Segmentation of Satellite Imagery Based on Pulse-Coupled Neural Network

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***Abstract*— Vegetation encroachment under overhead high voltage power lines and its monitoring is a challenging problem for electricity distribution companies. Blackout can occurs if proper monitoring of vegetation is not done. The uninterrupted electric power supply is vital for industries, businesses, and daily life. Therefore, it is mandatory for electricity companies to monitor the vegetation/trees near power lines to avoid the blackouts. Pulse-coupled neural network (PCNN) considered as differently from converntial neural networks used in many signal and image processing applications. The main step to develop the automatic detection of vegetation is performing an image segmentation which is normally used to identify or marking of vegetation from the acquired images.We apply PCNN for image segmentation on satellite images for vegetation monitoring purposes and compared the performance with a thresholding image segmentation method with Pulse coupled neural network. The results show that PCNN produce outperform as compared to the thresholding method in terms of detection accuracy.**

Keywords— Pleiades Satellite Stereo Images; Pulse-Coupled Neural Network ; Segementation; Thresholding technique; LIDAR.

I. Introduction

The Pulse Coupled Neural Network (PCNN) was developed by Eckhorn in 1990s. It is based on experimental evidences of pulse burst synchronously in the monkey and cat visual cortex [3]. PCNN are spatiotemporal-coding models, which attract much attention from researchers in that they real neurons improved mimic and have more powerful computation performance than traditional neural network models due to the time ability . It can be used in many applicatiosn related to image processing and pattern recognition [2],[6] e.g., removing noise, object detectiion, image thinning and segmentations in images. Currently, vegetation and tree monitoring, under power lines, is expensive for power companies.

There are many techniques used for tree and power poles detection, and height estimation. Conventionally, visual inspection of power lines by professional and well trained people is employed. They rise the pole and monitor nearby vegetation with the help of a special software and a vehicle [4]. This method is treacherous and time consuming as well, particularly during bad weather conditions and non-uniform long terrains. It may also cause errors due to the wrong judgment made by human experts with the naked eye. On the other hand, aerial inspection using helicopters or airborne devices [4,5], which use video surveillance camera is used to get video film or sequence of images for vegetation monitoring near power poles. Electric power distribution companies spend a handsome amount on this technique. Airborne method utilizing LiDAR (light detection and ranging) technology can provide accurate results for vegetation height monitoring, but it has very expensive [7]. To provide a cost effective solution to the power distribution companies, it is possible to develop an automated method for monitoring the power lines based on computer vision techniques. Satellite imaging can provide a cost effective solution and also involves less human resources and expertise.

Monitoring and the scanning time is less because acquiring images from satellite is much easier as compared to other techniques we have discussed. We want to detect vegetation and trees using satellite images based on pulse-coupled neural network.

PCNN is considered as two-dimensional neural network. There is resemblance between each neuron and each pixedl in an input image having pixels color information as external stimulus [6,7]. Neighbour neurons are linked togeteher and getting information of local stimulus. It updates the information from external and internal stimulus until the dynamically set threshold is achieved which results in pulse output. Hence, iterative process generates the pulse output time seris. This time series contains the information about the input images and can be used for image processing applications e.g., feature extraction ,image and video segmentation [8,9].

Related with conventional image processing means, PCNNs have many important advantages, including strength against noise, independence of geometric variations in input patterns, capability of linking insignificant intensity deviations in input patterns [10]. The motivation behind this paper is used to investigate the segmentation method for dectection of vegetation or trees near power poles based on satellite stereo images. The PCCN is an effective algorithm to segment the satellite image as compared to the existing algorithm like threhsolding segmentation method.

II. METHODOLOGY

The PCCN has a single layer pulse coupled array of neuron linked with another neuron in a two dimensional way. Every pixel associated with image has one-to-one correspondence with the unique neuron [11]. Therefor, each pixel of image is connectecte to this unique neuron and further each neuron is linked with neighbouring neurons with radius of the linked field [12,13]. The basic binary image segmentation using simplified PCCNs network has the following number of parameters and as shown in the block diagram.The receptive field with input signal send the signal to modulation part and modulation field transmit the signal to pulse generator module as shown in the block diagram.

