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A Proficient Satellite Image Building Detection Using Fuzzy and Neural Network Techniques

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Abstract

Building Detection in urban area satellite image is a most helpful and needful one which is agreeable in urban area planning. This is a puzzling job to human software developers for the segmentation of building area from urban area satellite image. The governance of a country is nowadays mostly depending upon a satellite images. So new and better building detection method is urgently required one. This research develops a fresh approach for building detection using a noise reduction scheme FIDRM, a novel Feedback Adaptive FCM and BPN methods. The noise reduction scheme reduces noise in a significant level and the FAFCM method partially segments the urban images which can be supportive to training data for the BPN training stage. The trained BPN network segments the building portion from the background part. This method is further refined to get better segmentation. This new method is implemented and evaluated with other existing methods to take over a better analysis. The proposed method grants a successful segmentation building detection with a significant level of accuracy.

Keywords: Building detection, urban area segmentation, Feedback Adaptive FCM, BPN, satellite images, Quick Bird.

I. INTRODUCTION

Urban area is a term, means it consist of crowded human population and crowded human built features like building, vegetation, road etc. From the past 23 years detection of buildings from satellite image is more important for lot of applications including urban mapping and planning, mobile communications, environmental monitoring, risk assessment, military usage, war period and virtual tourism [1]. Building taking out from satellite pictures has been one of the most complex and challenging task. Unexpected usual calamities such as earthquakes, tsunamis, and hurricanes can strike in minutes and leave behind damage and loss of lives. The widely held of calamities cannot be disallowed and still have a deep effect on the socio economic system of the pretentious nations [1].The knack to successfully spot constructions helps in understanding the scene substances of the image and may be used for contented based taking out in databases and in other applications such as built-up growth planning, loss assessment and military target recognition [2]-[6]. DevisTuia et al. [7] uses SVM for classification and uses Quick Bird images for classification. The overall accuracy is low percentage (below 40).

The first direction [8]-[12] adheres unsupervised fashion. For example. Pesaresi et al. [8], proposed the gray level co-occurrence matrix (GLCM) based built up area index. Berilsirmacek et al. [13] presented dissimilar local feature vector extraction approaches. Each local feature vector specifies a building to be noticed in the image. But single one of them is not sufficient to detect the building. Here false alarm (FA) rate is somewhat higher. Sirmacek and Unsalan [14] suggested the distribution density map of local feature points for indexing built up areas. Sirmacek et al. [15] proposes SIFT method. SIFT is not adequate for spotting urban areas and building alone. Cognitive techniques use semantic features to identify an objects absence, presence or change in the damaged areas [16]. Simler [17] proposed a spectral-spatial object classification with SVM. In fact the bad building detection and the road false alarm problems are still present. CaglarSenara et al. [18] combines the detection results of numerous classifiers. In this paper the training data and test data are selected from dissimilar and irrelevant region, the performance values decrease drastically. Aymensellaouti [19] introduce a hierarchical region based extraction approach. A hierarchical growth is used based on a building template to identify the growth region. It allows an interaction between object construction and extraction along the hierarchy. A growing process based on expert knowledge is used to extract the building. Hongchaco Fan et al. [20] uses Georeferenced MLS raw data is taken as input and perform preprocessing, detecting seed points of manmade objects, identifying 3D points to manmade objects. The detection rates obtained are 83%and the overall accuracy is 92.37%. The limitation of this method is trucks are identified as tiny apartments, some of the fences are not identified and separated and it is identified as cars. Mohamed I.Elbackary et al. [21] Proposes a method that is panchromatic satellite input image is given to Biased Geometric active contours for segmentation. For dark region segmentation, Global processing, Geometric filter and shadow regions segmentations are performed. This method separates only the shadow of manmade construction of gray level satellite pictures only but not color figures. Yansheng Li et al. [22] proposes a complete and systematic approach. If first utilizer multikernal learning to incorporate multiple features to implement the block level image interpretation. Then multifield integrating for the block level and then multihypothesis voting and graph smoothing for pixel level built up area detection. This method has been confirmed in the ZY-3 and GF-1pictures from the result extract only edge of built-up areas.

