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Analyzing the Optimal Performance of Pest Image Segmentation using Non Linear Objective Assessments

Siva Sangari A[1], Saraswady D[2]
[1]Department of Electronics and Communication Engineering, GMR Institute of Technology, Visakapattinam, India
[2]Department of Electronics and Communication Engineering, Pondicherry Engineering College, Pondicherry, India

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ABSTRACT

In modern agricultural field, pest detection is a major role in plant cultivation. In order to increase the Production rate of agricultural field, the presence of whitefly pests which cause leaf discoloration is the major problem. This emphasizes the necessity of image segmentation, which divides an image into parts that have strong correlations with objects to reflect the actual information collected from the real world. Image processing is affected by illumination conditions, random noise and environmental disturbances due to atmospheric pressure or temperature fluctuation. The quality of pest images is directly affected by atmosphere medium, pressure and temperature. The fuzzy c means (FCM) have been proposed to identify accurate location of whitefly pests. The watershed transform has interesting properties that make it useful for many different image segmentation applications: it is simple and intuitive, can be parallelized, and always produces a complete division of the image. However, when applied to pest image analysis, it has important drawbacks (over segmentation, sensitivity to noise). In this paper, pest image segmentation using marker controlled watershed segmentation is presented. Objective of this paper is segmenting the pest image and comparing the results of fuzzy c means algorithm and marker controlled watershed transformation. The performance of an image segmentation algorithms are compared using nonlinear objective assessment or the quantitative measures like structural content, peak signal to noise ratio, normalized correlation coefficient, average difference and normalized absolute error. Out of the above methods the experimental results show that fuzzy c means algorithm performs better than watershed transformation algorithm in processing pest images.

Corresponding Author:

A. Siva Sangari,
Department of Electronics and Communication Engineering,
GMR Institute of Technology,
GMR Nagar, Rajam, Srikakulam Dt. Vizag, Andhra Pradesh, India.
Email: sivak_san04@yahoo.co.in

1. INTRODUCTION

India is the “Land of agriculture” which has many traditional and even a large variety of cultures. Approximately 75% of the Indian population is connected with agriculture. New modern agricultural technique is established in order to the quantity and quality of the yield. But the production is reduced nowadays due to reduction in landscape and also increasing of different kinds of pest, there is no possible way to increase the landscape but there is a possibility to reduce the effects of pest. In most of the cases, pests or diseases are seen on the leaves or stems of the plants like tomato plant, cotton, sugarcane and crop yielding are also reduced due to mealy bug. The identification of plants leaves with pests or diseases, symptoms of the pest or disease attack, plays a key role in successful cultivation of crops. Hence to conduct high throughput experiments, plant biologist need efficient computer software to automatically extract and analyze significant content [1] respectively, the applications of color transformation and Neural Networks (NNs) have been formulated for classification of diseases that affect on plant leaves [2]. Bodhe, T.S work suggests Entropy based thresholding in which the maximum information content is used to decide the segmentation rule dependent upon a color space selection. His suggested segmentation algorithm is applied for images of pest infected leaves ant their results are compared with the results of Fuzzy c-mean method. The application of different image segmentation and clustering algorithm addresses to solve the problem of checking the consistency of different algorithms based on some small number of images or images from one particular field [3] and [4] consider generic segmentation of the medical images which is carried out for different types of medical images and compared using quality measures [5]. Illustrate the consistency based on the study of multimodal biometric system, the feature of face and palm print are extracted separately using Gabor wavelet [6] demonstrates the k means clustering method is a useful technique, which can sustain exact detection and recognition of Plant pests in their various shapes, sizes, positions, and orientations. The detection and recognition of crop pests by many farmers in major parts of the world according to [7] is observation based on the naked eye. This method requires continuous monitoring of the crop stems and leaves, which are expensive, labor intensive, inaccurate for large farms [8]. Listed various methods to increasing throughput & reducing the labour arising from human experts in detecting the plant diseases. His research work reveals that different methods are used by different researchers for plant disease detection and analysis. The various techniques demonstrated Self organizing maps & back propagation neural networks with genetic algorithms for optimization & support vector machines for diseases classification [9].

