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EXTRACTION OF MAN-MADE FEATURES FROM REMOTE SENSING IMAGERIES BY DATA FUSION TECHNIQUES

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ABSTRACT:

Satellite image acquisition systems are generating more data than can be analysed by human experts. In this work, automated detection and recognition of buildings in remote sensing imageries is explored. Local changes or variations of the intensity of an imagery (such as edges and corners) are important information for image processing and pattern recognition. Wavelet Analysis is one of the most popular techniques that can be used to detect local intensity variation. This technique coupled with the Canny edge detection, which has the double threshold technique and is less fooled by noise, forms a very strong tool in the detection of man-made features. With the edge map, pixels of interest are categorized as belonging to a building using the region of interest categorization method. The above-mentioned techniques are applied on a 1-meter Panchromatic IKONOS imagery of the highly urbanized Singapore city, to detect the building edges within that scene.

1. INTRODUCTION:

A multitude of research efforts is concentrated on dealing with segmentation, more specific aspects of it, like edge detection. Concerning edge detection, it is well known that much information regarding image structure, even in gray-scale images, is provided by means of extracting its edges. The mainstream of current research attempts in edge detection considers it as a linear filtering problem. Experts detect their presence based on the straight edges and right angles of their contours, often accompanied by the contrast to the background [5]. The main difficulty of traditional image segmentation is the lack of adequate tools to characterize different scales of texture effectively. Recent developments in multi-resolution analysis such as wavelet transforms help overcome this difficulty. The ability to discriminate features is generally dependent of scale. Many methods share one common weakness: that is, they primarily focus on coupling between image pixels on a single scale. Recent developments in spatial/frequency analysis such as Gabor transform, and wavelet transform provide good multi-resolution analytical tools [1], [2], [3], [4]. Another difficulty with the common edge operators is that they detect too many edges, which makes the edge map difficult to interpret. The Canny edge detector uses the thresholding technique by which the noise is reduced and only the wanted edges are picked by setting the thresholds.

Buildings are the most relevant man made structures. Their detection is valuable because of the strategic human activity occurs in, or in association with, a building of some sort. In addition, as they do not move, they serve as good references for the relative position of other type of objects. But in a highly urbanized city, detecting individual buildings is a problem, due to the proximity of the buildings to each other and heights of the buildings which causes relief displacement. This study deals with developing an algorithm to rapidly and automatically extract man-made features (buildings) from remote sensing imageries by data fusion techniques like wavelet analysis, edge detection and morphological operations.

2. THE WAVELET ANALYSIS:

Transform methods convert raw data to transform coefficients in order to obtain a more efficient representation of the data for processing tasks such as feature extraction. Wavelet transform has made much account of as a new method of information processing. Wavelet transform, which is called “mathematical microscope”, has resolution in both time field and frequency field. It can focus onto any detail of the analysed object by taking increasingly fine step of time or space field. The best-known and most often used transform methods are based on the classical Fourier transforms. But, wavelet methods offer several advantages over the Fourier-based methods. One of the most important advantages of the wavelets is that wavelet bases have local support in the space and frequency, whereas Fourier basis functions are local in frequency, but have a global support in the space domain. This means that the representation of a function in the wavelet domain rests more on its local behavior. In this way, wavelets can specify a specific shape attribute at a specified location. Other advantages of the wavelet transform are the availability of fast algorithms, and that it allows an integrated technology to handle a variety of data processing tasks, such as feature extraction. The Discrete Wavelet Transform (DWT) has been used. Discrete Wavelet Transforms are fast (linear complexity) algorithms implemented via digital filter banks. The Discrete Wavelet Transform can be extended to two dimensions as a combination of two one dimensional transforms, applied independently in the horizontal and vertical directions. This independent application is possible because the DWT is a separable transform. A different filter can be used in each direction and the filter tree generalises to a quad-tree structure where only the tree branches which use the filter in both directions are used for further calculation. The DWT make use of the fact that a signal may be decomposed into two parts -- a smoothed signal and a detail signal. The smoothed signal is decomposed over a set of basis functions (the scaling function) while the detail signal is over the wavelet basis. During the decomposition, the resolution decreases exponentially at the base of 2. In the case of 2D images, the DWT can be applied to each dimension separately. This results in an image X being decomposed into a first level approximation X_a^1 , and detail components X_h^1, X_v^1 and X_d^1, correspoding to the horizontal, vertical and diagonal details. Thus,