Haoshi et al. [23] proposes approach in which satellite image is given as input and performs Down sampling, Edge extraction and homogeneous region extraction on input image. From Down Sampling result, Feature point extraction Gaussian weighted voting matrix and adaptive segmentation is performed and fused with edge extraction and given input for guided image filtering then contrast was enhancing and decision making. Finally urban areas are detected. Certain limitation of this algorithm is (i) roads around the buildings are extracted together (ii) when the edge of the building is fuzzy or the edge feature is not obvious, then the result will be that a buildings become lost (iii) If the roof of the buildings are too large and somewhat smooth, then it will be recognized as non-urban areas. The methods used in this paper are revised shadow information, detection of dark regions, fuzzy landscape and detection of initial building regions and these methods allows us to detach regions belonging to dark objects from cast shadows and it is applied the images like IKONOS-2(1m)and Quick Bird(0.60m) sensors. Natalia Sofina and Manfred Ehlers [24] present a semi-automated feature based method to the identification of man made parts using geographic information system and remote sensing information. The integrity and homogeneity of the area inside the building footprint satellite images are used .The demerit of this approach is the building that are completely or partially occluded by trees can't be detected as intact.

D.Chaudhuri et al. [25] proposes an algorithm. It takes input as high resolution satellite imagery and perform enhancement, IGV feature computation, seed point detection from IGV feature, clustering, Binarization, Thinning and component filtering operators, etc. This approach uses IKONOS and Quick Bird panchromatic imagery. But this approach is unable to fully detect the buildings. Qian Zhang and GuixuZhang [26] develop the morphological building index method. Further adjust the MBI output and eliminate the commission bugs and undergo the process of morphological spatial pattern analysis. This approach is evaluated by using Geo Eye-1and World view-2 images. But the performance is more apparent in rural areas with dense buildings. Existing papers suffers lack of accuracy, In order to avoid that we need a robust algorithm for building detection. In this work we propose new algorithm BD-FAFCM-BPN. In this algorithm FAFCM and BPN technologies are used to provide high accuracy for detecting buildings from satellite images. In this paper section II provides proposed method. Section III provides Results and Discussion and Section IV provides conclusion of this work.

The proposed method BD-FAFCM-BPN uses FIDRM, Feedback Adaptive FCM and BPN Neural network and it uses two types of image databases like ASTER and Quick Bird as input.

II. PROPOSED METHOD

The gray scale image is taken as input to the proposed method and it segments the satellite images into building area and background area. The urban area satellite images are used for this purpose. The Proposed method BD-FAFCM-BPN is constructed by three main parts. They are

i) FIDRM based Noise reduction
ii) FAFCM based partial segmentation
iii) BPN based building detection.

The input image is fed to the FIDRM noise recognition and reduction and produces the noiseless image. The noiseless image is converted to vector and it is input to the Adaptive FCM clustering method. Then computes the building area index and it is taken as input to the Adaptive FCM. It produces the refined building area index. The small objects and roads are removed. BPN training process and BPN testing process are carried out and finally it produces the segmented building marked image to the user. The following Fig.1 shows the Architectural diagram and Fig.2 shows the Data flow diagram.

(i) FIDRM based Noise Reduction

The impulses noises are removed using the Fuzzy Impulse detection and reduction method. This method is made up of two main steps which are fuzzy noise detection and fuzzy noise reduction. The noise reduction part is activated by using GOA filter to the evaluation of the noise occurrence. A 3x3 size window is used to find the gradient value related with the neighbor pixel [28][29]. The eight gradient values are called as basic gradients and this value can be used to determine the ratio for the effect of noise. The heavy value gradient indicates that the pixel is a noisy pixel. The detected noise pixel is solved by the neighbored elements of the current processing window with mean calculation.