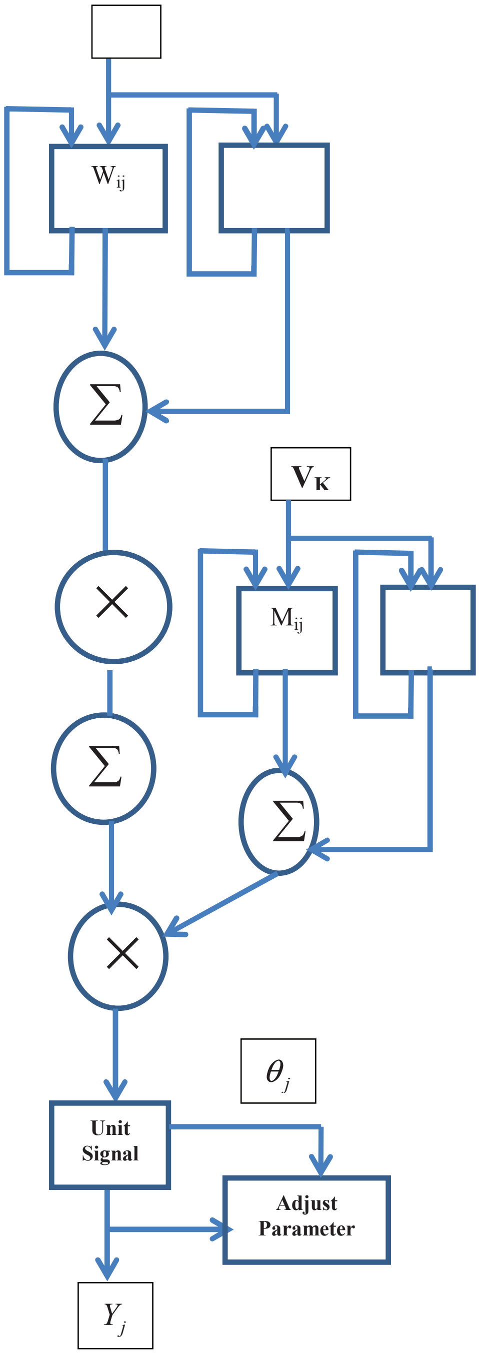

Fig. 1. Block diagram of Pulse Coupled Neural Network.

Initialization parameters

$$\alpha = 0.1; \beta = 0.1; F = input\ image$$
$$threshold = zeros(width, height);$$
$$Output = Y = zeros(width, height);$$

$$W = \begin{bmatrix} 0.707 & 1 & 0.707 \\ 1 & 0 & 1 \\ 0.707 & 1 & 0.707 \end{bmatrix} \quad (1)$$

$$V = \begin{bmatrix} Y_{i-1,j-1} & Y_{i-1,j} & Y_{i-1,j+1} \\ Y_{i,j-1} & Y_{i,j} & Y_{i,j+1} \\ Y_{i+1,j-1} & Y_{i+1,j} & Y_{i+1,j+1} \end{bmatrix} \quad (2)$$

$$L = \sum_{n>} V.W \quad (3)$$

$$U = F.\left(1 + \beta \sum_{n>} V.W\right) \quad (4)$$

$$U = \begin{Bmatrix} Y_{i,j} = 1 & U > Thershold \\ Y_{i,j} = 0 & Otherwise \end{Bmatrix} \quad (5)$$

$$\text{Threshold} = e^{-(alpha \times\ threshold)} \quad (6)$$

Now we deployed the output of the simplified neural network into the advanced PCNN and have the following number of equations.

$$alpha\_T = 0.9; alpha\_F = 0.5; alpha\_L$$
$$\beta = 0.1; V\_F = 0.2; V\_L = 2; V\_T = 0.5;$$

$$I = Y \quad (8)$$

$$K = \begin{bmatrix} 0 & 1 & 0 \\ 1 & 0 & 1 \\ 0 & 1 & 0 \end{bmatrix} \quad (9)$$