$$X = X_a^1 + \{ X_h^1 + X_v^1 + X_d^1 \} \quad (1)$$

and iterating the process to N levels,

$$X = X_a^N + ?\{ \sum_{i=1}^{N} X_h^1 + X_v^1 + X_d^1 \} \quad (2)$$

Accordingly, wavelets provides a framework for decomposing signals into a hierarchy of frequency components, each represented with spatial resolution proportional to frequency. The sub band decomposition obtained by wavelet transformation allows for the more precise modification of edge details at various scales. As a result, the edge resolution can be more accurately controlled than through simple linear filtering. The wavelet approach effectively reduces the contrast of the image. By only scaling the high frequency components of the decomposed image, the contrast of the small-scale features of the image is reduced, while the contrast of the large-scale objects is preserved. Thus, details are reduced in a scale dependent fashion. In contrast, the filters simply smoothes all the edges, irrespective of scale.

3. THE CANNY EDGE DETECTION:

Edges of an image reflect the information of the image mostly. They contain the basic character of the image. Edges within an image correspond to intensity discontinuities that result from different surface reflectance of objects, various illumination conditions, or varying distance and orientations of objects from a viewer. Edge detection is a common problem and of fundamental importance in image analysis and computer vision. Edges however generally occur at various resolutions, or scales, and represent transitions of different degrees, or gradient levels. Perhaps the most commonly used method for detecting edges in an image is through the spatial gradient. In this approach, the edges are identified by the local extrema in the differentiated image through thresholding. The Canny edge detector has been used considering various factors, one important feature being that this edge detector is less likely to be “fooled” by noise and more likely to detect true weak edges, which are very important for the detection of building edges. The double thresholding of the Canny edge detector plays the main role in edge detection. The method uses two thresholds - to detect strong edges and weak edges, and includes the weak edges in the output only if they are connected to strong edges. The Canny operator works in a multi-stage process. The Canny edge detection algorithm has the following steps:

- Smoothens the image with a Gaussian filter.
- Computes the gradient magnitude and orientation using finite-difference approximations for the partial derivatives.
- Applies non-maxima suppression to the gradient magnitude.
- Uses the double threshold algorithm to detect and link edges.

The upper tracking threshold can be set to quite high and lower threshold quite low for good results. Setting the lower threshold too high will cause noisy edges to break up. Setting the upper threshold too low increases the number of spurious and undesirable edge fragments appearing in the output.

4. MORPHOLOGICAL OPERATIONS:

The edge map obtained with the above methodology is cleaned using morphological operators to remove stray pixels and to connect all those un-connected pixels. The various operations include, cleaning, spurring, removing, bridging, etc.

