Change Detection using Pulse Coupled Neural Network

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ABSTRACT
In this paper a context sensitive technique for unsupervised change detection in multitemporal images using Pulse coupled neural network is proposed .PCNN is an biologically inspired neural network based on cats visual cortical neurons. The key strength of PCNN model is that it can operate without training and in comparison with more traditional Neural network s it has benefits like signal associated to the PCNN has properties of invariance to changes in rotation ,scale ,translation of an input patterns .This property is very useful when dealing with very high resolution images.

General Terms
Unsupervised, context sensitive change detection

Keywords
Pulse-coupled neural networks (PCNN), unsupervised change detection and multitemporal images.

1. INTRODUCTION
In remote sensing detecting regions of change in images of same scene taken at different times is of great interest due to a large number of applications, like land use change analysis, study on shifting cultivation, monitoring of pollution, assessment of burned areas, monitoring of shifting cultivations, burned area identification, analysis of deforestation processes, assessment of vegetation changes, monitoring of urban growth and oceanography .The existing methods of change detection in remotely sensed data can be classified in supervised or in unsupervised manner in the literature several supervised and unsupervised techniques for detecting changes in remote sensing images have been proposed. The supervised methods require the availability of a ground truth whereas unsupervised approaches perform change-detection without using any additional ground information. Compared to unsupervised methods supervised approaches result in higher change detection accuracies, still unsupervised techniques are more common as the ground truth information is not available in many change-detection applications. Unsupervised change-detection techniques consist of three-steps which are Pre-processing, image comparison and image analysis. Preprocessing step is performed to make two multitemporal images comparable to each other. In second step difference between the two multitemporal images is found by performing different mathematical operators like change vector analysis After finding difference image final change detection map is obtained by image analysis using context insensitive or complex context-sensitive methods in image thresholding procedures threshold is set and the difference image is compared with it to identify the changes. Threshold can be obtained by manual trial and error method or with automated techniques [2].

Context sensitive method requires the need of selecting a statistical model for changed and unchanged class distributions, which is overcome in proposed method. The presented technique automatically detects the changes in the difference image using a pulse coupled neural network. A neural network approach applied for land cover change detection on multitemporal and multispectral images change detection providing good results . Pulse-Coupled Neural Network (PCNN) is a biologically inspired neural network based on cat's visual cortical neurons. The key advantage of the PCNN model is that it has simple structure and can operate without training. Since introduced by Eckhon in 1990 [1], the model has proven to be powerful tool in digital image. Processing tasks such as image segmentation, registration, feature generation, image fusion, motion detection, pattern recognition face detection etc. . In the comparison with other image processing algorithms, the PCNN algorithm is anti-noise and robust against the translation, scale, and rotation of the input patterns [7]. The visual cortex is that part of the brain that receives information from the eye and converts the eye image into a stream of pulses The pulses generated by each iteration of the PCNN algorithm create specific signatures of the scene, which are compared for the generation of the change map. The advantage of proposed algorithm is that step 3 is not necessary anymore, which significantly increases the speed [1].

2. PCNN MODEL
A PCNN is a relatively new biological neural network based on understanding of the visual cortical models of small mammals .PCNN is derived from Eckhorn model in the 1990s it an single layer, two dimensional, laterally connected network of integrate and fire neurons .The size of the PCNN is the same size as the input image This is a neural network that without any training generates a sequence of binary images for the input digital image. Biological neuron is consists of dendrites, a cell body an axon and synaptic buttons. The cell body or soma acts as a threshold function a neuron receives signals from its neighbors via synapses and performs weighted algebraic summation on the inputs the architecture of the network is rather simpler than most other NN implementations. PCNNs do not have multiple layers, which pass information to each other. PCNNs only have one layer of neurons, which receive input directly from the original image, and form the resulting pulse image. The PCNN neuron model is made up of feeding and linking receptive fields and pulse generator. The feeding Compartment receives both an external and local stimuli; whereas the linking compartment only receives the local stimulus which represents dendrites. The PCNN is mathematically modeled for the i^{th} and ,j^{th} neuron by following equations .The value of feeding compartment Fij is

determined by the addition of the input image intensity at pixel (i,j),the weighted contributions of other neurons from the previous iteration and the feeding input of the prior iteration scaled by a decay constant as shown in equation 1.

