The image is classified as foreground when the pixel is greater than threshold otherwise it is background. The performance is evaluated using peak signal to noise ratio and mean square error. The proposed method produced the PSNR of 37.35 and MSE of 0.892 [9].

Jiangbo Lia et al., 2018, proposed and improved watershed method for segmentation. The image was preprocessed using morphological filtering, and then morphological gradient of the image was obtained. By using the opening and closing operations the image was reconstructed. Then watershed line can be drawn by simplifying the gradient image. Based on marker constraint then gradient image is then segmented by watershed algorithm. The proposed method was not sensitive to surface color [10].

Somnath Mukhopadhyay et al., 2019, proposed a method for identifying the diseased tea leaves. The diseased area was detected using NSGA-II based clustering algorithm. Using Principal component analysis feature extraction was performed. The extracted features were then used in SVM for identifying the diseases parts. The objective of proposed method was optimizing Intra-cluster and Inter-cluster distance functions. To calculate the distance between the pixels the Euclidean distance function was applied [11].

Chengfan Li et al., 2019, proposed a method which segmented the common images and also the satellite images. The proposed method proved to be fast convergence speed. The method combined both the color spatial feature with the CA iteration to achieve the maximum speed I segmentation process. The pixel values of boundaries were kept constant. Fuzzy clustering is applied for segmentation and also the color weighting features were applied which keeps on updating and at last the high precision image is obtained. The performance of proposed method was evaluated on basis of time consumption (19.88 s) and PSNR (22.52) value [12].

Vijai Singh et al., 2019, proposed Particle swarm optimization algorithm. The preprocessing was done using Median filtering method. The output segments obtained from Particle swarm optimization method were fused for classification. Every pixel had its Red, Green and Blue components. The chromosome was represented by K cluster center. In all the sequence process the chromosomes were updated and the population was also initialized randomly. Each particle was updated by two best values in each iteration. The performance was evaluated using the average accuracy [13].

Chunlong Zhang et al., 2020, proposed a segmentation algorithm which selects the color and texture features at the first step and in the second step based on machine learning the pixels were classified and segmentation was carried out. 21 color features were obtained. The grey-level co-occurrence matrix (GLCM) included characteristic values such as dissimilarity, contrast, homogeneity, energy, ASM, correlation. Machine learning algorithm based classifiers were built which classified the pixels from other pixels. Performance was evaluated based on true positive values. The final resultant values of AF, FPR and FNR were 0.07, 0.13 and 0.15 respectively [14].

Chunyan Huang et al., 2020, proposed a threshold based method for segmentation. Fruitfly optimization algorithm (FOA) is very simple metaheu-heristic algorithm. FOA-OTSU segmentation Algorithm was applied. Initial positions were randomly generated. Then the density of taste was calculated using the distance formula. Then the fruit fly with high concentration of taste is traced out. A new population id formed when all the flies reach that new point. The calculation of speed was done using FOA which searched the threshold method and thus the performance was improved. The performance was evaluated by signal-to-noise ratio (SNR) and peak signal to-noise ratio (PSNR). Compared with the OTSU algorithm the proposed method consumes fewer time [15].

IV. DISCUSSION

Otsu algorithm works by finding the threshold value which minimizes the variance within the classes. It works well with the bimodal distribution. When combined with the particle swarm optimization method it produces considerable result. Image segmentation based on K-means algorithm proved to be accurate but it lacks in computation time. The image preprocessing step can be enhanced in such a way that the number of pixels in the can be reduced to speed up the process. When cluster centers are not estimated correctly then the results produced are not reliable. Fuzzy C-means algorithm based on weighted gray and spatial features proves that without being effected by the background noise segmentation were done effectively and also achieves accurate segmentation on sharp edges. The variation of lightening affects the output.

K- Means based on adaptive clustering method was used which works based on the optimal number of clusters based on the validity index of the images. Sometimes the over segmentation may happen which was avoided by selecting only two dimensional parameter for testing. Entropy results were best. K- Means and FCM are sensitive to noises. It misses the spatial information which in turn leads to the degradation of results. Superpixel based segmentation overcomes this issue by considering the spatial information for segmentation. Then color histogram is incorporated into function to achieve fast segmentation. The integration of adaptive k-means and thresholding produced good results because thresholding increases the accuracy of segmentation in all types of environments. The adaptive k-means id better suited for darker objects [17, 18, and 19].

DBSCAN, Mean Shift, threshold segmentation, traditional K-means algorithm are some of the most commonly used algorithms. The DBSCAN, Mean Shift algorithm can be over-segmented or under-segmented quickly because of the complex input parameters. The Segmentation algorithm proposed from Mask R CNN detects the overlapping fruits effectively. The images are classified based on entity class in the image. The samples are marked manually.

The apple was effectively segmented from its background using the ostu method based on RB boundary object removal method. The k means and adaptive threshold methods were not effective in the segmentation process. The pixel classification based image segmentation method is effective here. Neural network models based algorithms are found to have more desirable segmentation results, besides being robust these algorithms Segmentation with clustering technique is one of the most efficient techniques and shows better results than other segmentation methods [20,21].

The performance of segmentation algorithms is subjective to many aspects. With one metric it is not possible to decide all properties of segmentation, different methods and especially different evaluation metrics are to be combined. Some of the most commonly used metrics are Tanimoto Coefficient, FNR value, AF, FPR, Precision Rate and Recall Rate, F1-measure and Entropy quality measure.

V. CONCLUSION

In this paper a review on recent image segmentation techniques have been done. The most widely used performance measures in segmentation were also discussed. We have thus identified large number of operators widely used in image segmentation. A detailed discussion has been carried out to focus on the complications generally faced and also the answers have been notified. The intention of this work is to give direction to the researchers to understand about the segmentation algorithms. This work also highlights the useful measures of segmentation performance for the continuation of research work.

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