Identified the rate of browning within Braeburn apples and created an image recognition system to detect pest damage with the use of a wavelet based image processing technique and a neural network **[**10**]**. Measured the pest detection and positioning depends on binocular stereo to get the location information of pest, which is used for guiding the robot to spray the pesticides automatically, if there are changes in the orientation or position of the pests on the leaf, the robot is likely to miss the target and spray on areas not affected by the pest [11]. Starts with an estimate of the local distribution, which efficiently avoids pre-assuming the cluster number. Then the seed clusters that come from a similar distribution are merged by this clustering program was applied to both artificial and benchmark data classification and its performance is proven better than the well-known k-means algorithm [13].

Demonstrated a cognitive vision approach to early pest detection in greenhouse crops, his work concentrated on low infestation cases, which is crucial to agronomic decision making, particularly on white flies. It was very good work for early detection of white fly but did not extend to more complex cases and on all forms or species of the pest, especially when the pest changes position or orientation. Researchers have extensively worked over this fundamental problem and proposed various methods for image segmentation.

This paper is organized as follows. In Section II, for the integrity of this paper, we simply describe the problem identification based upon the white fly pest. In Section III, Image segmentation based FCM clustering algorithm is discussed. In Section IV, Marker control based watershed transformation is presented. In Section V, we evaluate the non linear objective measures for the proposed techniques using pest images and compare the leading technique from the literature. Section VI presents the experimental results of the proposed system and finally concludes this paper.

2. PROBLEM IDENTIFICATION

There is the great economic loss for farmers because of plant diseases and insect pests every year. Tiny pests such as aphids, whiteflies, and spider mites are more likely to infest greenhouse crops than beetles or caterpillars Therefore, it is of great both theoretical and practical significance to develop the automatic identification and diagnose system of Whiteflies insect about 1.5 mm long; found in conjunction with tiny yellow crawlers or green, oval often present on leaves. It snacks on foliage, coating the leaves with a sticky white residue that shrivels them and attracts black mold to the fruit. Using the whiteflies as the research subject, image of insect pest of whiteflies based on Fuzzy C means clustering algorithm with Marker controlled watershed transformation was proposed and also analyzing the performance based on non linear objective assessments.

3. IMAGE SEGMENTATION BASED FCM CLUSTERING ALGORITHM

Fuzzy C-means [11], [15] is an algorithm based on one of the segmentation methods which allows data to have membership of multiple clusters, each to varying degrees. This method, used in pattern recognition, was developed in 1973 by Dunn and improved by Bezdek in 1981. The algorithm is based on minimization of the following function:

$$J_m = \sum_{a=1}^{N} \sum_{b=1}^{C} u_{ab}^{m} \|x_a - c_b\|^2, 1 \le m < \propto \quad (1)$$

where:
a. m is any real number greater than 1,
b. u_{ab} is the degree of membership of in the x_a cluster j,
c. x_a is the d-dimensional measured data,
d. c_b is the d-dimension center of the cluster,
e. $\|x_a - c_b\|$ is any norm expressing the similarity between any measured data and the center.

This algorithm realizes an iterative optimization J_m of the function, updating membership u_{ab} and the cluster centers C_b using the following formulas:

$$C_b = \frac{\sum_{a=1}^{N} u_{ab}^{m} . x_a}{\sum_{a=1}^{N} u_{ab}^{m}} \quad (2)$$

$$u_{ab} = \frac{1}{\sum_{k=1}^{c} \left(\frac{\|x_a - c_b\|}{\|x_a - c_k\|} \right)^{\frac{2}{m=1}}} \quad (3)$$

The minimization of J_m is achieved when u_{ab} function are saturates that is, the stop criterion is given by the equation

$$max_{ab}\left\{\left|u_{ab}^{k+1} - u_{ab}^{(k)}\right|\right\} < \varepsilon \quad (4)$$

