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Research Paper

Semi automatic road extraction from digital images

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A B S T R A C T

Road extraction from digital images is of fundamental importance in the context of automatic mapping, effective urban planning and updating GIS databases. Very high spatial resolution (VHR) imagery acquired by airborne and space borne sensors is the main source for accurate road extraction. Manual techniques are fading away as they are time consuming and costly. Hence, road extraction method that is significantly more automated has become a research hotspot in remote sensing information processing. This paper proposes a semi-automatic approach to extract different road types from high-resolution remote sensing images. The approach is based on edge detection and SVM and mathematical morphology method. First the outline of the road is detected based on Canny operator. Then, Full Lambda Schedule merging method combines adjacent segments. Then the entire image was classified using Support Vector Machine (SVM) and various spatial, spectral, and texture attributes to form a road image. Finally, the quality of detected roads is improved using morphological operators. The algorithm was systematically evaluated on a variety of satellite images from Worldview, QuickBird and UltraCam airborne Images. The results of the accuracy evaluation demonstrate that the proposed road extraction approach can provide high accuracy for extraction of different road types.

1. Introduction

Road extraction from aerial and satellite images is of great importance for urban and transportation planning, urban disaster management and automotive navigation (Mena, 2003).

With the development of high resolution optical satellite imagery, large volumes of spatial and spectral data are available. In order to take advantage of these data accurate and efficient information extraction methods are crucial in remote sensing (Salehi et al., 2010). Manually extracting roads from digital imagery, although has high accuracy, but in terms of time and cost is not cost-effective especially when the scenes are very complex. Therefore, it is urgent to develop a semi-automatic/automatic road extraction method. In the literature, an automatic method implies a fully automatic process. An automatic road extraction method based on different Morphological direction filtering and road intersections is presented by Ahmed and Rahman (2011). An automatic road detection approach in urban region based on preprocessing to reduce the unwanted objects and extraction of road segments using texture progressive analysis and normalized cut method is proposed by Senthilnath et al. (2009). Pankaj et al. proposed a road network segmentation technique using adaptive global thresholding along with morphological operations (Singh and Garg, 2013). Road regions are segmented using average intensity values, and morphological operators are used for further processing. They gave experimental result for an image and evaluated their work by measuring quality parameters. Theoretically, a fully automatic approach requires no human intervention, but this is not practical (Subash, 2011). There are some limiting factors of automatic extraction of roads such as background coverage, features in the neighborhood of the road, complications such vehicles on roads, bridges, and their shadows. Moreover, problems that are created by shadows, clouds, error of sensor, etc., increase the complexity. In semi-automatic method, operator plays an important role at the first stage of extraction of the road. Therefore, human knowledge plays an important role in the correct identification and segregation of different objects. A semi automatic road network extraction method based on neural-dynamic tracking framework is presented in Wang et al. (2015) and Chaudhuri et al. (2012)

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proposed a semi-automatic method for urban road extraction based on customized directional morphological filter and a set of post-processing steps, including hole-filling, pruning, and segment linking (Huang et al., 2014; Sghaier and Lepage, 2016) applied multi kernel SVM for multi-index learning, to separate the road class from other classes a set of indices such as morphological shadow index, morphological building index and variation indices based on the wavelet transform were employed. Miao et al. (2015) presented a semi-automatic object-based method. The proposed method consisted of five main steps. First, satellite images were segmented to generate objects. Then, object-based Frangi's filter (OFF) and object-based shape filter (OSF) were applied to compute object features to select road candidates. After that, the road class is extracted using the support vector machine (SVM) based on the extracted feature set. Finally, tensor voting (TV), active contour, and the geometrical information are integrated to eliminate road gaps and improve road smoothness. In a recent study (Khesali et al., 2016) a semi Automatic Road Extraction based on two fusion methods, including neural network and knowledge-based fusion are proposed. The first method consists of two stages: separate road detection using each dataset and fusion of the results obtained using a neural network. The second method is a knowledge-based fusion using thresholds of narrow roads and vegetation gray levels. In the present study, in order to implement the proposed system of semi-automatic extraction of the road, first pre-processing operations, including contrast enhancement using histogram linear adjustment was made on the images. Then, Full Lambda method was used for image segmentation, as well as the SVM algorithm was used for image classification and extraction of the road. In the end, in order to remove noise and pixel unrelated to the class, and to increase the system's accuracy, morphological disruption and closing functions were used.

