Elimination of False Detections by Mathematical Morphology for a Semi-automatic Buildings Extraction of Multi Spectral Urban Very High Resolution IKONOS Images

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ABSTRACT: *We propose in this paper a method based on mathematical morphology for building extraction in a very high spatial resolution satellite urban areas images, it requires no exogenous variable, unlike other approaches (e.g., using elevation data or supervised classification postprocessing [1]). It consists on using several morphological operations such as hit-or-miss transform (HMT), the geodesic reconstruction and smoothing. Comparative studies of two methods (including that of [1]) are presented showing the interest of the approach we used.*

Keywords: False Detections, Mathematical Morphology, Building Extraction, Very High Spatial Resolution Satellite Urban Areas Images

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1. Introduction

The mathematical morphology has been successfully used in various fields such as materials characterization, medical imaging, or vision. In remote sensing, it has been used to extract parameters to classify the elements constituting the image as the work of [2] and [3] or even to detect buildings such as [4] and [1].

In this paper We focus for the builded regions detection and we believe it is better suited to this application because it is based on the study of the form (spatial information): building are characterized by those informations.

The Hit or Miss transform is one of the methods based on mathematical morphology. Among existing work using this method to detect buildings, we quote the one of [1] for example, who used one type of panchromatic urban images (from the satellite Quickbird). From the principle on which is based their approach, we propose in this paper a method for improve the building detection, this time we applied it to a multi spectral images from two very high spatial resolution satellite (Ikonos and Quickbird).

We are particularly interested for those images because they contain geometric information, so they are well suited for pattern recognition using morphological operators.

2. Principle of the First Method Hit or Miss Transform with a Variable Size Structurant Element

Before beginning the proposed method, it is useful to recall the principle of the Hit or Miss transform of an image.

The Hit or Miss transform used in this work has the same priciple as the classique Hit or Miss transform exept that we must use here an variable size structurant element. So we must apply a double erosion (on image A and its complement A^c) with two disjoint structurant elements having the same origin, denoted *E* and *F*:

$$A \otimes (E, F) = A \ominus E) \cap (A^c \ominus F) \tag{1}$$

With:

$\otimes$: The operator indicating the hit or miss transform of the image *A* with the structurant elements *E* and *F*.

$\ominus$: The erosion operator.

The operator seeks to ensure that the *A* elements are included in *E* and A^c elements (image background) are included in *F*. All positions for which these relationships are respected participate in the definition of the resulting image.

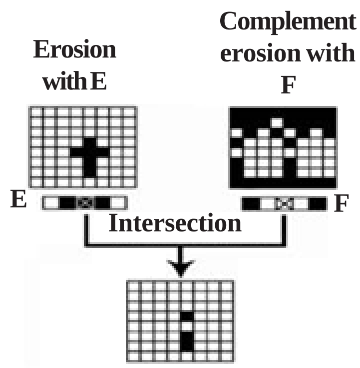

Figure 1. The « Hit or Miss » transform with two disjoint structurant elements *E* and *F*

3. Principle of the Second Method [1]

The proposed approach by [1] is based on the application and the concatenation of operators from binary mathematical morphology (Figure 2)

Thus, the steps that constitute the method are:

Step1: Image binarization with a global thresholding. [5].

Step 2: Morphological Smooth: It eliminates objects whose size is smaller than the minimum size supposed by buildings in the studied scene, it is a morphological opening which the principle is detailed in equation (2) below:

$$I_{somt} = A^o B = (A \ominus B) \oplus B \tag{2}$$

With:

I_{somt} : The resulting image of the smoothing (morphological opening of the image A with the structurant element *B*).

$\oplus$: Dilatation operator.

A: The binary image.

B: The structurant element whose choice depends on the buildings size.

Step3: Buildings detection by applying a hit or miss transform using a variable size structurant element.

$$I_{hmt} = \cup (I_{somt} \ominus E) \cap (I^c_{somt} \ominus F) \tag{3}$$

With :

I_{hmt} : The resulting image of the hit or miss transform.

I_{somt} : Smoothed image.

I^{c}_{somt} : The complement of the resulting image of smoothing.

E, F : The structurants elements.

Step 4: Restoring the buildings forms with a geodesic reconstruction: the application of the hit or miss transform..allows deleting image regions that are not buildings and keep only the objects of interest. However, it also has a modifying effect of the original form of the existing buildings because of the method which is based on erosions which have the reducing size effect of objects in the image.

The purpose of this fourth step is to restore the original shape of buildings using a marker image dilated and conditioned by a mask image.

The marker image is the result of step 3; in this step it will undergo a succession of dilatation.