(ii) Feedback Adaptive FCM method

The novel Feedback Adaptive FCM method is used to have the partial segmentation of building images. The Adaptive FCM function which is referred in the paper [30], this AFCM method preserves the advantages of FCM which it works even in the intensity inhomogeneities. Here the centroids are multiplied by some unknown multiplier field m(i,j).

The objective function is similar with the FCM objective function. The first derivative of J_{AFCM} with respect to u_K (i,j), v_k and m(i,j) is considered to segmentation. The initial values of the centroids v_k are assigned and the multiplier field m(i,j) is assigned as 1 for all (i,j). The membership values are computed using the Equation (1).

$$u_k(i,j) = \frac{|y(i,j)-m(i,j)v_k|^{-2}}{\sum_{i=1}^{k} |y(i,j)-m(i,j)v_1|^{-2}} \quad (1)$$

The new centroids are calculated based on Equation (2).

$$v_k = \frac{\sum_{i,j} u_k(i,j)^2 m(i,j) Q y(i,j)}{\sum_{i,j} u_k(i,j)^2 m(i,j)^2} \quad (2)$$

$$K \in [1, c]$$

The new multiplier field is derived from the following space-varying difference equation for m(i,j)

$$y(i,j) \sum_{k=1}^{c} uk^2(i,j) v_k = m(i,j) \sum_{k=1}^{c} uk^2(i,j) vk^2 + \lambda 1(m(i,j) ** H1(i,j)) + \lambda 2\big(m(i,j) ** H2(i,j)\big) \quad (3)$$

Where

$$H1(i,j) = D_i * D_i + D_j * D_j$$

$$H2(i,j) = D_{ii} * D_{ii} + 2\big(D_{ij} * D_{ij}\big) + D_{jj} * D_{jj}$$

Then the algorithm iteratively segments the buildings until it gets converged and then it quits its duty. The convergence is happened when the iteration gets a lower value than threshold value .This method allows the membership matching values in between 0 and 1.The higher membership value is allocated for the resultant cluster for a (i,j) pixel and the lower is allocated for presenting non relevant clusters.

The noise free image is given to AFCM process and the AFCM segments the satellite image into three clusters. The corresponding segmentation indexes are utilized to separate the building parts away. The separated part is again given to AFCM and segmented into three parts. The unique parts of these segments are background, roads and buildings. In buildings are further refined from theroad and building clusters. Finally all the building blocks are combined and they are used to create the training vectors.

c) BPN based building detection

The Back Propagation Neural network is a powerful classifier and this can be used to segment the buildings. The training vectors are given as input for the 'Known Input' and the unknown output is derived by setting 1 for buildings and 0 for non-buildings. The final segmented building is displayed to get the visual view of the user. The BPN modifies the network weights to shrink the MSE between the desired and actual outputs of the network. The given set of training vectors are used to train up the neural network with known input and known output. The network makes testing by checking the entries of its memory for the examination of output response to the sample input pattern. The output response is compared to the known and desired output and the error value is calculated [31]. The BPN iteratively checks out the matching process until it reaches the goal of itself and the network displays the segmented display.