$$Work = \sum I \otimes K \quad (10)$$

where $\otimes$ is two dimensional convolution

$$F = e^{-\alpha F} + V\_F.W + I \quad (11)$$

$$L = e^{-\alpha L} + V\_L.W \quad (12)$$

$$U = F \times (1 + \beta L) \quad (13)$$

$$Y = \begin{cases} 1 & U > threshold \\ 0 & Otherwise \end{cases} \quad (14)$$

$$T = e^{-\alpha T} + V\_T \times W + I \quad (15)$$

n is considered as current iteration which varies from 1 to $N-1$ where N describes the total iterations. All alphas defined are the normalizing constants i.e., $alpha\_F$, $alpha\_T$ and $alpha\_T$. W and V defines constant synaptic weights. Linking field is L and F is the input which is being fed respectively. K is defiend as square matrix containg the dimension of 1 + linked field radius with center value of 1. Local intensity of surrounding neurons firing is computed by calculating the convolution between I and K . β is considered as the linking strength and has significant role in image segmentation [5].

During each iteration, the linking strength β is depending upon α and subsqeuently updated by a factor α . The intensity of the corresponding pixel denotes the feeding input. Gain strength matrix W represents the pixels have similar gray value neighborhood to the corresponding pixels. If the corresponding pixels have similar intensity then by firing output neuron to stimulus the the neighboring other neurons, in this way output pluse sequences $Y_{(n)}$ are attained. Noticeably, $Y_{(n)}$ infers a diversity of information, image edge and texture features values and image image area information.The ouputs of the pulse coupled neural network image segmentation is the binary image consisting of output sequences $Y_{(n)}$ which characterizes the textured area, image similar patches area and edge information.

The image segmentation algorithm is based on PCNN which takes the input signals from neurons and external sournces through linking fields. When eceptive fields collects all the inputs and further separated into more than two internal channels. Each channel is defined as feeding input F and linking input L. The linking inputs shows biased behavior and it further multiplied with each other and also multiplied with the feeding input F to generate the total internal activity represented as U.

The pulse generator of neurons works as step-function generator and also threshold signal generator. The neurons output Y is set to 1 at each time step when the internal activity U is higher than the threshold function T. Further , this threshold input is updated at each time step. The output of the neuron is in result reset itself to zero when the threshold function T is larger than U. Hence, at each time step, the pulse generator generates the single pulse output when the value of U is exceeding T.

III. EXPERIMENTAL RESULTS

In December, 2011 from French Guiana, Pleiades satellite sensor was launched. The Pleiades collection delivers optical very-high-resolution sensor in daily products in highest time, contribution daily reconsiders to any point on the globe and acquirement competences custom-made to encounter the full spectrum of civil and military necessities.The ground sample distance of Pleiades satellite image is 0.5m. The area of interest scanned by Pleiades is 100 square kilometer (Sqkm).

We cover power transmission poles from 71 to 123 in the area of Kota kinabalu in Sabah, East Malaysia. Total 52 poles are covering the area of 100 km from starting to ending. The result shown in figure 3 exhibit that PCNN technique performs accurate segmentation in the satellite image, Figure 4 shows that when we applied threhsolding technique, the result is not good and accurate. The boundaries of the object are not well seen and also the roads are not seen clearly.

In the second case, we take the image using same satellite sensor of Pleaids and now we considered the image have very close buildings, small trees and small roads. In this case we can see that our proposed PCNN technique performs well, as shown in figure 6, as compared to thresholding technique. Moreover, it segments the roads and buildings suitably and also properly segments small objects like trees and vegetation.

Similarly, we considered the third case in which we have the satellite image, as shown in figure 8, which consists of large highway, small vehicles, vegetation, and buildings. Now this time the image has very good textured and less occluded area.It contains fewer objects as compared to the previous case and we can see that when we applied the PCNN on this image[14], the segmentation of image result is very accurate and small vehicles and highway can be noticed with good accuracy. However, after applying thresholding technique the segmentation result is not clear, but gives good accuracy as compared to the previous case.

We conclude that the PCNN technique based on segmentation performs very well as compared to the thresolding segmentation method on aerial images. We need a good segmentation method for the detection of vegetation near power poles for monitoring of vegetation using satellite images instead of using UAV (unmanned aerial vehicle) images. Therefore, PCNN provides a very good opportunity for the satellite image.

