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ISSN: 0193-4120 Page No. 3858-3862

A Comparative Study of Leaf Disease Classification using SVM Kernel Functions

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Article Info
Volume 83
Page Number: 3858-3862
Publication Issue:
May-June 2020

Article History
Article Received:*19 November 2019*
Revised: *27 January 2020*
Accepted: *24 February 2020*
Publication: *12 May 2020*

Abstract
This leaf disease classification is an important task to be performed. So, leaf extraction from the complex background is a difficult task and to achieve this different algorithm are used for segmentation. Active contour is used for the segmentation and in this paper three different algorithms are used Gradient Vector Flow (GVF), Vector Flow Convolution (VFC) and Adaptive Diffusion Flow (ADF). Using these methods segmentation is performed and later 7 features are extracted from the image. Finally, it will be fed to the Support Vector Machine (SVM) classifier and in this comparison of different kernel functions is used. The linear kernel function gives 90 % accuracy result when compare to other kernel functions.

Keywords: *Active contour, GVF, VFC, ADF, SVM, kernel function*

1. Introduction

Plants play an important role in day today life. Being an important part of life if the plants gets effected by disease than the yield gets reduces. So, its significant that we should try to detect and take the necessary steps to avoid reduction in the yield. The major crops grown in India are cotton, rice, wheat, jute, coconut, Maize etc. Among these, cotton also is one among the major crop grown in different regions like Punjab, Haryana, Rajasthan, Gujrat etc. So, early stage detection will be helpful to increase the crop yield. There are parts in the plant body which get effected like stem, leaf, fruit etc. Among that if leaf gets affected than crop also gets affected so identifying the disease becomes important. Cotton crop come across with various diseases like Alternia leaf spot, cercospora leaf spot, anthracnose etc. To perform this task in image processing we have different steps acquiring the images, filtering or performing some processing before extracting the region or object of interest, segmentation, extracting the features, classification. By using the above steps, it can help the farmers to find out the disease at the early stage and take the necessary actions based on that.

There are various methods to perform these operations like clustering algorithms or k means algorithm [11], active contour etc. Among these the active contour is one among to give the better results compare to other methods. So, in this active contour is used for the process of the leaf disease images. Active contour is the process of curve moving towards to the edges of the object of interest. There are 2 different types of active contour are namely parametric and geometric active contour. Parametric active contour [12] is the contour formed based on the parametric curve and the evolution of the curve relies on the internal and external forces. There are different parametric models namely traditional snake, Gradient vector flow, vector field convolution, adaptive diffusion flow etc. Geometric active contour is based on the contour split and merge depending on the detection of objects in the image. In this paper, we have used Gradient vector flow (GVF)[8,13,14], vector field convolution(VFC)[9,15] and adaptive diffusion flow(ADF)[10] for segmentation. Later features are extracted and classification is performed. There are various features extracted for diseased and non-diseased plant leaf images and the same has been used for our database also. And classification of plant leaf images using different classifiers like artificial neural network, support vector machine (SVM), k means clustering, KNN classifier etc. The support vector machine mostly widely used when compared to

other methods. In this paper, support vector machine kernel functions comparison is performed.

2. Related Work

Plants play an important role in day today life. Being an important part of life if the plants gets effected by disease than the yield gets reduces. So, its significant that we should try to detect and take the necessary steps to avoid reduction in the yield. The major crops grown in India are cotton, rice, wheat, jute, coconut, Maize etc. Among these, cotton also is one among the major crop grown in different regions like Punjab, Haryana, Rajasthan, Gujrat etc. So, early stage detection will be helpful to increase the crop yield. There are parts in the plant body which get effected like stem, leaf, fruit etc. Among that if leaf gets affected than crop also gets affected so identifying the disease becomes important. Cotton crop come across with various diseases like Alternia leaf spot, cercospora leaf spot, anthracnose etc. To perform this task in image processing we have different steps acquiring the images, filtering or performing some processing before extracting the region or object of interest, segmentation, extracting the features, classification. By using the above steps, it can help the farmers to find out the disease at the early stage and take the necessary actions based on that.