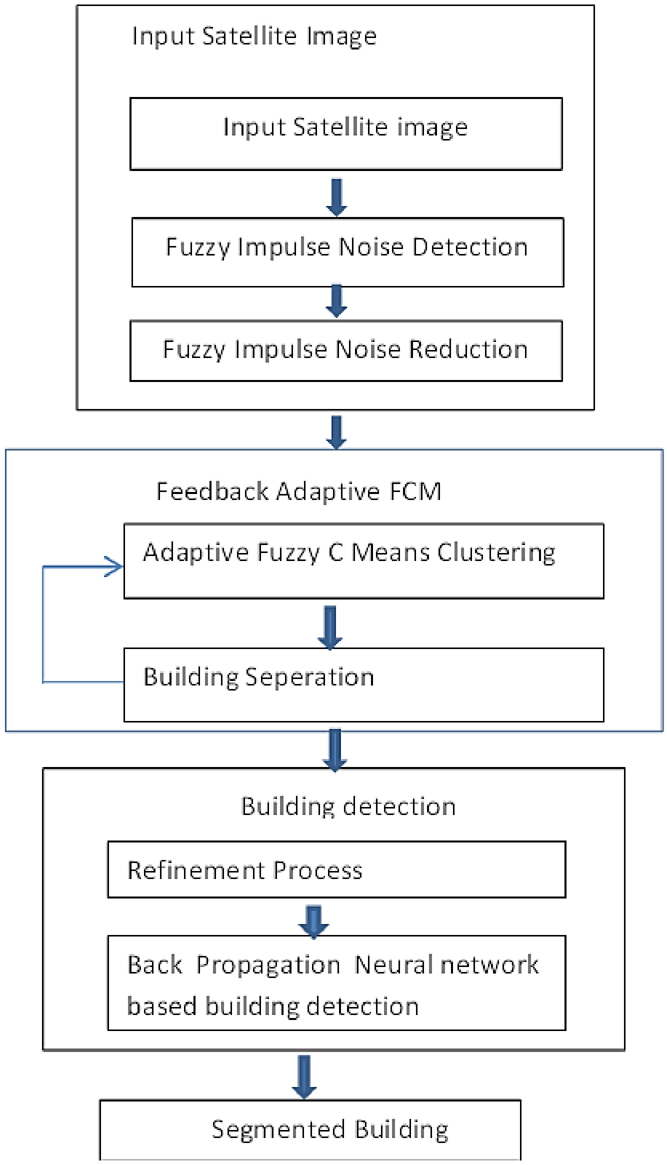

Fig.1. Architectural Diagram.

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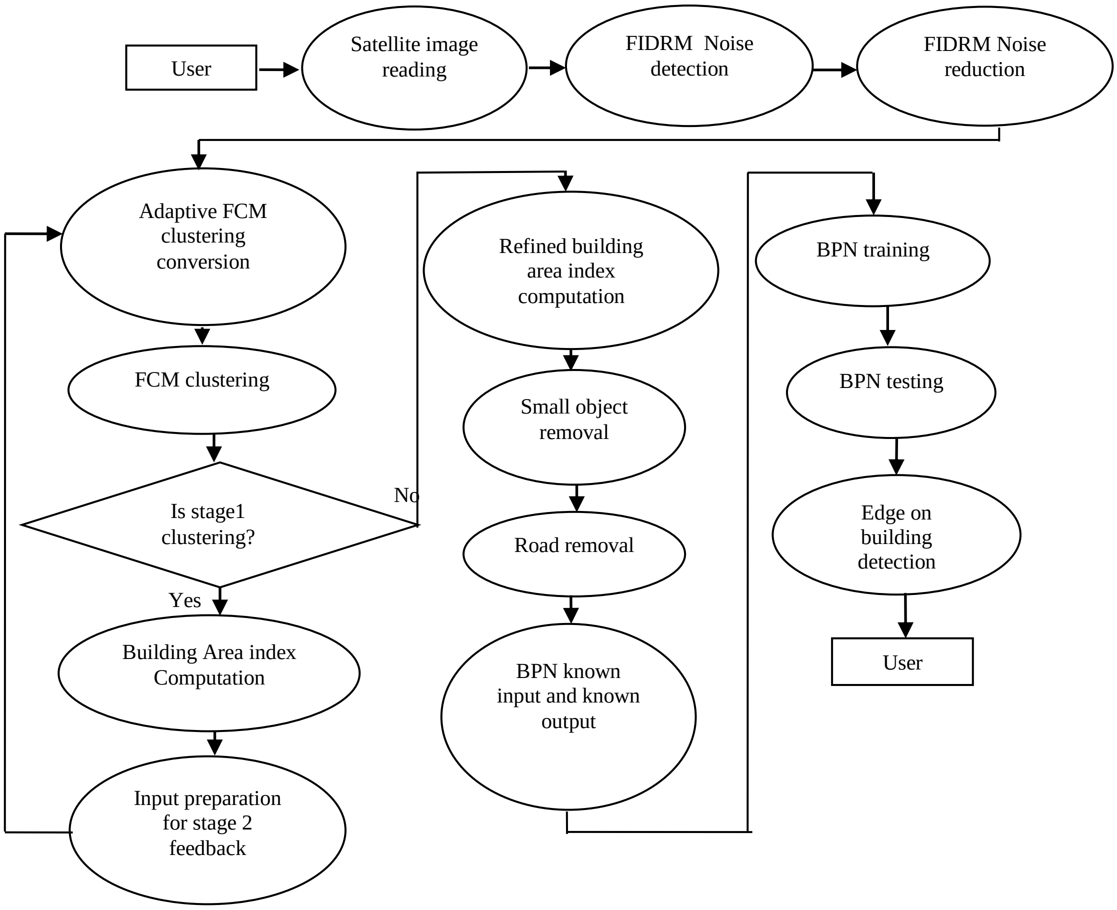