The mask image is the result of step 2; it contains the undeformed elements but also other elements that must be eliminated.

$$I_{rec} = (I_{hmt} \oplus I_{smo}\, C_i)^{\infty} \qquad (4)$$

With an application until idempotence (transformation invariance) of the conditional dilation defined by:

$$I_{hmt} \oplus I_{smo} C_i = (I_{hmt} \oplus C_i) \cap I_{smo} \qquad (5)$$

With:

I_{rec} : The reconstructed image.

I_{hmt} : The resulting image of the hit or miss transform.

C_i : The structurants elements ($1 \leq i \leq 3$)

I_{smo} : Smoothed image.

4. Principle of the Third Method (Method Proposed)

We applied the two methods mentioned before on several multi-spectral very high spatial resolution images. From there, some disadvantages have been identified, which are:

• The global thresholding is not always well suited to the available images, especially those who present a significant heterogeneity spectral, as a solution we proposed adding an empirically (experimental) thresholding. The empirically thresholded image will be used as a reference image; the comparison is defined by an element by element multiplication. so we compare it with the reconstructed image to get a better result.

$$I_{com} = I_{rec} \cap I_{tem} \qquad (6)$$

With :

I_{com} : The resulting image of the comparison.

I_{rec} : The reconstructed image.

I_{tem}: Empirically thresholded image.

• There are objects belonging to the background of the image that have been detected as buildings. To remove them, we proposed a morphological smoothing after the comparing step.

$$I_{res} = I_{com} {}^{\circ} D = (I_{com} \ominus D) \oplus D \qquad (7)$$

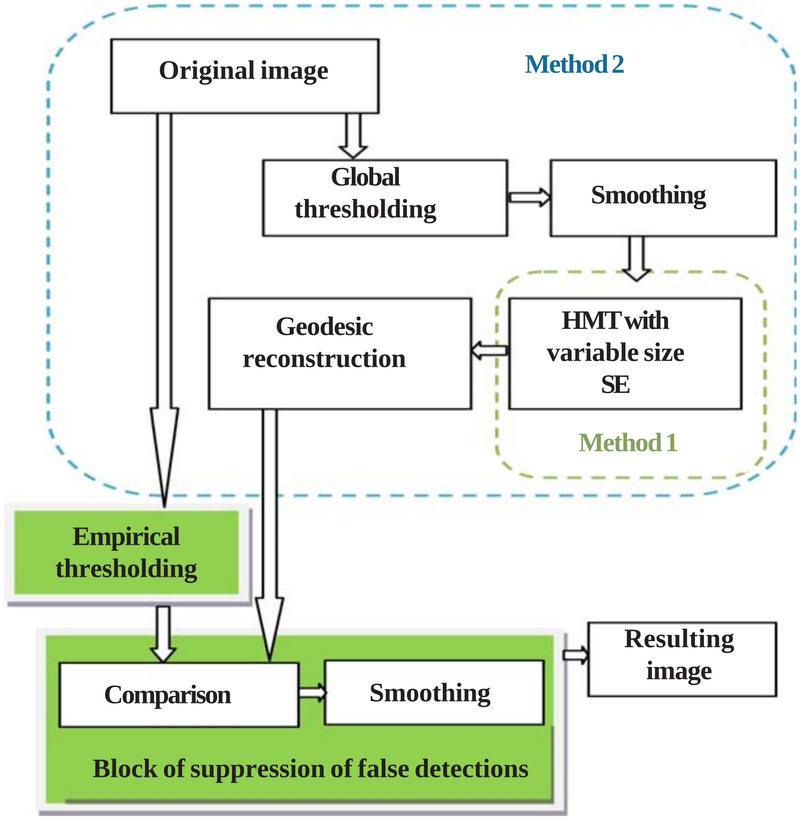

Figure 3. Flowchart of the proposed method for the buildings extraction

With:

I_{com} : The resulting image of the comparison.

D : The structurant element whose choice depends on the buildings detected size.

I_{res} : The final resulting image.

5. Experimental Results

We applied the proposed method on several multi spectral very high resolution spatial images; we simply illustrate on this paper

(A)

(E)

Figure 4. (A). (E) Original images used

the results of two images (Quickbird and Ikonos) with varying degrees of complexity.

We can see in the figure 4, that the image A contains buildings of the same color and homogeneous structures, however, the image *E* is composed of buildings with more complicated structures and colors relatively close.

From the available images, a visual review was applied to determine the parameters required by the morphological operators used (size and shape of the SE).

The structurants elements are selected according to the size of the smaller buildings existing in the original image. They also depend on the shape of the structures to be removed, and, like we have in the original images a buildings with forms square and or rectangular, structurants elements used are with the same shape.

