Road Extraction from Lidar Data Using Support Vector Machine Classification

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Abstract

This paper presents a method for road extraction from lidar data based on SVM classification. The lidar data are used exclusively to evaluate the potential in the road extraction process. First, the SVM algorithm is used to classify the lidar data into five classes: road, tree, building, grassland, and cement. Then, some misclassified pixels in the road class is removed using the road values in the normalized Digital Surface Model and Normalized Difference Distance features. In the postprocessing stage, a method based on Radon transform and Spline interpolation is employed to automatically locate and fill the gaps in the road network. The experimental results show that the proposed algorithm for gap filling works well on straight roads. The proposed road extraction algorithm is tested on three datasets. An accuracy assessment indicated 63.7 percent, 60.26 percent and 66.71 percent quality for three datasets. Finally, centerline of the detected roads is extracted using mathematical morphology.

Introduction

Road information plays an important role in many modern applications, including transportation, automatic navigation systems, traffic management, and crisis management, and enables existing geographic information system (GIS) databases to be updated more efficiently. In the past two decades, automatic road extraction has become an important topic in remote sensing, photogrammetry, and computer vision. In addition, recent advances in lidar systems and their enormous potential in automatic feature extraction motivate the development of automatic road extraction algorithms based on lidar data.

Many studies have been performed on road extraction from remotely sensed data. Mena (2003) provided a bibliography of nearly 250 references related to this topic. Hu (2003) proposed a method for road extraction from lidar data. In this approach, specified range and intensity thresholds were used in an exponential membership function. Alharty and Bethel (2003) successfully extracted roads from lidar data using some constraints proportional to the road properties such as intensity and proximity to a digital terrain model (DTM). Zhu *et al*. (2004) extracted city road by use of digital image and laser data. Height and edge of high objects were obtained from laser data and road edges were detected from a digital image. Shadowed parts were reconstructed by a spline-approximation algorithm. Hu *et al*. (2004) used high-resolution imagery combined with lidar data for road extraction. They used an iterative Hough transform algorithm to distinguish car parks from roads stripes. Clode *et al*. (2005) presented a road classification technique for lidar data based on region growing. Akel *et al*. (2005) suggested a method to extract roads from lidar data using a segmentation technique. Clode *et al*. (2007) used a hierarchical classification technique to progressively classify the lidar points into road or non-road groups. The resultant binary classification was then vectorized by convolving a Phase Coded Disk (PCD). Youn *et al*. (2008) utilize lidar data and true orthoimage for urban road extraction in sequential steps. First, the candidate road pixels were selected from the true orthoimage based on a free passage measure that is called the "acupuncture" method. Then, a first-last return analysis and morphological filter were used with the lidar data to mask building pixels. Supervised classification techniques were used with the lidar intensity and true orthoimage to mask grass pixels. In (Li *et al*., 2008) a method based on a parallel algorithm was proposed for road extraction from lidar data. Harvey and McKeown (2008) successfully extracted roads using both lidar and multi-spectral source data. Choi *et al*. (2008) proposed a method to extract urban roads using range and intensity lidar data combined with clustered road point information and the global geometry of the road system. Tiwari *et al*. (2009) proposed an integrated approach to road extraction using lidar and high-resolution satellite data. An object-oriented fuzzy rule-based algorithm identifies roads based on high resolution satellite images, and then a complete road network is extracted from a combination of lidar and high-resolution satellite data. In (Zhu and Mordohai, 2009) the lidar data are segmented based on both edge and region properties and these two features are combined to obtain a heat map of road likelihood using hypothesis testing. A minimum cover algorithm is then used to find a set of road segments which best cover this likelihood map. Samadzadegan *et al*. (2009) proposed a method based on a multiple classifier system (MCS) to extract roads from lidar data. Gong *et al*. (2010) extracted roads from lidar data using k-mean clustering method and refined the results using spectral information from aerial images. Zhang (2010) presented a method to identify road regions and road edges using lidar data. The road segments and road edge points were detected according to a local extreme-signal detection filter according to elevation data whit a prior knowledge of the minimal with of roads. Wang *et al*. (2011) applied lidar data fused with aerial images to extract 3D road information by use of

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