There are various methods to perform these operations like clustering algorithms or k means algorithm [11], active contour etc. Among these the active contour is one among to give the better results compare to other methods. So, in this active contour is used for the process of the leaf disease images. Active contour is the process of curve moving towards to the edges of the object of interest. There are 2 different types of active contour are namely parametric and geometric active contour. Parametric active contour[12] is the contour formed based on the parametric curve and the evolution of the curve relies on the internal and external forces. There are different parametric models namely traditional snake, Gradient vector flow, vector field convolution, adaptive diffusion flow etc. Geometric active contour is based on the contour split and merge depending on the detection of objects in the image. In this paper, we have used Gradient vector flow (GVF)[8], vector field convolution(VFC)[9] and adaptive diffusion flow(ADF)[10] for segmentation. Later features are extracted and classification is performed. There are various features extracted for diseased and non-diseased plant leaf images and the same has been used for our database also. And classification of plant leaf images using different classifiers like artificial neural network, support vector machine (SVM), k means clustering, KNN classifier etc. The support vector machine mostly widely used when compared to other methods. In this paper, support vector machine kernel functions comparison is performed.

3. Methodology

There are various steps in image processing like acquiring the images, pre-processing the image and later segmenting the region of interest, leading to extract the features which will be fed for the classification.

The figure 3.1 shows the block diagram which represent the different steps to perform the plant disease classification. The first step is to collect the database for the processing of the images, nearly 100 images are acquired by the Nikon digital camera of size 6000x4000. The images will be pre-processed with the filter for removing the noise from the image so that it will be helpful in extracting the features of an image and later the same is used for the classifying the images as diseased or non-diseased images.

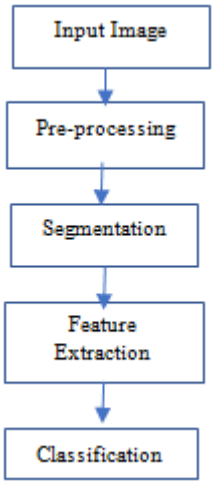

Figure 3.1: Leaf disease classification

After creating the database later pre-processing of the image is performed and which in turn how to segment the image from background. The resultant image is further classification of images is performed.

Image acquisition & Pre-processing

The images are acquired using Nikon digital camera of size 6000x4000. These images are captured in controlled in environment and stored in JPEG format.

Segmentation

Extracting the region of interest from the background using different segmentation techniques like gradient vector flow, vector flow convolution and Adaptive diffusion flow. The active contour model is the process of contour formation based on the energy of the curve.

Gradient vector flow

Xu and Prince [5], proposed a gradient vector flow method to overcome the problems of traditional snake. The traditional snake had a problem with the

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convergence towards the concave region and also with the limited capture range. So, in this author introduced a new external force which helps the snake to move towards the concave regions.
The equation for the traditional snake is given by

$$E_{int} = \int_0^1 E_{snake}(v(s))ds$$
$$= \int_0^1 E_{int}(v(s)) + E_{ext}(v(s))$$

(1)
Where E_{int} and E_{ext} are the internal and external energies.
E_{ext} is calculated from the image. In this author proposed an new external force which is given by

$$E_{ext}(v(s)) = -|\nabla[G_\sigma(x,y) * I(x,y)]|^2$$

(2)
Where $G_\sigma(x,y)$ is a two dimensional Gaussian function with standard deviation σ and ∇ is the gradient operator. This energy helps in moving the snake towards the edges.
It will give better performance with respect to deep concavities of an image.

Vector flow convolution

Bing Li[9], proposed a new external force called as vector field convolution(VFC). Here the external force The vector flied kernel k(x,y) in which all the vectors point to the kernel origin.
k(x,y)=m(x,y)n(x,y)
(3)
The VFC external force is given by calculating the convolution of kernel k(x,y) and edge map f(x,y) generated from the image I(x,y).
$f_{vfc} = f(x,y) * k(x,y)$
(4)
Here edges are more prominent compare to homogeneous regions. The VFC will result in edge map which doesn't depend on the origin of the vector field kernel but it depends on the magnitude of the vector field kernel m(x,y). Author proposed a two magnitude functions given by

$$m_1(x,y) = (r+\epsilon)^{-\gamma}$$

(5)

$$m_2(x,y) = \exp\left(\frac{-r^2}{\zeta^2}\right)$$

(6)
Where γ and ζ are positive parameters to control the decrease of vector field, ε is a positive constant to prevent division by zero at the origin.$m_1(x,y)$ which influence the FOI as increases as γ decreases. $m_2(x,y)$ ia a Gaussian shape function and ζ represents the standard deviation.

