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A study on Plant Species Identifying using Digital Infrared Thermal Image

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Abstract— Thermography produces thermal images that helps to identify intensity of color. The intensity of color helps to recognize meaningful object in the image, image segmentation plays a significant role to discover the region of interest in the Leaf image. The average temperature in the middle part of the leaf is 0.94^{o}C higher than the leaf apex and 0.81^{o}C higher than the leaf base. The results also showed that the leaf temperature is higher than that of the stem. And the average temperature of the whole blade is 24.07 ^{o}C, which is higher than the background soil temperature (19.53 ^{o}C). For the same maize variety, the leaf temperature of drought stress treatment is higher than that of normal water treatment. It was also found that the temperature of maize with good drought resistance is higher than that of the bad one, furthermore, the better the higher. The results above showed that the characteristics of temperature distribution in crops could be effectively obtained by using thermal infrared images, which also provided potential for the rapid identification of crop drought resistance.

The goal of segmentation is to decompose an image into different areas for further analysis and another is to perform a change of the representation of an image for faster analysis. On the basis of application, a single or a combination of segmentation techniques can be applied to solve the problem effectively. Segmentation is performed by mark off an object on an image using pixel - level or object - level properties of the object. These properties can be edges, texture, pixel intensity distinction inside the object, shape, size and orientation. There are many segmentation techniques are available that segments the thermal image. The segmentation techniques in particular are watershed segmentation, thresholding segmentation, clustering based segmentation and artifitial neural network. These segmentation technique uses algorithm namely global thresholding, watershed transform, k-medoids, k-means clustering, otsu thresholding, kapur thresholding. This paper involves the literature review on pioneering segmentation techniques and applicable algorithms used for segmentation of thermal images.

Keywords - *Global thresholding, watershed transform, k-medoids, k-means clustering, otsu thresholding, kapur thresholding*.

INTRODUCTION

The main goal of this research is to build a computer aided classifier that classifies leaves and assigns the names of the plant they belong to, when supplied only with the leaf image as input. This goal is met through a series of sequential steps, namely, image enhancement techniques, extraction of ROI region, extraction of features and finally classification. Several researchers have contributed and proposed various algorithms in each of these steps. This section presents a review of some important publications made in these steps to understand the current research status.

IMAGE ENHANCEMENT

Most of the reviewed solutions consider denoising as an important step in image enhancement. Various other preprocessing techniques can also be used to enhance the leaf image obtained. Examples include boundary or edge enhancement, smoothening and contrast adjustment. These techniques can also be applied to improve the quality of the leaf image (Tzionas et al., 2005). In this study, the input leaf image is enhanced through three operations, namely, denoising, contrast adjustment and edge enhancement. This section presents studies related to these three areas.

Noise Removal

Plant leaf image is normally affected by three types of noises, namely, Fixed-Valued Impulse Noise (Salt-and-Pepper Impulse Noise), Random-Valued Impulse Noise (Uniform Impulse Noise) and Gaussian Noise. Solutions were proposed that denoises any one of the above mentioned noise using various techniques. Some of these techniques are presented in this section. Rui et al. (1996) proposed a Modified Fourier Descriptor (MFD) method to achieve translation, scaling and rotation invariance by considering the distance between the FD (Fourier Descriptor) magnitude and the phase angle separately so as to decrease the discrimination noises. A Minimum Noise Fraction (MNF) transformation was performed to control the noise in the imagery by Green et al. (1988).

According to El-Helly et al. (2003), image enhancement is a sub-field of image processing and consists of techniques to improve the appearance of an image, to highlight important features of an image and to make the image more suitable for use in subsequent tasks of leaf classification. They proposed a three-step algorithm for enhancing an image. The first step used HSI transformation to take advantage of their capability of separating color information from its intensity information. The second step used histograms to analyze the intensity channel and used threshold method to enhance the contrast of the image. The third step again used threshold methods to adjust the intensity of the image.

A histogram equalization method was used by Pan and He (2008) to enhance the leaf image. A coupling method was adopted by Li et al. (2010) who combined adaptive local smoothing method and wavelet to cope with noisy leaf image. The method was able to preserve edges while removing noise while maintaining the contrast and visual effect of the leaf image. Ma et al. (2010) used an image preprocessing technique to reduce noise from source leaf image and enhanced areas of interest using minimum error threshold method. Sathyabama et al. (2011) used the difference of Gaussians to increase the visibility of edges and other details present in the digital leaf images.

According to Wang and Wu (2009), noise in an image can be detected at a high noise level. Using this information Zhang (2010), introduced a two-phase method for removing noise using Adaptive Center-Weighted Median Filter (ACWMF) and variation method. This method successfully removed the noise, but was sensitive to the size and shape of the filter window. Bigger size window resulted in over smoothening of the image, and smaller size did not remove the noise efficiently. The window size problem is a common problem that is shared by many filtering algorithms.