5. EXPERIMENTS AND DISCUSSION:

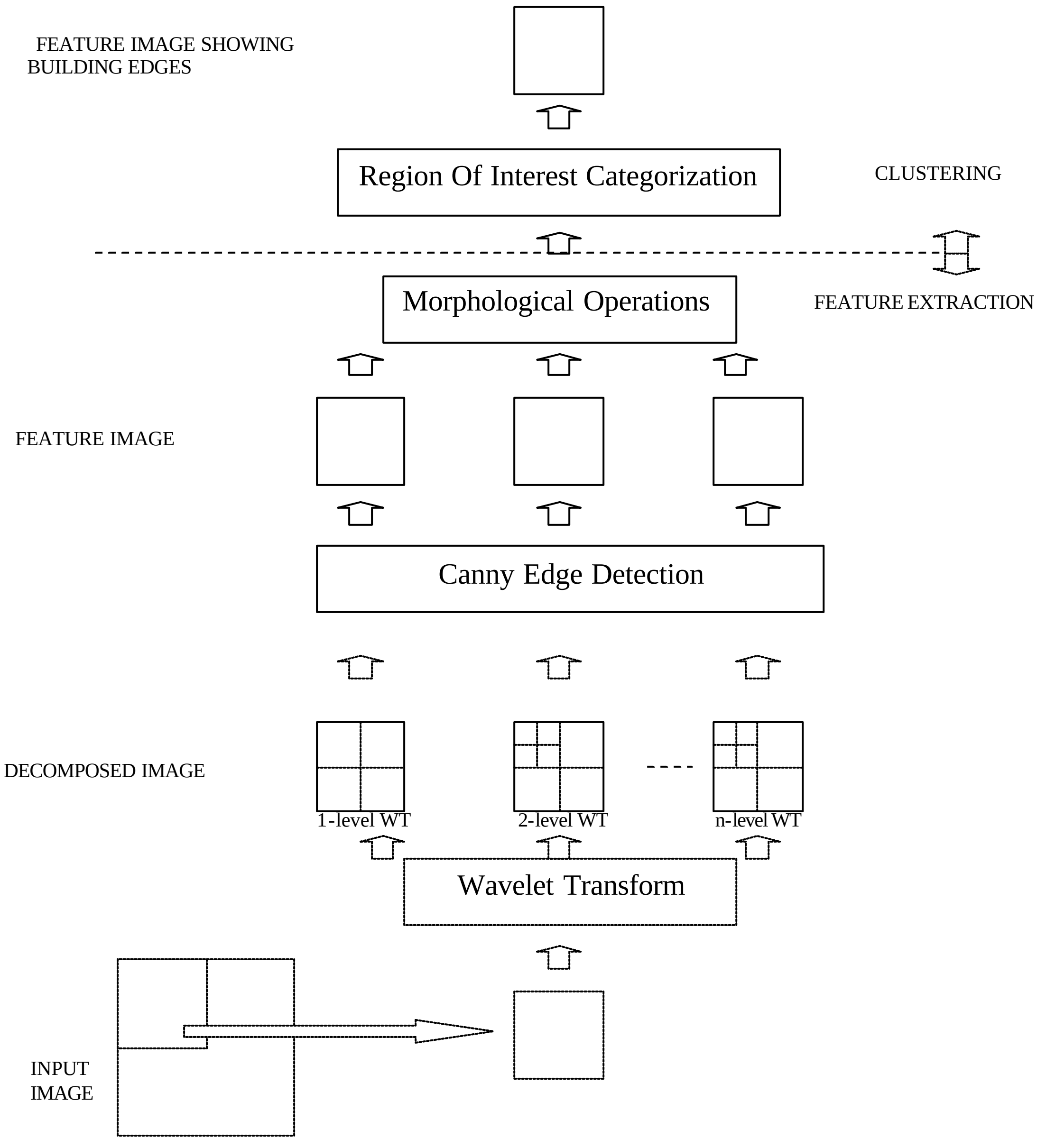

Fig. 3. Block Diagram of feature extraction procedure using the data fusion techniques.

The image-segmentation procedure is shown schematically in figure 3. In this study, IKONOS satellite imagery with a resolution of 1m, of the Singapore city is used. The wavelet analysis is first applied on the input imagery. Then this is passed through the canny edge detection. The necessary morphological operations are done. All the experiments are conducted using a Workstation NT4.0. All the computations involving Wavelet transform and edge detections are implemented using MATLAB 6.0. Application of the wavelet transform takes very less time; this quick response is mainly due to the property of wavelet decomposition that has fast algorithm, which is based on convolutions with a bank of filters.

6. PRELIMINARY RESULTS:

A few results showing a part of the IKONOS imagery as tested with above mentioned techniques.