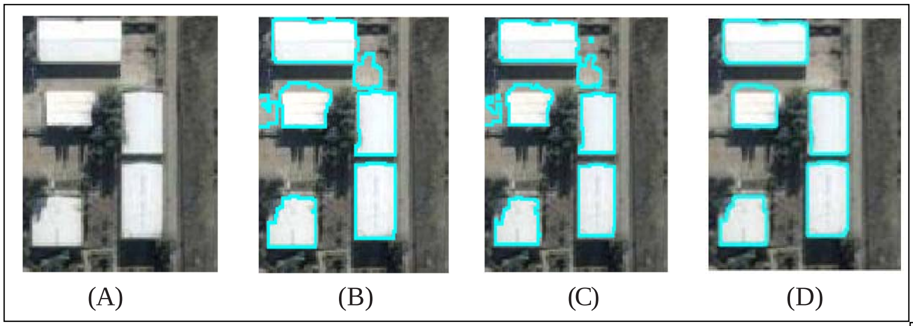

Figure 5. (A). Original image, (B). Resulting image of method 1 (HMT with varying size structurant element), (C). Resulting image of method 2 (of [Sheet al 07]), (D). Resulting image of the proposed method

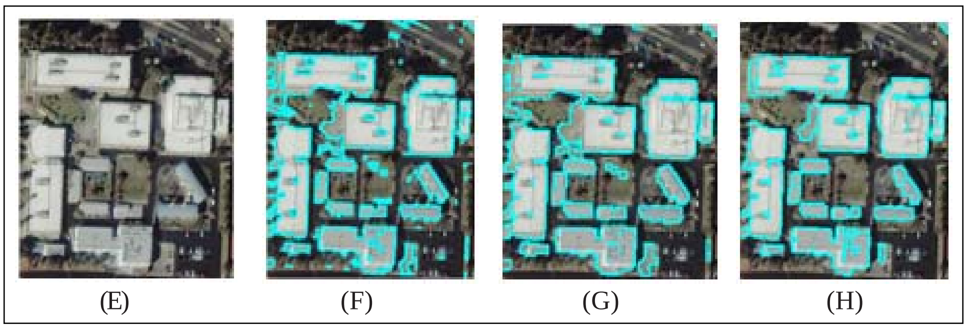

Figure 6. (E). Original image, (F).Resulting image of method 1 (HMT with varying size structurant element), (G). Resulting image of method 2 (of [Sheet al 07]), (H).Resulting image of the proposed method

		Image (A)	Image (E)
Méthode 1	FRA	6.75 %	25.9 %
	FRR	2.43 %	0.45 %
Méthode 2	FRA	3.71 %	22.11 %
	FRR	0 %	0.19 %
Méthode proposée	FRA	1.47 %	13.18 %
	FRR	0 %	0 %

Table 1. Results qualitative evaluation

6. Results Evaluation

From the figure 4 and 5, it is clear that the proposed method allows better buildings detection compared to methods 1 and 2.

We add to the visual evaluation, another qualitative assessment, which is a calculation of false rejection rate and false acceptance rate of detected buildings.

On the first image (A), the false rejection rate (FRR) resulting from the method 1 is 2.43%, the application of method 2 reduced it to 0%, the proposed method maintained the same result. Regarding the false acceptance rate (FAR), the proposed method reduced the value to 1.47%.

Those results explains the interest of the suggestion for the block to suppression of false detections in Method 3, the comparisonstep that it contains which caracterised by comparing between the reconstructed image and empirically thresholded image (reference image) can reduce in a considerable way the artifacts caused, the smoothing eliminates the holes that have not been supressed.

Those holes are more important in the images (*F*) and (*G*) resulting from the application of methods 2 and 3 respectively on the original image (*E*), in this case, where the building structures have different shapes and colors and more complicated than the image (*A*) the interest of the proposed method is more important where the FRR reached its best value 0 %.

FAR has decreased until around 50% compared to methods 1 and 2, this reduction is small compared to the FRR due to the fact that the background color of the image is quite close to the buildings color to detect, therefore it influences on the result of the thresholding and thereafter on the detection.

7. Conclusion

We proposed in this paper, a method for structures built detection for multi spectral very high resolution spatial images. This method is based on the use of operators from mathematical morphology, it has been compared against other methods based on the same domain (morphology), the first one is a hit or miss transform with a variable size structurant element and the second one method of [1].

The originality of the proposed method lies in the use of empirically thresholded image as a reference image, this image was compared to the reconstructed image geodesically to provide a better result, smoothing was added at the end to reduce or eliminate aggregates created, the results obtained are satisfactory.

The proposed method is semi-automatic, since the adjustment of structurant elements is left to the operator because it depends on the content of images used, the reference image is a thresholded image empirically, so in perspective, it is possible to propose a creation of a new automatic thresholding technique that will automate the method and improve results.

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