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Development of Algorithms for the Study of the Image in Digital Form for Satellite Applications: Extraction of a Road Network and Its Nodes

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Abstract**—**In this paper we propose a novel methodology for extracting a road network and its nodes from satellite images of Algeria country.

This developed technique is a progress of our previous research works. It is founded on the information theory and the mathematical morphology; the information theory and the mathematical morphology are combined together to extract and link the road segments to form a road network and its nodes.

We therefore have to define objects as sets of pixels and to study the shape of these objects and the relations that exist between them.

In this approach, geometric and radiometric features of roads are integrated by a cost function and a set of selected points of a crossing road. Its performances were tested on satellite images of Algeria country.

Keywords**—**Satellite image, road network, nodes.

I. Introduction

THIS paper presents a developed approach for extracting a road network and its nodes from satellite images of Algeria country. It is thus a progress of our previous research works [1]-[6]. The difference between this developed approach and the previous research works, is due to the principle of the algorithms of extraction and to the execution time of the obtained results.

II. Literature Overview

Models for the automatic and semi-automatic extraction of roads and road network by remotely sensed imagery can be found in the literature. In fact, many strategies, methodologies and algorithms for road network extraction have been presented since 1970s, which have achieved varying degrees of success. According to the level of automation, the techniques for road extraction with the aid of computer vision can be coarsely classified into automatic and semi-automatic approaches [7].

Many methodologies for road network extraction and its use for several applications, particularly for updating geographic information systems GIS have been presented by different works, such as the work [8] which presented a method for road network extraction and cited some applications of this method (automated correction, updating for geographic information systems GIS, registration with multi temporal images for change detection, automatically aligning the spatial datasets, etc.). Also, the study of [9] which introduced utilities of processing of multi-temporal images and change detection; in fact, change detection is very important for economic construction and national defense; it is a core problem in resource and environmental monitoring, disaster monitoring, land cover, change, city expansion, geographic information update and military defense.

After reviewing the existing works on roads and road network extraction, it was realized that a combination of few algorithms (in our case two principles are used: information theory and mathematical morphology) is more robust for extracting roads and its road network and also its nodes (points of intersections between each pair of roads) from satellite images than the multiple or individual algorithms.

III. Methodology of Extraction

Our idea for the extraction of a road is based on the criterion that a road can be defined like a set of arcs; each arc is a set of lines. So, we want to reconstitute the shape of a curved object after its digitalization. The best shape of a road is that minimizes the variance calculated in the possible directions of propagation, that maximizes the covered distance and that is most rectilinear. Thus we must detect homogeneous elements then linear components of the road.

Calculating the homogeneity of elements road requires four masks of directions: 0, $\pi/4$, $\pi/2$ and $3\pi/4$.

The linearity of components of road needs a partition of the image of homogeneous elements in windows of size fxf pixels.

This is to calculate the two vectors X (binary vector for the exact location of a segment of road in each pair of windows) and Y (random vector of likelihood for the presence of a segment of road in this pair of windows). The calculation makes finding a path representing a road on the decomposed image. For the choice of the best road, this is to calculate the vector x (vector composed by a set of points where x_i belongs to the segment road located by the vector X). The calculation of the vector x permits of find an exact detection of road on original image.

This suggested approach takes in account the time of execution of the different treatments concerning extraction of objects: a road, a road network and its nodes. The main objective is to obtain results in fast way. The reference [2] gives the full principle of extraction of these objects.

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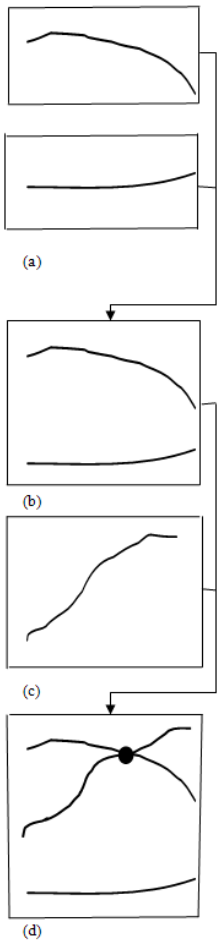


Fig. 1 Example of work procedure of extraction of a road network with its nodes: (a) Extraction of two roads; (b) Combination of the two extracted roads; (c) Extraction of a road; (d) Road network with its node extracted

A. Algorithm of Extraction

- To fix the number of roads that composed the road network, which will be extracted.
- Application of the algorithm of extraction of a road [2] in two steps: the result is two roads.
- Application of the algorithm of the morphology operator 'union' for having the first road network composed by the two extracted roads [2].
- Application of the algorithm of the morphology operator 'intersection' [2] for having the first node if the two extracted roads have this same node.
- To repeat the three algorithms for extracting a road then extracting a road network and finally extracting a node until the fixed number of roads is reached.
- The result is two images: the first one comprises the extracted road network and the second one contains all nodes of this road network.
- Application of the algorithm of the morphology operator 'union' for having the novel image of the extracted road network with its nodes.

As an example, Fig. 1 shows this work procedure of extraction of these objects.

IV. Results and Discussion

A. Data Sets

As an example, Figs. 2 and 3 show original and subsets of satellite image over Oran, Algeria (these typical images are selected to test the proposed method; they contain different types of roads) and their extracted results.

The results in Fig. 3 demonstrated that the presented road network with its nodes extraction algorithm works very well.