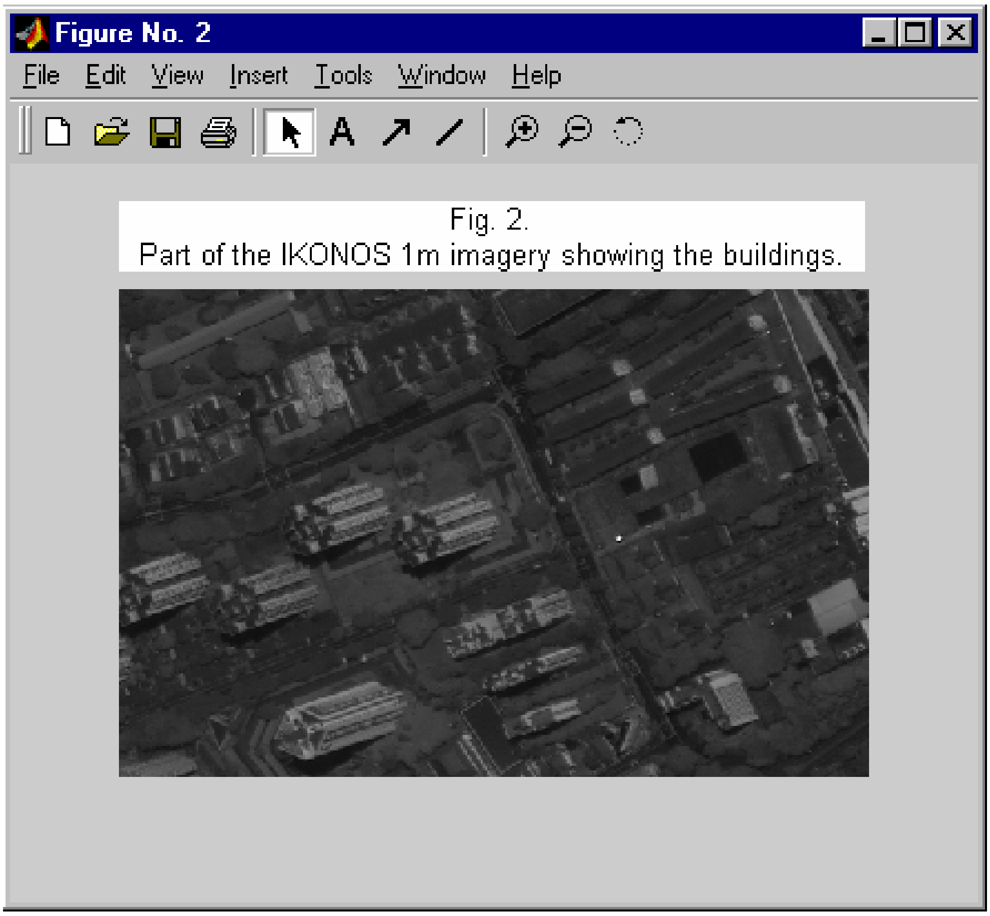

Fig. 2.
Part of the IKONOS 1m imagery showing the buildings.

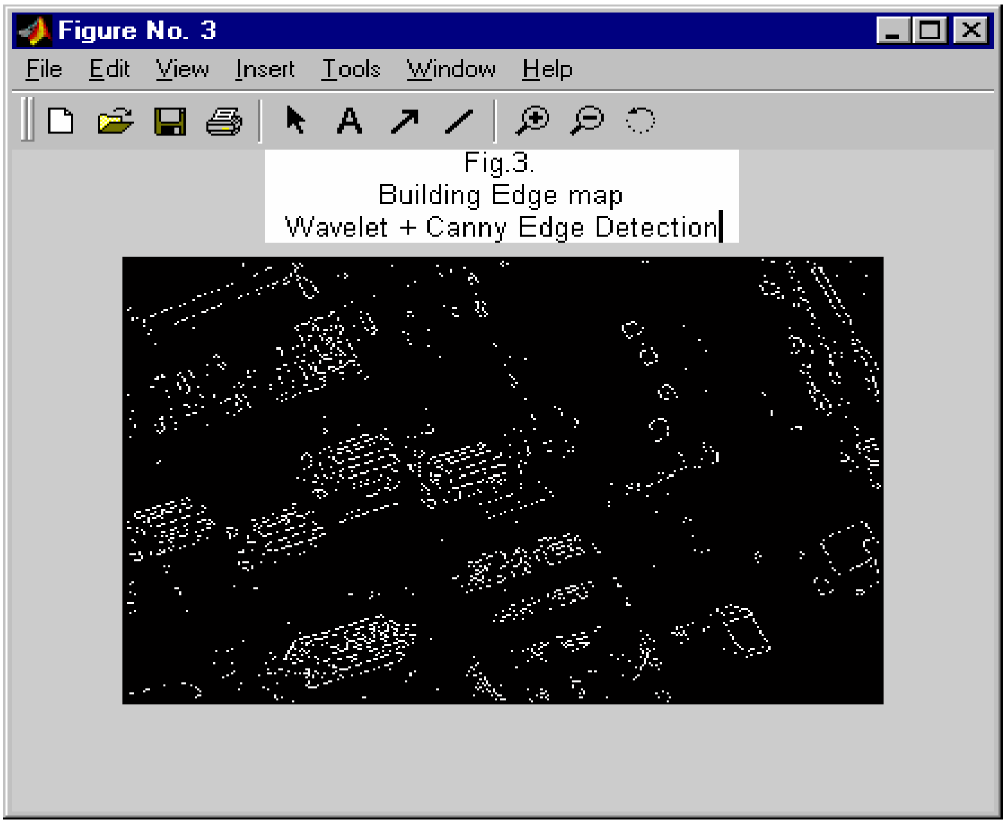
Figure No. 3
File Edit View Insert Tools Window Help
Fig.3.
Building Edge map
Wavelet + Canny Edge Detection