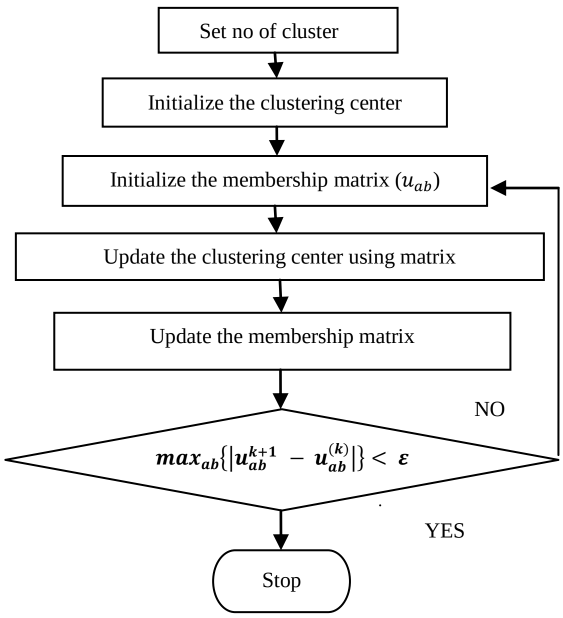


Figure 1. Flow chart for FCM clustering Algorithm

Figure 1 represents the flow chart of FCM algorithm in which the first step is to choose a number of clusters in a given image and set the iteration value according to clusters. Second step relate the initial clustering center C_b, $2 \le C_b < x_a$ where x_a is the number of data item. Third step, Initialize the membership matrix (u_{ab}), calculate the c cluster centers C_b with (u_{ab}) using equation (4) and update the membership matrix (u_{ab}^{k+1}) using equation (5). Finally Compare $u_{ab}^{(k)}$and u_{ab}^{k+1} in a convenient matrix norm; if $max_{ab}\left\{\left|u_{ab}^{k+1} - u_{ab}^{(k)}\right|\right\} < \varepsilon$, stop; otherwise, set K=K+1, and go to third step by updating the cluster centers iteratively and also the membership grades for data point [16].

4. MARKER CONTROLLED BASED WATERSHED TRANSFORMATION ALGORITHM

4.1. Image Preprocessing:

The original image needs reasonable preprocessing to make it suitable for watershed segmentation. We here first, convert the image into grayscale and then use a morphological filter which combines disk-shaped structuring element to enhance the contrast of the image [12]. Morphological reconstruction is a very useful operator based on mathematical morphology. Morphological reconstruction can be conceptually regarded as repeated dilations of an image called the marker image, until the contour of the marker image fits under a second image called the mask image. Morphological reconstructions turns out to be particularly effective to extract marked objects, detect or remove objects touching the image border and filter out spurious or low points. Based on the morphological reconstruction, a filter combining opening by-reconstruction operation and closing by reconstruction operation is utilized to smooth image and eliminate the noise. The opening-by-reconstruction is erosion followed by a morphological reconstruction while closing-by-reconstruction is a dilation followed by a morphological reconstruction. Compared to simple opening and closing, construction-based opening and closing can restore the original shapes of the objects after erosion or dilation [12].

4.2. Markers:

An alternative approach to watershed is to imagine the landscape being immersed in a lake with holes pierced in local minima. Basins (also called `catchment basins') will fill up with water starting at these local minima and at points where water coming from different basins would meet, dams are built. When the water level has reached the highest peak in the landscape, the process is stopped. As a result, the landscape is partitioned into regions or basins separated by dams called watershed lines or simply watersheds [11]. Hence, to find out catchment basins and watershed lines, markers are used. A marker is a connected component belonging to an image. Internal and external markers are used to find out region of interest. Internal markers are associated with object of interest and external markers are associated with background [11].

1) Foreground markers - Foreground markers can be defined as region surrounded by points of higher altitude, Points in region form connected component and all the points in the region have same intensity [11]. We compute the foreground markers by extracting the local maxima of the preprocessed image. Local maxima are connected components of pixels with a constant intensity value, and whose external boundary pixels all have a lower value.

2) Background markers - Each external marker consists of single internal marker and part of background [11]. The background marker extraction can be achieved by computing the watershed transform of the distance transform of the foreground marker image. The distance transform converts a binary image into a distance map where every background pixel has a value corresponding to the minimum distance from the light points. The background marker extraction can be achieved by computing the watershed transform of the distance map of the foreground marker image [12].

The watershed transform is implemented on the gradient image. The gradient defines the first partial derivative of an image and contains a measurement for the variation trend of gray levels. It is better to reflect the variation trend of the image than the original image [13]. Sobel operator is adopted to calculate the gradient magnitude of the gray image. The extracted foreground markers and background markers are imposed on the original gradient magnitude image so that its region minima only occur at foreground and background marker pixels. Finally, the ideal segmentation result is achieved by computing the watershed transform on the modified gradient magnitude image [12].