Solutions to these weaknesses in noise removal algorithms were provided. They proposed a method based on Interval-Valued Fuzzy Sets (IVFS) entropy application to denoise an image. The method combined image histogram information and spatial information about pixels of different gray levels by using an IVFS multi-thresholding technique. The advantage of this method was that it was able to remove both impulse and Guassian noise.

Rubio (2010) extended this method to remove impulse and Guassian noise present in the same image by using Iteratively Reweighted Norm (IRN) method to yield predictions of the original pixel values and compute the corresponding predicted errors and train the noise model by using an Expectation-Maximization (EM) algorithm. The proposed algorithm can effectively remove the impulse noise with a wide range of noise density and produce better results in terms of the qualitative and quantitative measures of the images.

Contrast and Edge Enhancement

Improving the quality of edges in leaf images is a critical factor that can improve the performance of recognition and identification. While considering digital images a maximum number of reported works concentrated on edge detection (Yu and Acton, 2004) but only a few have been reported with edge enhancement.

According to Li et al. (2007), edge enhancement is an important operation which helps in detecting object boundaries and in subsequent steps of recognition and classification. It helps in differentiating the features by improving the visual quality perception of the image and provides insight into the shape and outline of objects and offers vital information to the Human Visual System (HVS).

One of the early methods to address the problem of edge quality enhancement uses anti-aliasing, wherein, two adjacent pixels in the oblique direction are detected and a corrective pixel is inserted to smooth the line (Yonezawa et al., 1978). Techniques that (slightly) manipulate image content for better edge quality was studied by Gupta (1981) where the intensity of a pixel is chosen depending on the distance between the center of the pixel and the edge of the image. Ort (1981) proposed a technique for shifting pixels by half a position while printing diagonal elements. Shirasaka (1998) used a similar technique to detect the staircase regions. This is not a very effective approach for regions containing complex contours. Template matching is another widely used technique for edge quality enhancement, wherein the image region is scanned in the piece-wise order (windows) and compared against a defined set of patterns to be rectified (Yao et al., 2006; Lund, 1997; Tung, 1989). However, this approach requires predefined regions and conditions that can add to the processing time depending on the image complexity. Clayton (2006) first converted image to binary form (black and white), enhanced edges, removed noise and then reconverted to its original colour domain.

Braica (2006) states a method of enhancement by increasing the contrast of the image at the edges. Chen et al. (1997) globally shifted the intensity value in the approximation-coefficients to achieve contrast enhancement. But they did not provide an efficient way to decide the size of the shifting step. They also established a zero-crossing tree, which consists of zero-crossings of each component in multiple-resolution levels, to represent multiple-resolution edges that are used to suppress noise.

Fu et al. (2000) analyzed the drawback of the HEQ procedure in the spatial domain. Then they proposed a wavelet-based contrast enhancement method. In their method, after performing the HEQ procedure in the spatial domain, the output image was transformed into the wavelet domain. Then, all approximation-coefficients were squared. They claimed that the proposed process could compensate the information that was lost during the HEQ process.

Reeves et al. (1997) investigated a wavelet transform domain filter, based on the LLMMSE filter (Kaun et al., 1985) to suppress noise and enhance edges. They also applied global HEQ to the wavelet approximation-coefficients at the coarsest decomposition level to enhance contrast. But further investigation was required in order to understand how the selection of the approximation-coefficients' range and histogram bin values affect the reconstructed image.

Xu et al. (1997) combine a wavelet phase filter at finer scales in the wavelet domain to reduce noise, and a semi-soft wavelet shrinkage technique was proposed by Bruce and Gao (1996) at coarse scales in the wavelet domain to further reduce noise and enhance edges. But the proposed method still could not automatically adjust its parameters to achieve optimal result.

There are some other enhancement attempts. For example, Gong et al. (2000) rationally enlarged coefficients on multiple scales in the wavelet domain. Xu et al. (2000) altered the amplitude of coefficients in the wavelet domain. Peng et al. (2000) used a non-linear enhancement operator on coefficients at multi-scale in the wavelet domain. However, these attempts aimed at improving only image contrast and ignored edges.

DIFFERENT SEGMENTATION TECHNIQUES

The goal of the image segmentation is to remove the noise at the background, By separating the object from the background the Region of Interest is get highlighted. Distinct segmentation techniques are described in this section.