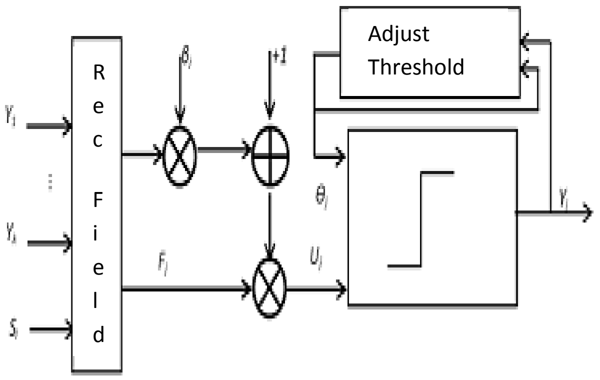


Fig1: Representation of a PCNN neuron

$$F_{ij}[n] = e^{-\alpha f} F_{ij}[n-1] + S_{ij} + V_F \sum M_{ij} Y_K [n-1] \qquad (1)$$

The value of linking compartment Lij is computed by Y1 tion of the weighted contribution of neighboring neurons ...n previous iteration and the linking input of the prior state scaled by decay coefficient as shown in equation 2

$$Y_k \quad {}_{j}[n] = e^{-\alpha L} L_{ij}[n-1] + V_L \sum W_{ij} Y_K [n-1] \qquad (2)$$

Where $S_{i,j}$ is the input to the neuron (i, j) belonging , . Each of e neurons communicates with neighboring neurons (kl) Yj ugh the synaptic weights M and W, respectively. M and W are dependent on distance between neurons traditionally they follow very symmetric patterns. Y indicates the output of a neuron from a previous iteration [n − 1]. The distinction between the feeding and the linking is that the feeding connections have a slower characteristic response time constant than those of the linking inputs. The constant V_F and V_L are the normalizing constants If the receptive fields of M and W change then this constants are used to scale the resultant correlation to prevent saturation .U is the internal activity of neuron and determined by combining the states of feeding and linking compartments . The combination is controlled by the linking strength β. The internal activity is given by

$$U_{ij}[n] = F_{ij}[n]\{1 + \beta\, L_{ij}[n]\} \qquad (3)$$

The pulse generator of neuron consists of a step function generator and a threshold signal generator The internal state of the neuron is compared to a dynamic threshold θ to produce the output Y

$$Y_{ij} = \begin{cases} 1, \text{if } U_{ij}[n] > \theta_{ij}[n] \\ 0, \quad otherwise \end{cases} \qquad (4)$$

$$\theta_{ij} = e^{-\alpha_\theta} \theta_{ij}[n-1] + V_\theta Y_{ij}[n]. \qquad (5)$$

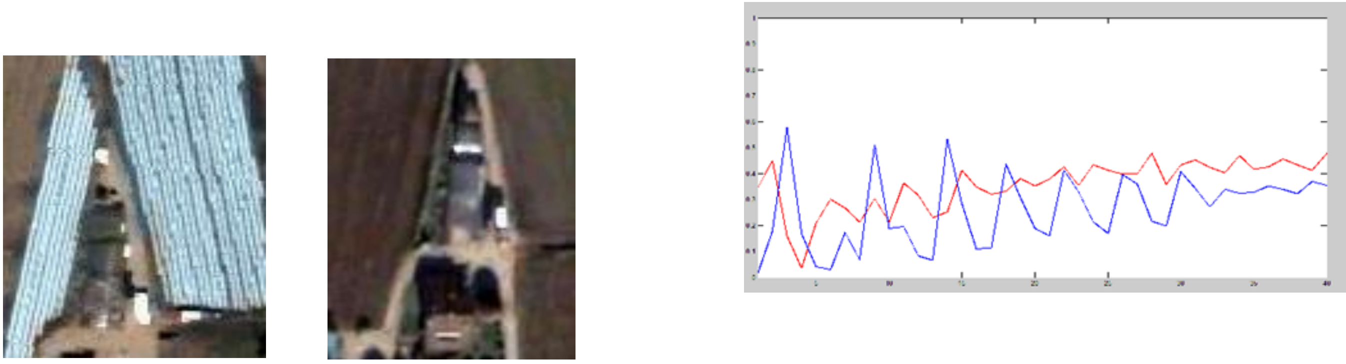
In the pulse generator, if U_{ij} is greater than the threshold, the output of neuron (i, j) turns into 1, neuron (i, j) fires, thenY_{ij} feedbacks to make θ_{ij} rise over U_{ij} immediately, and them output of neuron (i,j) turns into 0. It will then take several iterations before the threshold values decay enough to allow the neuron to fire again. All compartments have a memory of the previous state, which decays in time by the exponent term that decay is modeled by constant term α_L , α_F and α_Θ they are the attenuation time constants .The PCNN algorithm is a iterative procedure in which output of one iteration stimulates the next iteration single iteration include computing (1)–(5) . From series of output images from PCNN, Johnson created an image signature also called the time signal It is important to observe that this time signal associated to the PCNN has the properties of invariance to changes in rotation, scale, shift, or skew of an object within the scene [7]. This quality makes the PCNN a powerful tool in change detection where the view angle of the satellite can cause false alarms [1]