5. NON LINEAR OBJECTIVE ASSESSMENTS

A good objective quality measure should reflect the distortion on the image, for example, blurring, noise, compression, and sensor inadequacy. Such measures could be instrumental in predicting the performance of vision-based algorithms such as feature extraction, image-based measurements, detection, tracking, and segmentation [19].

Two ways to analysis the performance

1. Pixel difference-based measures: (e.g. the Mean Square Error and Maximum Difference).
2. Correlation-based measures: A variant of correlation based measures can be obtained by considering the absolute mean and variance statistics (e.g. Structural Content, Normalized Cross Correlation).

The proposed algorithms have been implemented using MATLAB. The performance of image segmentation approaches are analyzed and discussed. 1) Structural Content (SC) 2) Peak Signal to Noise Ratio (PSNR) 3) Normalized Correlation Coefficient (NK) 4) Normalized absolute error (NAE) 5) Average Differences is considered for study in this work on the original image $x(i,j)$ and on the segmented image $y(i,j)$.

5.1. Structural Content (SC)

Correlation, a familiar concept in image processing, estimates the similarity of the structure of two signals. This measure effectively compares the total weight of an original signal to that of a coded or given. It is therefore a global metric; localized distortions are missed .This measure is also called as structural content. The Structural content is given by Eq. (5) and if it is spread at 1, then the decompressed image is of better quality and large value of SC means that the image is of poor quality.

$$C = \frac{\sum_{i=1}^{M}\sum_{j=1}^{M} x(i,j)^2}{\sum_{i=1}^{M}\sum_{j=1}^{M} y(i,j)^2} \quad (5)$$

5.2. Peak Signal to Noise Ratio (PSNR):

Larger SNR and PSNR indicate a smaller difference between the original (without noise) and reconstructed image. The main advantage of this measure is ease of computation but it does not reflect perceptual quality. An important property of PSNR is that a slight spatial shift of an image can cause a large numerical distortion but no visual distortion and conversely a small average distortion can result in a damaging visual artifact, if all the error is concentrated in a small important region. This metric neglects global and composite errors PSNR is calculated using equation (6).

$$PSNR = 10.\log_{10}\left[\frac{\max(x(i,j))^2}{\frac{1}{n_i \times n_j}\left[\frac{\sum_0^{n_i-1}\sum_0^{nj-1}(x(i,j))^2}{\sum_0^{n_i-1}\sum_0^{nj-1}(x(i,j)-y(i,j))^2}\right]}\right] \quad (6)$$

5.3. Normalized Correlation Coefficient (NK):

The closeness between two digital images can also be quantified in terms of correlation function. It measures the similarity between two images like an original color space in the image other one converted color space image, hence in this sense they are complementary to the difference based measures. All the correlation based measures tend to 1, as the difference between two images tend to zero. As difference measure and correlation measures complement each other, minimizing Distance measures are maximizing correlation measure and Normalized Correlation is calculated using equation (7).

$$NK = \frac{\sum_{i-1}^{M}\sum_{j-1}^{N}[x(i,j) \times y(i,j)]}{\sum_{i=1}^{M}\sum_{j=1}^{M} x(i,j)^2} \quad (7)$$

5.4. Normalized Absolute Error:

Normalized absolute error computed by equation (8) is a measure of how far is the conversion image from the original image with the value of zero being the perfect fit. Large value of NAE indicates poor quality of the image.

$$NAE = \frac{\sum_{i=1}^{M}\sum_{j=1}^{N}|x(i,j) - y(i,j)|}{\sum_{i=1}^{M}\sum_{j=1}^{N}|x(i,j)|} \quad (8)$$

5.5. Average Difference (AD):

A lower value of Average Difference (AD) gives a “cleaner” image as more noise is reduced and it is computed using equation (9)

$$AD = \frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}[x(i,j) - y(i,j)] \quad (9)$$

6. EXPERIMENTAL ANALYSIS AND RESULTS

Table 1 shows the experimental results conducted over the pest images. FCM clustering and marker controlled watershed transformation based image segmentation methods are applied to images and the values of parameters are calculated.

Table 1. Input Image and Processed Output

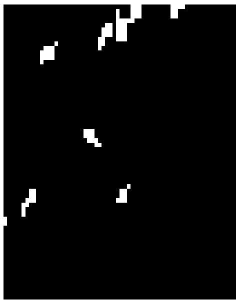
Original Pest Image	FCM Processed Image	Marker Controlled Watershed Image
		

Table 2 shows the average results of different parameters. The value of PSNR should be in the range of 25 to 40db, the small value of PSNR means the image is of poor quality [2] [3], SC with value spread at 1, indicates a better quality image. Large value of NAE, NK and AD indicates poor quality of the image [17].