Fig. 4 shows the evaluation results from our test data sets. The evaluation shows that the road network with its nodes have been extracted with a satisfactory accuracy.

Fig. 2 An original 749x472 satellite image of Oran, Algeria

B. Discussion

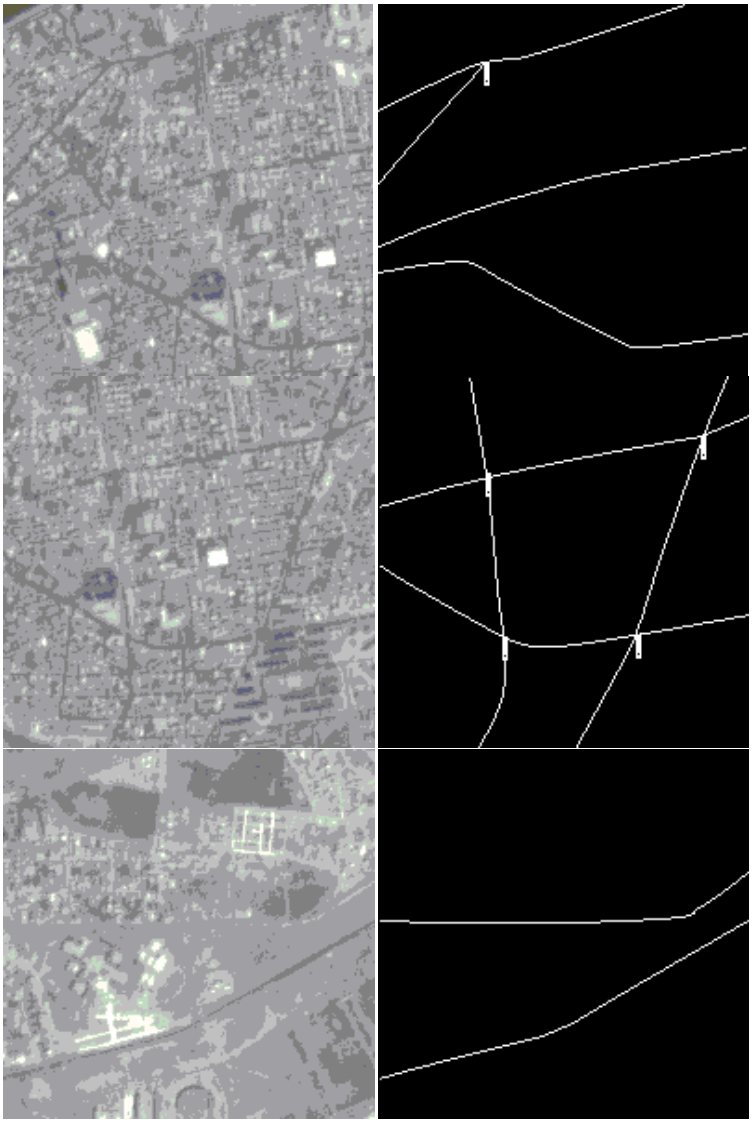
The studied methodology can have better detection results. The main disadvantage of this proposed methodology is that the algorithms are more complex and difficult because to their parameters which they must be changed in function of resolution of image, its type, and its size.

V. Conclusion

The main idea of this work is to propose a fast method for an extraction of a road network and its nodes from satellite images of Algeria country.

This paper has presented a semi-automatic method which has used the two concepts: information theory and mathematical morphology; it takes in account the doing time of each treatment concerning extraction of the three objects: road, road network and its nodes.

This proposed method is a progress of our previous research works; all treatments in this method for extraction the three objects (roads, road network, and nodes) are doing in parallel way. The obtained results were in general good.



(a) (b)

Fig. 3 Road network with its nodes extraction from satellite image: (a) Subset of original image of Fig.2; (b) The final result

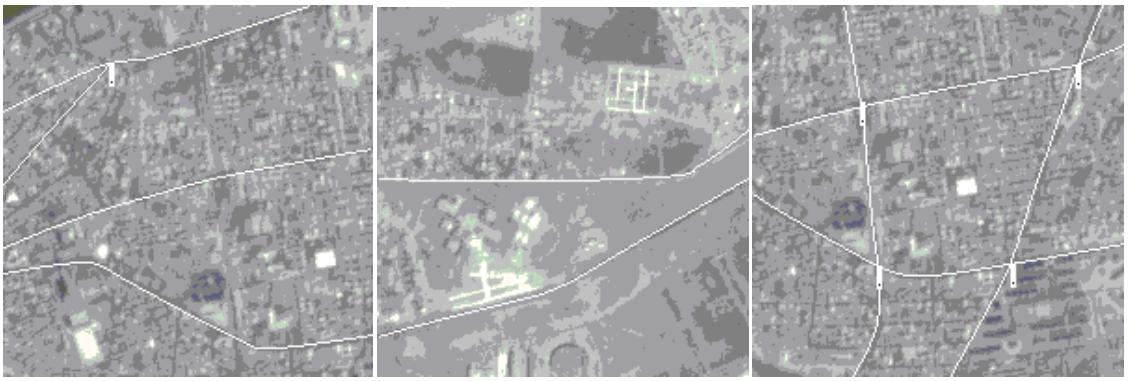


Fig. 4 Evaluation result: overlapping scenes (a) and (b) of Fig. 3

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