3. PROPOSED CHANGE DETECTION ALGORITHM USING PCNN

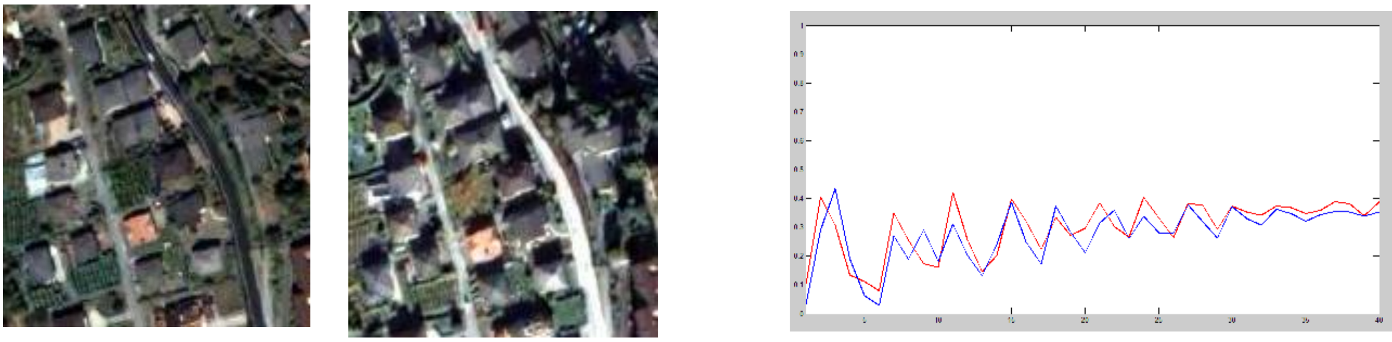
The application of PCNN to change detection is performed by measuring the similarity between PCNN signal associated to the former image and one associated to the latter. Equation 6 is used to convert pulsed image into single vector information

$$\boldsymbol{G[n] = \frac{\sum_{ij} Yij[n]}{N}} \qquad (6)$$

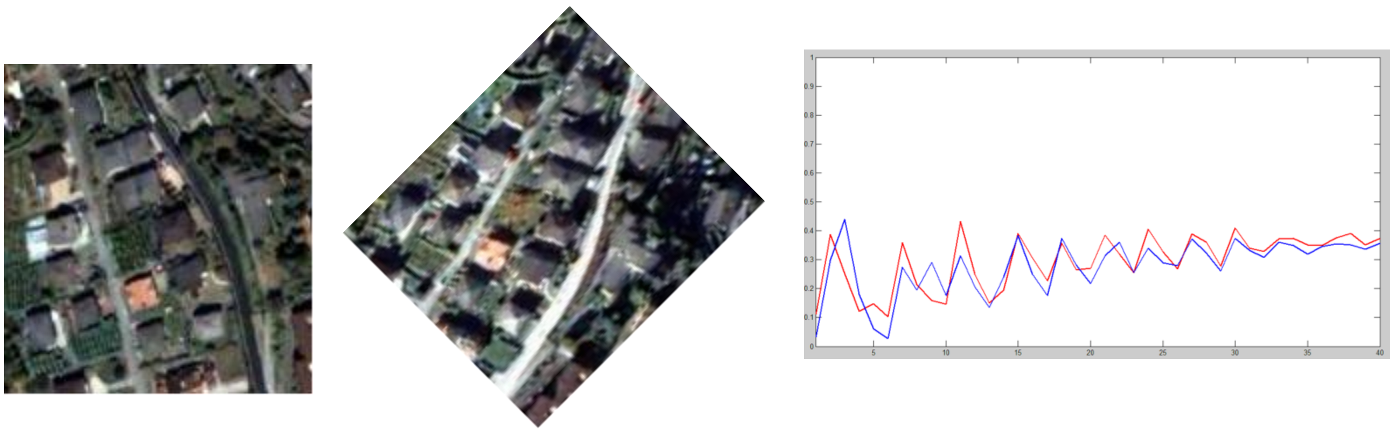
Similarity between feature vector of two multitemporal images can be found by using correlation function operating between outputs of PCNN. In figure 2 PCNN output G[n] for considered test areas is plotted by calculating mean over RGB bands .In figure 2 We observe that in test area A few changes have occurred and results show that that pulsing nature of PCNN output is highly correlated it is also observed that rotation and scaling do not effect pulsing nature of PCNN output .For test area B the pulsing nature of two signals is different corresponding correlation values associated to each image pair are reported in Table1.



