Automatic road extraction from high-resolution images applied over urban areas

M. NAOUAI[1,2] , A. HAMOUDA[1] AND C.WEBER[2]

[1] Faculty of Sciences of Tunis, Unit of Research in Programming, Algorithmic and Heuristic
[2] University of Strasbourg Laboratory « Image, Ville et Environnement », UMR7011-CNRS
naouai@polytech.unice.fr, atef_hammouda@yahoo.fr,

christiane.weber@lorraine.u-strasbg.fr

Road extraction plays an important role in many applications such as car navigation. However, the manual extraction of roads is a laborious and tedious task. Road extraction from satellite images has drawn considerable attention in last years due to the recent availability of commercial high-resolution optical satellite imagery.
Road extraction strategies are usually classified into two categories according to the degree of human interaction: semi-automated and automated extraction.
Different strategies for road extraction require specific algorithms. For semi-automated, initial seed points, sometimes with directions, must be provided to an algorithm that attempts to connect these points using various search path criteria.
For automated extraction, salient roads, called road seeds, must be detected automatically and tracked or linked to form the road network. These approaches involve many techniques such as template matching [1,2,3], heuristic reasoning [4,5], dynamic programming[6,7] or stochastic tracking[8,9].
In this paper, we propose a new method for automatic road extraction from high-resolution images applied to urban areas (fig1). In order to deal with the high complexity of this kind of scenes, we integrate detailed knowledge about roads and their context using explicitly formulated models. The knowledge about how and when certain parts of the road and context model are optimally exploited is expressed by an extraction strategy. Scale space and Edge-detection techniques are used as pre-processing for segmentation and estimation of the road width. The detection of road is based on the Energy minimization techniques. The estimation of the Energy depends on many parameters including variance, direction, length and width of the road in consideration. The use of width and variance information for road extraction expects high-resolution images. The contribution of this paper consists of Energy minimization and path following by using at first pre-processing through scale-space and canny edge detector adapted to road extraction. The paper also handles tracing of road junctions.

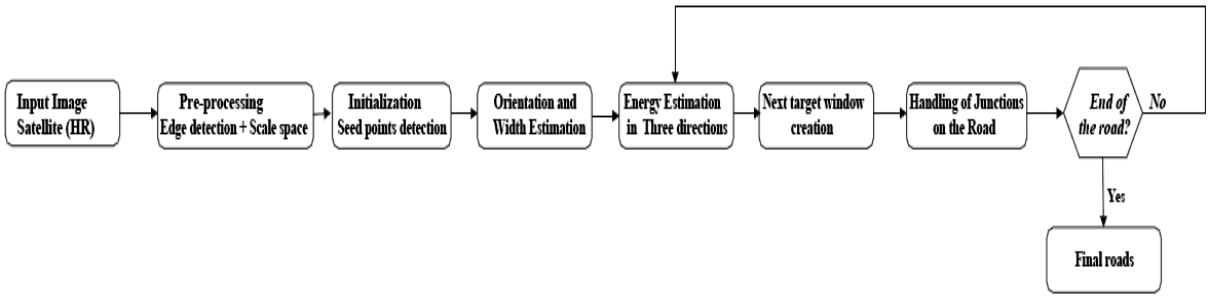

Fig1: Flow diagram of Road Extraction

The key feature of the presented approach is the integral treatment of two essential issues of object extraction in complex scenes.

1. Specific parts of the road model and extraction strategy are automatically adapted to the respective contextual situation.

2. The extraction includes components for self-diagnostics which are internally evaluated hypotheses indicating their relevance for further processing.

However, our approach consists in an automatically detection and extraction method of roads from high resolution imagery where we integrate the similarity of the grey value and the edge point distribution of roads. The grey value of road surfaces is a very characteristic property of a road but it is sensitive to the disturbing influence of cars, trees, or other objects. Nevertheless the edge point distribution is robust to partial occlusions.
The not-uniformness of the image brightness changes in the surface material imply many road sight variations. To handle these appearance changes, the tracking algorithm is allowed to update the road model during temporally stable image observations. Automatically road extraction needs to be initialized for each road extracted. In order to solve the initialization problem, our method uses a simple segmentation method, together with the Hough Transform and gradient operators.

CONCLUSION

In this paper, we showed automatic road extraction algorithm (fig1), from the high-resolution satellite image. Road segments are extracted by using path following approach. The experiments with Quickbird images showed that from a few input seed points maximum of road segments were extracted automatically. The contribution of this paper is that it showed Energy minimization and path following approach with preprocessing by scale-space and canny edge detector works well for roads of considerable width. It also handles junctions of the road also with minimal seed points. The high-resolution images are preferable due to use of width and variance information for road extraction. These techniques are applied to one-meter and two-meter resolution images. Current limitations are that the algorithm may not work on the road cast by shadow and the valid road seeds must be selected since algorithm cannot judge the validity of input seeds. The roads that will not give edges in edge detector will not be extracted. The algorithm requires input roads of significant width. These limitations are currently being examined.

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