Adaptive diffusion flow

Xu and Prince [5], proposed a gradient vector flow method to overcome the problems of traditional snake. The traditional snake had a problem with the convergence towards the concave region and also with the limited capture range. So, in this author introduced a new external force which helps the snake to move towards the concave regions.
The equation for the traditional snake is given by

$$E_{int} = \int_0^1 E_{snake}(v(s))ds$$
$$= \int_0^1 E_{int}(v(s)) + E_{ext}(v(s))$$

(7)
Where E_{int} and E_{ext} are the internal and external energies.
E_{ext} is calculated from the image. In this author proposed an new external force which is given by

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Where $G_\sigma(x,y)$ is a two dimensional Gaussian function with standard deviation σ and ∇ is the gradient operator. This energy helps in moving the snake towards the edges.
It will give better performance with respect to deep concavities of an image.

Feature Extraction

The following are the features to be extracted from leaf diseased images.

- Contrast-

$$\text{Contrast} = \sum_{i,j=0}^{N-1} (i,j)^2 c(i,j) \quad (9)$$

- Energy-

$$E = \sum_{x=1}^{X}\sum_{y=1}^{Y}\sum_{z=1}^{Z} I(x,y,z)^2 \quad (10)$$

- Homogeneity

$$\text{Homogeneity} = \sum_{i,j=0}^{N-1} \frac{c(i,j)}{(1+(i-j)^2)} \quad (11)$$

- Mean

$$\mu = \frac{1}{XYZ}\sum_{x=1}^{X}\sum_{y=1}^{Y}\sum_{z=1}^{Z} I(x,y,z) \quad (12)$$

- Standard Deviation

$$S = \sqrt{\frac{1}{(XYZ-1)}\sum_{x=1}^{X}\sum_{y=1}^{Y}\sum_{z=1}^{Z}(I(x,y,z)-\mu)^2} \quad (13)$$

- Entropy

$$H = -\sum_{i=1}^{N_g} P(i)\log_2 P(i) \quad (14)$$

Where P is the first order histogram and P(i) the fraction of pixels with gray level i.

- Root-Mean-Square (RMS)

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$$RMS = \sqrt{\frac{1}{XYZ}\sum_{x=1}^{X}\sum_{y=1}^{Y}\sum_{z=1}^{Z} I(x,y,z)^2} \quad (15)$$

- Inverse Difference Movement (IDM)

$$S_I = \sum_i \sum_j \frac{1}{1+(i-j)^2} p(i,j) \quad (16)$$

Classification

There are different algorithms in literature like KNN , k means algorithm, SVM, ANN etc. Here we are concentrating on the kernel functions of the support vector machine.

SVM –

Among different algorithms for classification support vector machine algorithm is the most popular algorithm and figure 3.4.1 shows the support vector machine classifier with hyperplane.

Support Vector Machine(SVM) is castoff for classification and also for regression but it is mostly used for classification rather than for regression. In this feature are considered as support vectors for differentiating between the classes.

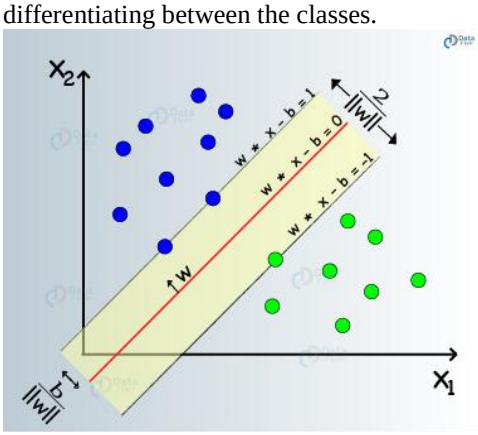

Figure 3.4.1: SVM classifier

The belief behind the working of SVM is simple and the method is to have a hyperplane which help in separating the classes. So, basically in this task to find the point which lies near to the both classes. Later we have to find the proximity between our dividing line which is called as margin. The margin should be maximized and it must reach to the maximum which lead to the optimal solution. There are various kernel functions and linear, nonlinear, polynomial, gaussian kernel, Radial basis function etc.