Table 2. Comparitive Performance Analysis

METHODS	PERFORMANCE MEASURES				
	PSNR (dB)	SC	NK	NAE	AD
Marker Controlled watershed segmentation	29.143	0.981	0.963	0.264	0.682
FCM	33.846	1.015	0.991	0.096	0.876

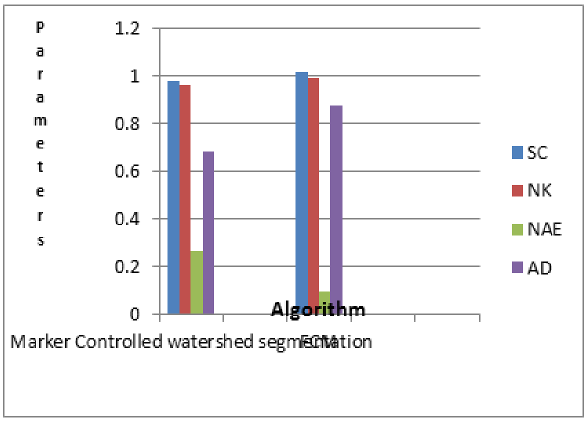


Figure 2. Graphical Comparison of Performance Analysis

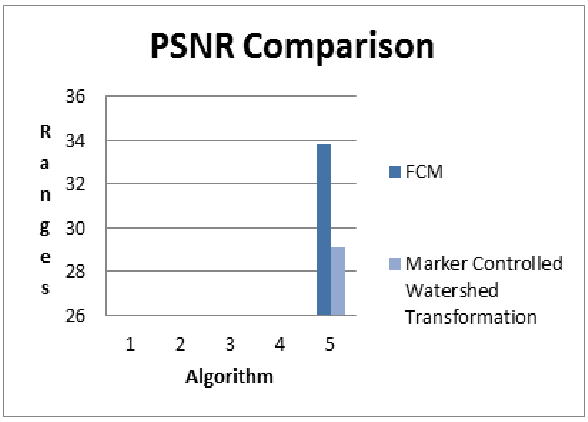


Figure 3. Graphical Comparison of PSNR

Figure 2 shows average performance analysis chart for pest image reveals that the parameters for FCM algorithm are more appropriate than Marker controlled watershed transformation. Structural content is a global measure, which compares the total weight of the segmented image and input image, is 0.981 for Marker controlled watershed, 1.015 for FCM. The structural content with value spread at 1 indicates a better quality image and it is very close to 1 for output.Normalized correlation gives closeness between the input and segmented image and is obtained as 0.963 for Marker Controlled watershed and 0.991 for FCM algorithm respectively. This value tends to 1 if the difference between the images is zero and from the computed values, it is observed that for the FCM segmented images obtained highly correlated to the original images. NAE which is a measure to study the quality of approximation of the images is 0.264, 0.096 for Marker controlled watershed and FCM respectively. The Average difference with low value indicates a good quality image and that is observed with the value of 0.682 for Marker controlled watershed and for FCM, it is the maximum with 0.876 indicating the poor quality of the segmented images.

Figure 3 shows the segmented image for Marker controlled watershed transformation is the lowest value of PSNR 29.143dB and for FCM segmented image is 33.836dB. Practically it is in the range of 25 to 40dB hence FCM shows highest value than Marker controlled watershed transformation. Of all the objective quality measures, PSNR which is the most commonly used quality measure which reflects the quality of segmented images approximately. Comparatively the Marker controlled watershed transformation provides better performance in image segmentation when compared to FCM algorithm.

7. CONCLUSION AND FUTURE WORK

This paper compares the performance of image segmentation methods such as Fuzzy c- Means and Marker controlled watershed transformation algorithm are discussed. The performance of proposed algorithms is measured using segmentation parameters PSNR, SC, NK, NAE and AD. Therefore from the computational results conclude that the Marker controlled watershed transformation performs better than Fuzzy c-means algorithm in terms of performance measures and better convergence rate. In future work, the performance measures will be analyzed based on optimization techniques and comparison will be extended to wide range of applications.

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