Fig.2. Data Flow Diagram.

III. RESULTS AND DISCUSSION

The proposed Building Detection Method is analyzed and assessed based on the subsequent three building detection methods to find the feasibility study and claims of the existing versions. Fuzzy C –Means based satellite Image building segmentation [27]. A Morphological Building Detection Framework for High Resolution optical imagery over urban areas [26]. In the above existing methods, the first paper which has FCM as foundation method, segment the satellite images based on fuzzy technique. The second method segments the buildings using Morphological operation. The analysis part is processed with the Quick Bird and ASTER database which is the satellite image database. The performance characterization of the new method against the above two methods is carried out using 100 satellite images of Quick Bird and ASTER database.

The Performance Characterization of the building detection methods can be calculated based on the succeeding performance measurements.

- Eye perception index
- Output Comparison
- Time Taken
- Mean Square error
- Peak Signal to Noise Ratio

The Eye Perception index (EPI) is the one which measures the visual quality of segmented image, assessed through the human eyes perception. It is a ranking method based on human through visual perception. If the higher ranking means higher eye perception index, which means a proposed method is a better method.

Table 1: Eye Perception performance Analysis

Images	Methods	Eye Perception Index
Satellite_img1	FCM	2
	BD-Morph	1
	Proposed Method	3
Satellite_img2	FCM	2
	BD-Morph	1
	Proposed Method	3
Satellite_img3	FCM	1
	BD-Morph	2
	Proposed Method	3
Satellite_img4	FCM	1
	BD-Morph	2
	Proposed Method	3

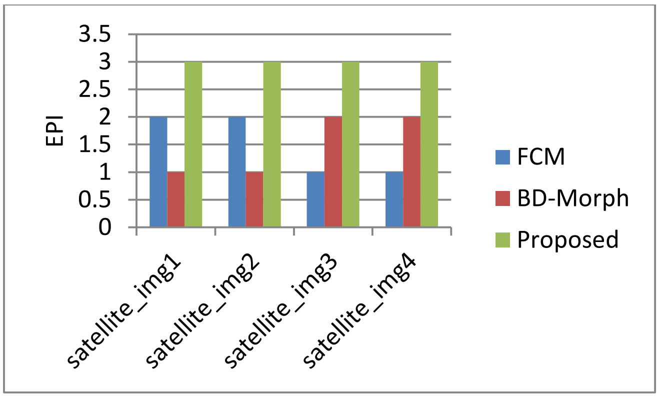
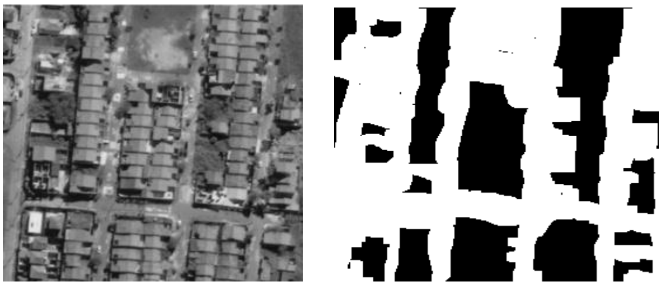


Fig.3. Eye Perception Index analysis.