These algorithms for kernel functions it uses a set of mathematical functions. The kernel function will take required data as input and later it will be transformed to the desired form. The SVM algorithms use different types of kernel function. Different types pf kernel functions are available like linear, nonlinear, polynomial, radial basis function (RBF), and sigmoid. Introduce Kernel functions for sequence data, graphs, text, images, as well as vectors. RBF is the mostly commonly used kernel function. Since it has localized and finite response along the entire x-axis.

There are different kernel functions – RBF, polynomial, linear, quadratic.

i) Polynomial kernel-

$$k(X_i, X_j) = (X_I . X_j + 1)^d \quad (17)$$

d – degree of the polynomial

ii) Gaussian kernel –

$$k(x,y) = \exp\left(-\frac{\|x-y\|^2}{2\sigma^2}\right) \quad (18)$$

iii) Sigmoid kernel-

$$k(x,y) = \tanh(\alpha x^T y + c) \quad (19)$$

iv) Linear kernel-

$$K(x,y) = x^T y \quad (20)$$

4. Results and Discussion

The input image is given by figure 4.1. Nearly 100 images are used for processing with the following steps. Among these 80 images are used for training and 20 images used for testing the SVM classifier. After applying the filter, the images are fed into three different segmentation methods. The figure 4,2, 4,3 and 4,4 are the output of the adaptive diffusion flow, gradient vector flow, vector flow convolution respectively.

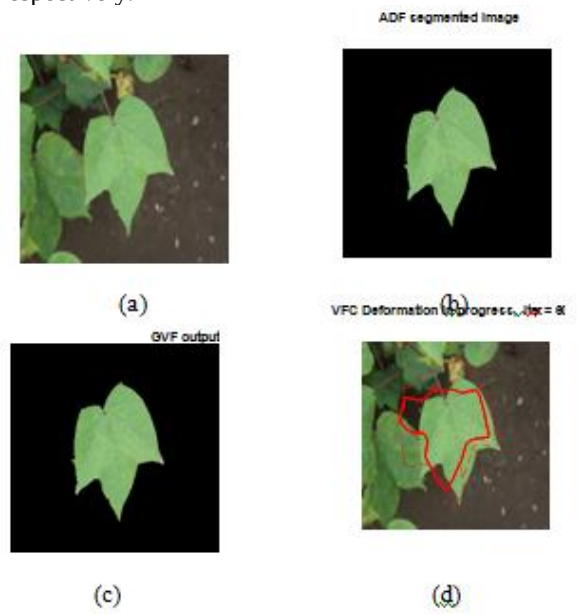

Figure 4.1: a) Input image b) ADF output image c) GVF output d) VFC output image

All the parametric methods are applied for 60 iterations. The performance of the kernel function differs based on the input as segmented image features. So, among three segmented methods ADF is much faster and properly segments the image from background.

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Table 4.1: Classification accuracy for different SVM kernel functions

SVM Kernel	Accuracy		
	ADF	GVF	VFC
RBF	70	70	60
Polynomial	80	80	90
Sigmoid	96	96	80
Linear	99	99	90

Table 4.1 shows the comparative study of various SVM kernel functions.

From this, kernel functions like linear, RBF, polynomial etc are used for the analysis. Among the above-mentioned methods linear kernel function gives better result compare to other kernel functions.

5. Conclusion

The plant leaf disease detection is the major concerned. So, in this paper three different parametric active contour models are used for segmentation and later features are extracted to fed to the SVM classifier to classify the leaf images as diseased and non-diseased leaf images. The accuracy of the kernel functions depends on the segmented images and according to the results obtained the ADF will give the good result

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