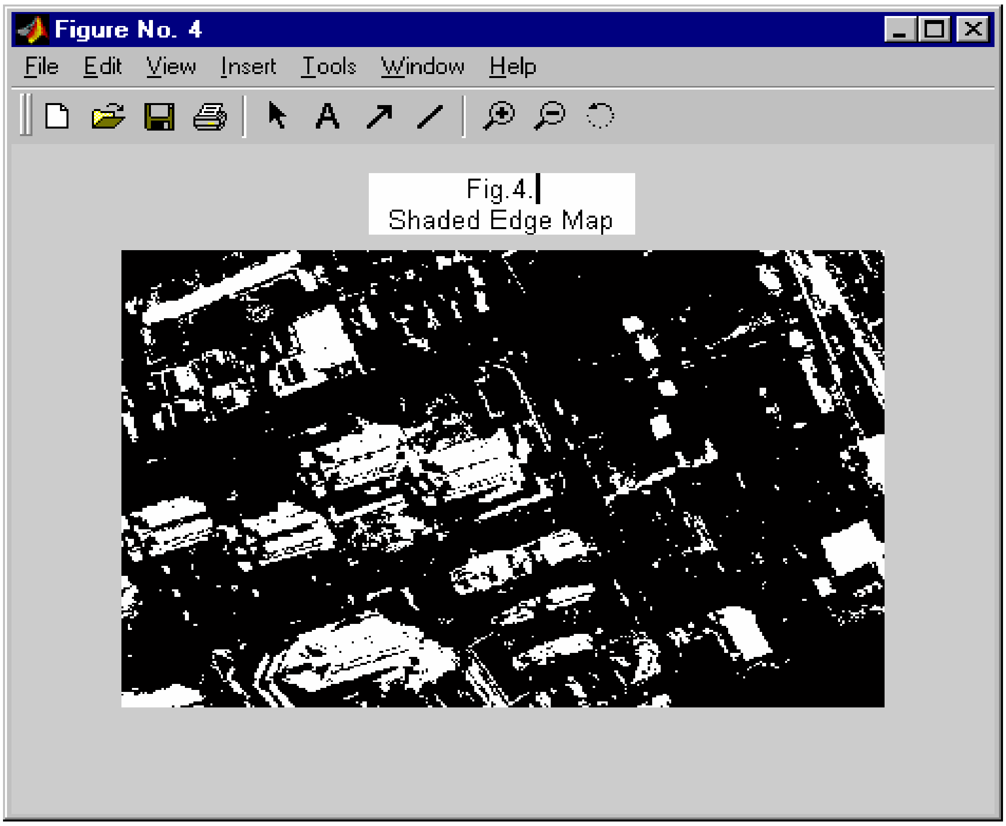
Figure No. 4
File Edit View Insert Tools Window Help
Fig.4.
Shaded Edge Map

6. CONCLUSION AND FUTURE RESEARCH AREAS:

The algorithm used in this research is a simple as well as an effective method. Wavelet Analysis is a growing area in the field of remote sensing, though its impact is already very strong in other engineering areas.

In the light of future research work, the upper level of given flowchart in fig.1. can be carried out. All the pixels belonging to a building feature can be clustered using the point-in-polygon algorithm or using the neural networks.

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