The Table1 and Fig.3 explores that the proposed method BD-FAFCM-BPN attains high rank based on human perception and the BD-Morph method achieves next higher rank and FCM method achieves the rank 3 and the BD-Morph achieves the rank 2 in major cases of implementations.



(a) (b)

Fig.4. Output of Proposed method (a) Original Satellite Image (b) Segmentation output

Fig.4. presents the segmentation output of the proposed BD-FAFCM-BPN method to know the power of the algorithm. Fig. 4.(a) shows the original satellite image and Fig.4.(b) shows the segmented image. This output proves the segmentation ability of the proposed method.

(a) (b)

Fig.5. (a) shows the original image and Fig.5.(b) shows the segmented output of the proposed method. The buildings lie on that image can be segmented in an established way through the proposed method.

Table 2: Average Time Taken Analysis

S.No.	Methods	Average Time taken (in seconds)
1	FCM	10.23
2	BD-Morph	39.48
3	Proposed	38.25

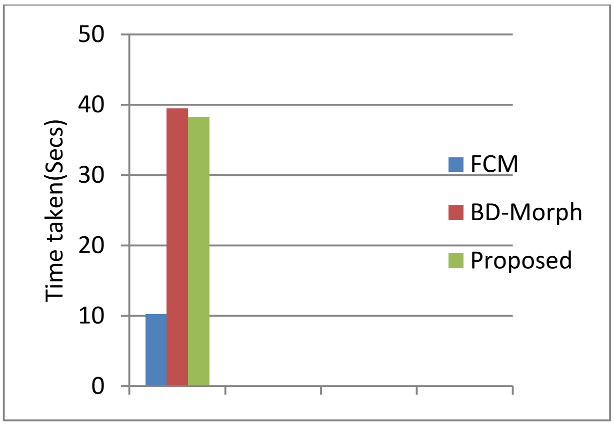


Fig.6. Average Time Taken Analysis for 4 Images.

The Average time taken analysis can be experienced through the Table2 and Fig.6.

The Table 2 demonstrates the less time taken of the proposed method to make segmentation of satellite image. The proposed method takes less time than the BD-Morph method while it takes more time than the BD-FCM method

Table 3: Mean Square Error Analysis(MSE)

Images	Methods	MSE
Satellite_img1	FCM	0.1017
	BD-Morph	0.0975
	Proposed Method	0.0383
Satellite_img2	FCM	0.1330
	BD-Morph	0.1305
	Proposed Method	0.0137
Satellite_img3	FCM	0.1213
	BD-Morph	0.1201
	Proposed Method	0.0279
Satellite_img4	FCM	0.1070
	BD-Morph	0.1070
	Proposed Method	0.0106

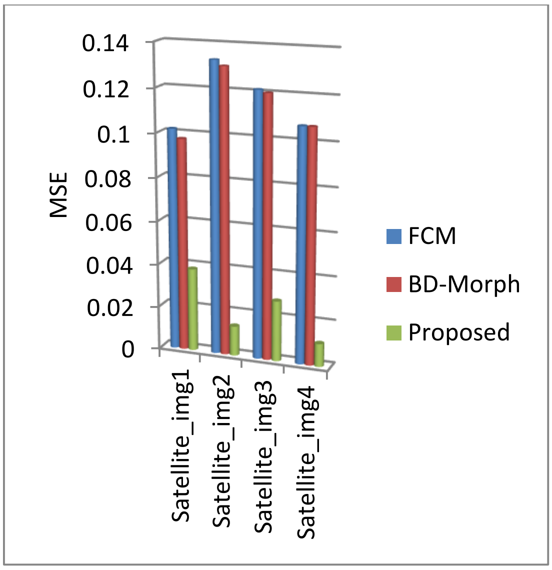


Fig.7. MSE Analysis Chart.

