NETWORK SNAKES FOR ADAPTING GIS ROADS TO HEIGHT DATA OF DIFFERENT DATA SOURCES – PERFORMANCE ANALYSIS USING ALS DATA AND STEREO IMAGES

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ABSTRACT:

In order to tackle the problem of consistently integrating 2D vector data and a DTM, we presented an approach for the adaptation of 2D GIS road objects to airborne laser scanning (ALS) data using active contours (snakes) in (Göpfert et al., 2011). In this paper the algorithm is modified for the integration of stereo images as an alternative data source for area-wide height information. For that reason, a new image energy is developed that exploits geometric and radiometric features derived from the image data. Afterwards, we compare the applicability of our method with respect to the ALS data and stereo images as input. In addition, a new approach is suggested that analyses the different energy terms of active contours after the optimisation process in order to automatically detect contour parts that did not reach a suitable position in the sensor data. This concept of an internal evaluation is able to guide the user during post processing. Experiments show that the snake approach with an image energy based on stereo images is generally able to adapt GIS road centrelines to the sensor data and thus to improve the quality of the 2D vector data. However, the comparison to the results for ALS data demonstrates that the algorithm perform slightly worse for image data in the high precision level.

1. INTRODUCTION

1.1 Motivation

Topographic information systems such as the German Authoritative Topographic Cartographic Information System (ATKIS®), usually consist of object-based 2D vector data and a digital terrain model (DTM). The vector data describe the objects on the Earth's surface and additional attributes, whereas the DTM is a continuous 2.5D representation of the terrain. For applications such as flood risk assessment, 3D modelling of the topographic objects is necessary, which requires the integration of the 2D vector data and the DTM. However, there are discrepancies between the vector data and the DTM due to different methods of acquisition, processing, and modelling. As a consequence, integration without matching the data sets leads to semantically incorrect results, e.g. road surfaces having large gradients in the DTM. Thus, the two data sets have to be adapted for accurate combined visualization and processing.

In (Göpfert et al., 2011), road centrelines from topographic data bases (as linear features) were adapted to airborne laser scanning (ALS) data by means of network snakes (Butenuth & Heipke, 2012). The road centrelines were used to initialise the snakes, defining their topology and their internal energy, whereas features in the ALS data exert external forces to the snake via the image energy. ALS delivers a 3D point cloud, from which the digital surface model (DSM) is interpolated. A DTM can be generated by filtering methods. The DSM also contains information about objects situated on the terrain, such as buildings and bridges. In addition, ALS intensity data contain reflectance information of the illuminated objects. We have shown that suitable image energies for the adaptation of road centrelines can be composed using these ALS features (Göpfert et al., 2011). However, ALS flights are expensive and thus many providers of topographic data acquire nation-wide height information by means of stereo images, which are often gathered in periodic flights for the purpose of map updating. To make use of these data in our framework, a new formulation of the image energy is proposed for the adaptation process. It is exclusively based on geometric and radiometric information from stereo images, whereas the general geometric object model of the snakes is not changed. The quality of the adaptation results is compared for the two different sensor data, i.e. ALS data and stereo images.

One major disadvantage of our previous adaptation approach and of active contour models in general results from the lack of a suitable internal evaluation. Thus, in this paper a strategy for the interpretation of the different energy terms of the snake nodes is suggested in order to detect contour parts that did not reach a suitable position in the sensor data.

It is the general goal of this paper to present a new algorithm for improving 2D road vector data using stereo images. The approach is tested using road centrelines from different GIS data bases, namely ATKIS and OpenStreetMap (OSM). ATKIS roads typically have an accuracy of 3-5 m, with local deviations that may reach 10 m. Roads from OSM have a very inhomogeneous accuracy due to the patchwork characteristic of this data set, which may disturb the local geometry of the road network and makes the adaptation process more challenging.

1.2 Related Work

Pilouk (1996) as well as Lenk and Heipke (2006) investigated the incorporation of the 2D geometry of the vector objects into a DTM modelled by a TIN, but the inconsistencies between the vector data and the DTM were not considered. Rousseaux and Bonin (2003) model 2D linear objects such as roads and dikes as 2.5D surfaces by using attributes of the GIS data base and the DTM heights with the goal of generating an improved DTM. They use slopes and regularization constraints to check the semantic correctness of the objects, but they do not adapt the