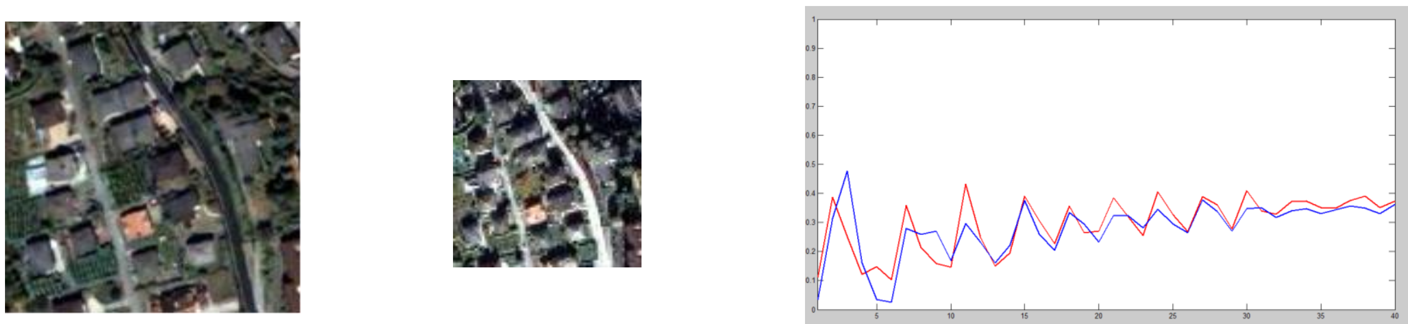
(a)



(b)



(c)



(d)

Fig2Test areas with feature vector Test area A (a),Test area B (b), Test area B rotated(c) and Test And Test area B scaled (d)

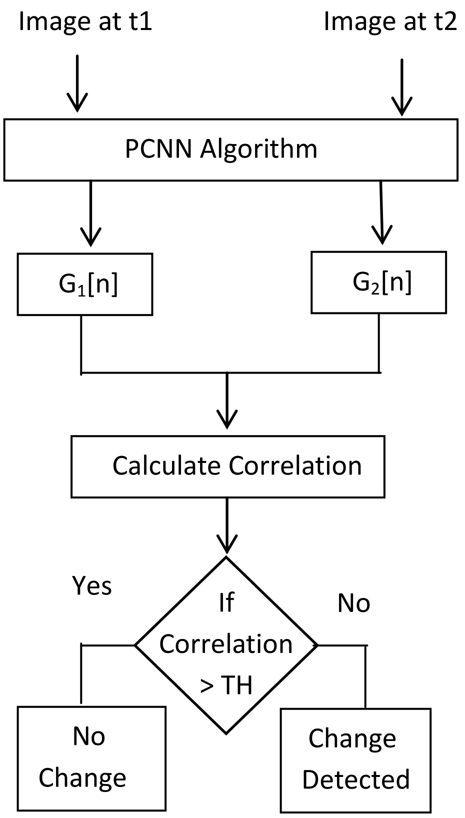


Fig3: Flowchart of proposed algorithm

Table1:Correlation values for the considered test cases

Test area	Correlation values	Result
A	0.22	CHANGE
B	0.82	NO CHANGE
B SCALED	0.81	NO CHANGE
B ROTATED	0.83	NO CHANGE

Table1

4. FUTURE SCOPE AND CONCLUSION

In coming future proposed approach can be extended using object analysis rather than on changed-pixel method for detecting changes in huge size of the images. The two feature vector generated by PCNN one for each image, can be compared for deciding about the occurrence of a change. Applying successively this procedure to a moving window will allows the processing throughout the whole image. PCNNs are unsupervised and context sensitive in addition they are invariant to an object scale, shift, or rotation, which, once the two images are registered, might be rather useful, particularly for VHR images.

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