The main purpose of this paper is to present a semi automatic method that combines the edge detection and SVM techniques to extract different type of roads. As an application, the proposed method is used to extract roads from high-resolution remote sensing images such as worldview, QuickBird and UltraCam images.

2. Materials and methods

2.1. Data

In this study, UltraCam aerial digital camera images of Shiraz region Fig. 1(a), WorldView images of Ahvaz, Fig. 1(b), as well as QuickBird image of Tehran, Fig. 1(c), were used. UltraCam aerial digital camera produce multispectral images in the spectral ranges of blue, green, red and near infrared with the size of 2672 × 4008 pixels, and panchromatic image with the size of 7500 × 11,500 pixels simultaneously. The physical size of the pixels is 9 μ in the panchromatic band, which leads to the high spatial resolution and according to altitude. For example, in the 330 and 1.400 m altitude, separation of the panchromatic and multispectral bands will be 3 and 12.5 cm respectively (Leberl and Gruber, 2005).

2.2. Methodology

In this paper, a semi automatic method is presented to detect the roads in high-resolution satellite images i.e. WorldView and QuickBird and UltraCam aerial images. The proposed method is based on four main steps. Firstly, canny edge detector is employed to segment roads from the images. Secondly, Full Lambda Schedule merging method applied to combine adjacent segments. The third, Support Vector Machine (SVM) was used to classify entire image.

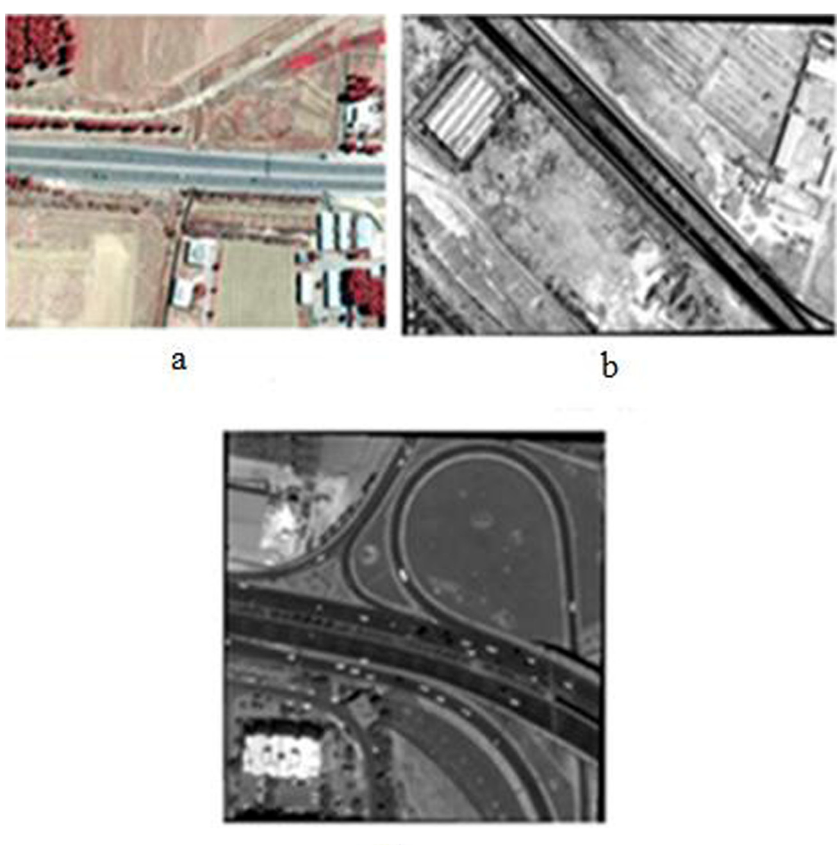

Fig. 1. Images used (a) Ultracam image (b) World View image (c) Quick-Bird image.

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