AUTOMATIC ROAD NETWORK EXTRACTION USING HIGH RESOLUTION MULTI-TEMPORAL SATELLITE IMAGES

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1. INTRODUCTION

The updating of road network database is crucial to many geographic information systems (GIS) application systems like navigation, urban planning, etc. Rapidly changing urban environments accelerate the need for frequent updates or revisions of road network databases. With the advent of high-resolution satellite images, there has been a resurgence of research interest in road extraction techniques. However, due to the extreme complexity of an urban scene, automatic road network extraction continues to be challenging research topic. In recent years a number of papers have been published in road extraction [1, 2, 3, 4]. Some papers applied semi-automatic methods such as tracking [1, 2], geometrically constrained template matching and snakes [4]. The others used automatic methods [3]. Road extraction techniques in which human operator provides the road seed points can be automated if a reliable method to detect these seed points exist. Several techniques to extract road seed points have been developed [1, 2, 5]. Often, the automatic road seed extraction methods make assumptions about the geometry of road segments which reduce the accuracy of road extraction. These methods are computationally intensive since the whole image has to be scanned for road seeds. Also, accuracy of road extraction is affected by artifacts such as vehicles, trees along the road, occlusions, etc.

The revisit capabilities of modern remote sensing satellites provide temporal data that can convey valuable information. However, the utility of such data has not been explored in the context of road extraction. The difference between two such consecutive revisits can be a major cue of the location of non-stationary objects like vehicles on the road. This paper proposes a novel road network extraction method which exploits such temporal variations in a set of images of a geographic location. The method proposed in this paper assumes that majority of the non-stationary objects detected are vehicles and locates potential road seeds in the neighborhood of those vehicle pixels. The detected road seeds are used in road tracking algorithm of the method which is a variation of Fourier based road tracking algorithm developed by Hu et. al. [1],. To further improve the accuracy of the road tracking algorithm, detected vehicle pixels are replaced with appropriate road pixels. Initial experiments are carried out on panchromatic images of CARTOSAT-2, an Indian satellite which has a spatial resolution better than one metre and a revisit time of four days.

2. METHODOLOGY

The first step in the proposed road extraction method is to find the difference between two images taken in consecutive revisits for the geographic location under study. This difference image is expected to indicate the presence or absence of the non-stationary objects like vehicles on the road. However, because of change in the time of the day of capturing the images and other atmospheric phenomenon (existence of cloud etc), there will be a variation in the reflectance values across the input images. This subtle variation in the reflectance value is eliminated by thresholding the difference image appropriately. The change in time of the day of capturing the images also results in variation of shape and shift in location of shadows of the objects in the scene. Occurrence of such phenomenon is captured as thin line segments in the thresholded difference image and are eliminated using a set of morphological operations. Road seeds are then located in the neighborhood of detected vehicle pixels.

The performance of the road tracking algorithm is improved by replacing the identified vehicle pixels with appropriate road pixels. To achieve this, the proposed method examines the homogeneity of pixel values in a window around the vehicle pixels

in both the input images and separates the vehicle pixels that have to be replaced in the first input image. These vehicle pixels are replaced with the road pixels in the corresponding location of the second input image. This enhanced first input image is used for further road tracking.

The road tracking algorithm used in this method is a variation of Fourier based road tracking algorithm developed in [1] and starts with identified road seed points. A local homogeneous region around a pixel enclosed by a polygon is defined as the pixel footprint and it is represented as distance function between the centre pixel and pixels on the enclosing polygon. This function is then mapped to the frequency domain using discrete Fourier transform and smoothed by discarding the coefficients corresponding to higher frequencies to get normalised footprint for the pixel. The dominating peaks of the normalised footprint denote the direction in which road tracking will be continued till entire road network is extracted.

3. CONCLUSION

In this paper, the utility of high resolution multi-temporal images in automatic road network extraction is demonstrated. The automatic extraction of road seeds using multi-temporal images and the procedure for eliminating vehicles from the scene is detailed. Intuitively, since the road seeds are picked from areas around the detected vehicles, higher confidence about the road seeds can be assumed. This is confirmed by the experimental results. Further investigation of the proposed method will be conducted by considering more than two satellite images taken in consecutive revisits.

4. REFERENCES

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