Table 3 and Fig.7 shows the MSE Analysis on the three methods for four images. The lower MSE express the better segmentation method while the higher MSE express the lower performance method. According to this statement the proposed BD-FAFCM-BPN method reaches the minimum MSE values for the four images while the others are more. So this table and chart proves that the proposed method is the best one. The MSE computation is done by using the Equation (4)

$$MSE(I,I') = \frac{1}{p \times q} \sum_{i=1}^{p} \sum_{j=1}^{q} (I(i,j) - I'(i,j))^2 \quad (4)$$

Table 4: Peak Signal to Noise Ratio Analysis

Images	Methods	PSNR
Satellite_img1	FCM	58.0576
	BD-Morph	58.2408
	Proposed Method	62.2988
Satellite_img2	FCM	56.8923
	BD-Morph	56.9747
	Proposed Method	66.7636
Satellite_img3	FCM	57.2922
	BD-Morph	57.3354
	Proposed Method	63.6748
Satellite_img4	FCM	57.8370
	BD-Morph	57.8370
	Proposed Method	67.8777

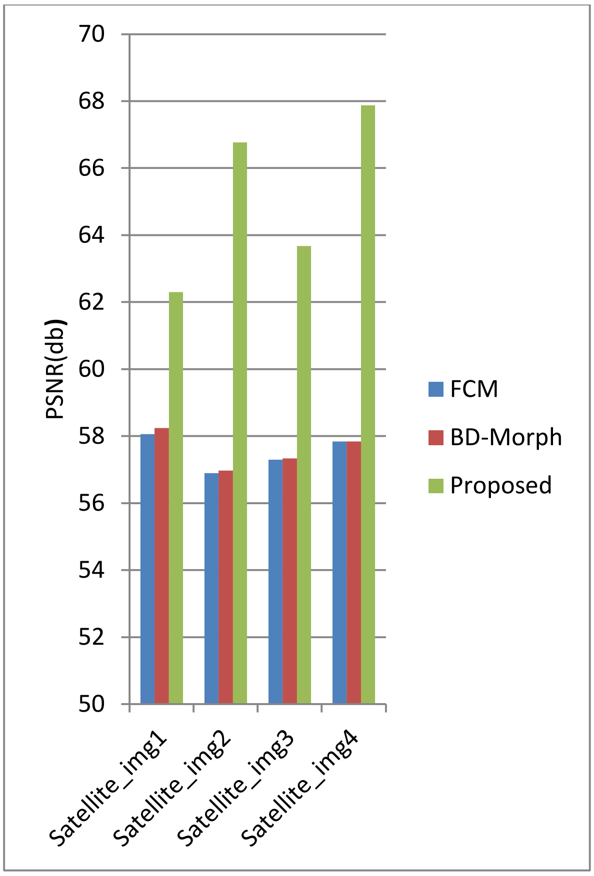


Fig.8. PSNR Analysis Chart.

The PSNR Analysis is done based on the Equation (5)

$$PSNR(I,I') = 10\log_{10}\left[\frac{R^2}{MSE(I,I')}\right]_{dB} \quad (5)$$

The better method owns the higher PSNR values and the others are taken less values. The proposed BD-FAFCM-BPN achieves the higher rank based on the PSNR among the other methods like FCM and BD-Morph. The PSNR Analysis is indicated by the Table 4 and fig. 8 for clear understanding.

IV. CONCLUSION

This effort presents an innovative method of building detection using FAFCM and BPN to solve the major drawbacks of existing systems. The chief goal of this effort is to improve the accuracy to higher level in building detection. This work reduces the false detection at higher level. The method BD-FAFCM-BPN gives less MSE and higher PSNR than other methods. The proposed method improves PSNR values up to 67.777dB. From MSE and PSNR values one can identify that the proposed method is better than the existing methods. The proposed method is fit to military based applications and urban planning of government agencies. In future a better preprocessing scheme can be cohesive with this method to reach higher segmented accuracy.

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