Fig. 2. Satellite image contains large buildings,small vegetation,roads

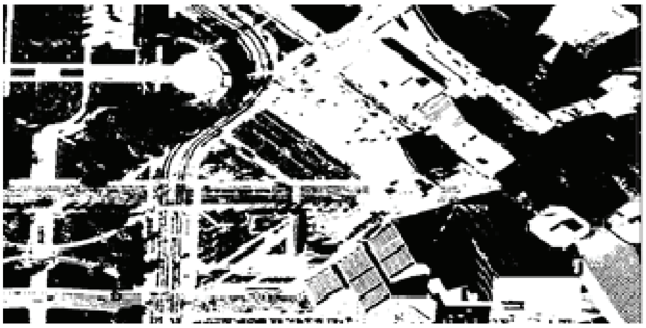

Fig. 3. PCNN segmentation result

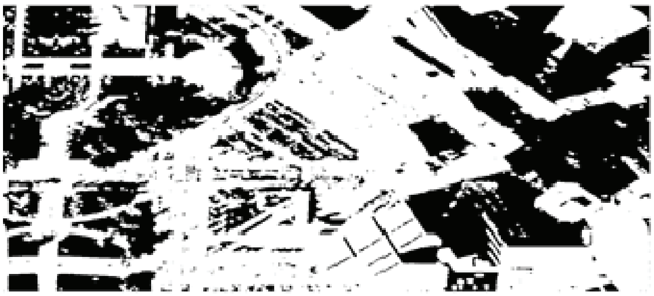

Fig. 4. Thresholding binary segmentation result

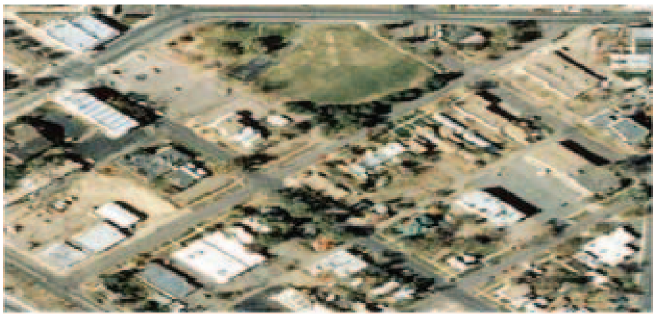

Fig. 5. Satellite image having small parks,highway,small roads,and small buildings.

Fig. 6. PCNN segmentation result.

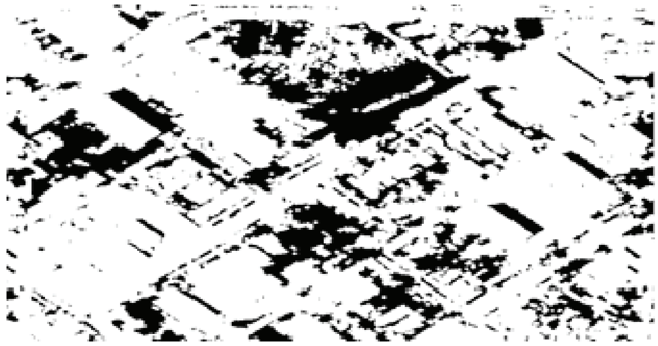

Fig. 7. Thresholding segmentation result

The structural similarity (SSIM) index can be used to measure the similarity between two signals and images. The SSIM is used to measure the quality based on reference and estimated image.The comparison between two images based on thresholding and PCCN algorithm as shown in the Table.1.The results show that our proposed algorithm based on pulse coupled neural netwrok performs good as compared to the Thresholding segmentation algorithm.

Table.1.Comparison of accuracy of our proposed and existing segmentation algorithms

Types of Satellite Images	Thresholding Algorithm	PCNN algorithm
Image1 (Fig.2)	75%	80%
Image2 (Fig.5)	78%	83%
Image3 (Fig.8)	77%	79%

Fig. 8. Satellite image comprises large highway, small vehicles, vegetation, buildings.

Fig. 9. PCNN segmentation result.

Fig. 10. Thresholding segmentation result.

IV. CONCLUSION

In this paper, we have presented an algorithm to segment the satellite image for detection of the vegetation/trees using PCNN and simple thresholding technique. We show the results in three different cases of satellite images and results show that our proposed method based on Pulse coupled neural network performs best in accuracy as compared to the threading technique. In the future, we can compare satellite stereo images to aerial images to detect the vegetation and trees for the monitoring power lines.

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