A. *Global Thresholding*

Global thrsholding is technique in which a single threshold value is applicable to all the region in the image we term this to be global thresholding in image processing, It means pixel value lower than threshold will be set 0 and higher will be 255. Global thresholding is used when the pixel values of background are fairly consistent in over the entire image. Recently Optimum global thresholding, global thresholding based on boundary selection these kind of technique is used. Carlos et al. [1] proposed the method of thresholding. In this method of segmentation black pixel replaced with each pixel in image, if the intensity of image is smaller than some fixed constant U, or a white pixel if the intensity of image is more than the constant U. In the experiment U is selected with value 0, For removing false positive regions. After thresholding, the objects in the image are labeled. If the number of objects (N) in image is unity, i.e. N = 1 the leaf is categorized as healthy leaf and if the number of objects is more than unity, i.e. N > 1 the leaf is categorized as unhealthy leaf. In the preprocessing of the image the H and V value of the HSV color space of the image are get separated for clear view of the diseased part. This experiment is performed on cherry leaves to identify the disease called powdery meldew. The threshold is applied using otsu adaptive method and some post processing tools are applied and the leaf disease is extracted. This algorithm proves with 99% accuracy.

B. Watershed Transform

Segmenting an image by the watershed transformation is a two-step process, first step is Finding the markers and the segmentation criterion, the criterion or function which will be used to split the regions - it is most often the contrast or gradient and second step is performing a marker-controlled watershed with these two elements. Akash Singh et al. [2] have proposed the image segmentation based on watershed transform. It is an efficient technique to determine to area of interest in an image. When a landscape is flooded by water with holes in local minima, catchment basins will fill up with water. The water will stop filling when apex of landscape has reached as a result image is partitioned into regions or basins dissevered by dams called watershed ridge lines. The catchment basins correspond to regions of an image and watershed ridge lines correspond to the edges of an image. Marker approach is used to avoid problem of over-segmentation in watershed transform [6]. Watershed transform is a popular technique utilized for image segmentation. Application of watershed transform technique in thermal images gives the desired pseudo-coloured segmented thermal image. The heated areas in thermal images are mapped with each of the grey levels of a black and white image into an assigned color. For better analysis of segmented thermal image this algorithm is used. When watershed transform is directly applied to thermal images without any pre-processing then thermal image leads to over-segmentation. Watershed transform implement marker based approach to reduce over-segmentation. This algorithm is performed on infra-red thermal images of solar panels and battery for visualization of heat. The features extracted from binary image of heated portions for solar panel and battery are obtained in terms of area, perimeter, major axis length and minor axis length, which are measured in image pixels. The thermal images show heated area only in terms of temperature but in order to know the depth of heat image segmentation is used. The extracted features like area, perimeter, major axis and minor axis are also calculated (in terms of image pixels) from segmented binary image to indicate seriousness of heated portion of component. The result come across to the reduction in over segmented area may come with 85% accuracy.

C. K-means clustering

K -means clustering algorithm is an unsupervised algorithm. Using this technique interest area is fragmented from the background. K-Means is a least-squares partitioning method that segregates an accumulation of objects into K groups. The algorithm iterates over two steps. First step is to compute the mean of each cluster. The second step is to compute the distance of each point from each cluster by computing its distance from the corresponding cluster mean and assign each point to the cluster it is nearest to. In K-means clustering a membership function is used for distance measure and it lies approximately between 0 and 1. Each data object belongs to only one cluster or do not belong to the cluster is valued with 0 and if belong to the cluster is assigned to 1, designate that whether the data point belong to the cluster or not. In the subsequent steps, the data points that belong to a set are moved towards the most proximate centroid so that no point remains unmoved. Yung-Yao et al. [3] have proposed an approach on usage of k-means clustering method. In this approach the initial image segmentation is performed in the grayscale thermal image. In this segmentation method a feature space is constructed based on the pixel value. Classification of all samples in the feature space into *K* Clusters is performed by using the *K*-means algorithm. The value of *K* is set within the range of three to six times the desired number of groups. For example, in the case of two foreground objects and one background, the desired number is three. After that each pixel in the thermal image is labeled using the *K*means result. The thermal image labeled by a cluster index based on temperature information. K-means clustering algorithm is performed the maximal similarity-based region merging this method is being used to reduce the over-segmentation problem, to successfully segment the object from the background in a thermal image. The execution time of K-Means algorithm is depends on volume of data. The K-means clustering algorithm is resulted with 50% accuracy.

D. K-medoids

K-medoid minimizes the absolute distance between the selected centroid. It is based on centroids (or medoids). The medoids are culled out of the cluster elements. Centroid as its name says that, it is the most centrally located object of the cluster, with minimum sum of distances to other points. A medoid is an entity in a cluster. Hence, medoid has the average disparity is minimal among the objects in the cluster. The design of algorithm is first compute the K representative objects which are known as medoids. Each object of the data set is assigned to the nearest medoid, only if set of medoids discovered. So, K-medoid algorithm has greater average time for normal distribution as compare to the average time for the uniform distribution. The aspect of this algorithm is that it requires the distance between every pair of objects only once, so that it will uses this distance at every stage of iteration. Arti N et al. [4] propound a k-medoids segmentstion method for detecting the leaf disease by identifying the region of interest. In k-medoids segmentation method images are segmented using k-medoids clustering methods. K-medoids clustering is partitioning based clustering method. K-medoids also known for PAM (Partition around medoids). In Partition around medoids every cluster is represented by one of the objects in the cluster. K-medoids reduce the noise and outlines; because a medoids is less influenced by outlines or other extreme values than a mean. K-medoids performs reasonably better than the K-Means algorithm. Compared to K-means, k-medoids is not sensitive to noisy data, outlines and effective for gray scale too. The execution time of K-medoids algorithm is better for large data. This method is applied on leaf images to detect the diseases or identify the infected areas of the diseases on the leaf. The diseases experimented are early scorch, cottony mold, late scorch, brown spot, Bacterial-Fungal. The experimental results indicate that it support an accurate detection of leaf diseases with 60% accuracy.

E. Otsu thresholding

This type of thresholding is global thresholding. The intensities of the pixels are stored in an array. By using the total mean and variance threshold value is calculated. The threshold value of each pixel is set to either 0 or 1 i.e. background or foreground. Thus here the vicissitude of image takes place only once. It is used to mechanically execute histogram shape-based image thresholding or, the decrease of a gray level image to a binary image. The algorith m take for granted that the image to be thres holded consists two groups of pixels or bi-modal histogram (for instance, foreground & background) and then evaluates the optimum threshold partitioning those two classes so that their joint spread (intra-class variance) is negligible .The expansion of the basic method to multi-level thresholding is addressed to as the Multi Otsu method. Salvador et al. [5] propound the most popular thresholding technique proposed by Otsu [9]. This unsupervised technique segments the image by maximizing the difference between various classes. Otsu's thresholding method iterates through all the possible threshold values and calculate a measure of spread for the pixel levels each side of the threshold pixels are either foreground or background. The main goal is to find the threshold value by calculating the sum of foreground and bachground. Otsu’s thresholding is used with other segmentation technique based on the application requirement.

F. kapur thresholding

Entropy based optimization methods namely maximization of entropy [6] and minimization of cross entropy methods [7] are the proficient image segmentation techniques. The maximum entropy criterion approach is introduced by proposed by Kapur et al. [8] named as Kapur's entropy. Kapur et al. [8] introduced the entropy-based method to maximize the entropy of the segmented histogram so that every separate region has a more centralized distribution. At the earlier stage, bi-level thresholding method is presented to identify the thresholds in the histogram to extract the object from background. Salvador et al. [5] propound an entropy-based method. In this method, the selection criteria suitable for threshold is the maximization of the Kapur's entropies based on gray-level histogram. Kapur's original method is very time-consuming due to the inefficient formulation of the entropy and the exhaustive search in multilevel

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thresholding. In entropy based approach, the overall entropy is increased by optimizing threshold in segmentation process. It is used to find optimal threshold values is the one presented by Kapur [8]. Generally, each entropy is computed independently based on the particular threshold value. The method is based on the probability distribution of the image histogram and the entropy. This method is use to analyze the thresholding problem of FLIR image. Statistical data of the Kapur's method applied to the selected evolutionay computation techniques.. The analysis of the result is a higher value of the mean of the objective function which shows a better segmentation. Kapur thresholding is avery rarely used technique. The entropy method is broadened to multilevel thresholding

Conclusion

This literature describes the various segmentation techniques used for segmentation of thermal image. Thermal imaging helps to identify the defects in the objects. To clarify the region of Interest of object the segmentation method is applied. In this research the segmentation methods may get used for thermographic image. Based on threshold value, gray scale image, Color image the segmentation method gets vary. This research work helps to identify the suitable segmentation method for thermal images. The clustering segmentation techniques K-means and k-medoids – both the methods find out clusters from the image. K-means drawback is sensitivity to noisy data outlines, where the k-medoids is able to overcome these kind of problem. Among the Otsus image thresholding techniques, Otsu's method which works on the principle of between-class variance and Kapur's method which works on the principle of entropy are proved to be two best thresholding methods. In order to choose the optimal threshold values, maximization of between class variance of gray levels of histogram is used in Otsu's method whereas maximization of the histogram entropy is used in Kapur's method. But segmentation techniques proves to be good are global threshoding used with otsu and watershed transformation techniques are resulted with accuracy and might be the most suitable techniques for thermal image segmentation based on their calculated accuracy level.

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