Towards rapid urban environment modelling

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Abstract
This paper will give a brief introduction to airborne laser scanning. We will also give an overview of the current research activities at FOI Laser Systems in the fields of laser data processing and environment modelling.

Introduction
Modern airborne laser scanners (ALS) and digital cameras provide new opportunities to obtain detailed remote sensing data of the natural environment. This type of data is very suitable as basis for the construction of high fidelity 3D virtual environment models. There are many applications requiring such models, both civil and military. Applications relying on 3D-visualization, e.g. visual simulation, virtual tourism, etc. are perhaps the most common ones but there are many other important applications such as urban and environment management, crisis management, spatial decision support systems, command and control, mission planning, etc.

To support these applications, new methods for processing ALS and camera data, extracting geographic information and supporting virtual environment modelling are needed. Applications such as disaster relief management, tactical mapping, etc. may also be supported depending on the turnaround time from data to information and models (McKeown, et al 1996).

In our work, the long term goal is the development of new methods for rapid and highly automatic extraction of geographic information to support the construction of high-fidelity 3D virtual environment models from remote sensing data. As remote sensing data we have used data from recent high resolution airborne laser scanners and digital cameras. Today, airborne laser scanning is a successful and established technology for terrain surveying (Wehr & Lohr, 1999). The integration of ALS and modern digital cameras for simultaneous data collection is also rapidly increasing. ALS systems are operated both from helicopters and airplanes today and measure the position, (x, y, z) of those points where the laser pulse is reflected from the terrain surface. The resulting data from laser scanner surveys are usually data sets consisting of a large number of irregularly distributed points representing a surface model of the survey area. Figure 1 below shows the laser point distribution from a forest area (top) and from a small urban area (bottom). Laser scanning and laser data processing are active and rapidly growing areas of research (ISPRS 1999, Annapolis 2001, Dresden 2003,)

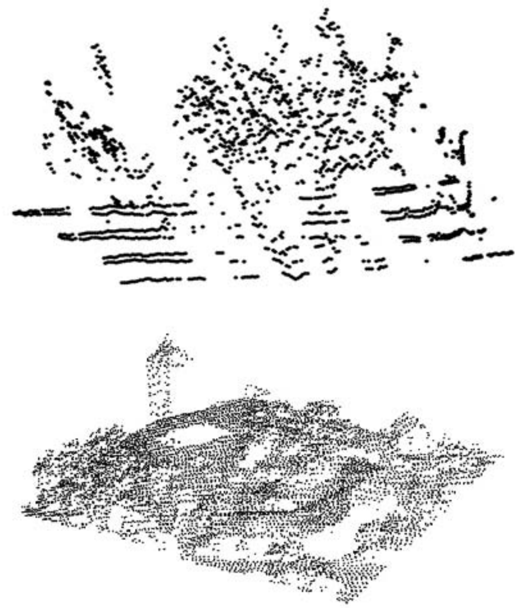

Figure 1: Laser point clouds.

Overview of developed methods
For the purpose of automatic generation of environment models, we have developed several novel methods for processing ALS data. For modelling the ground surface, we have developed a method based on active contours. The active contour is implemented as an elastic net that is pushed onto the laser data from below. Since the net has elastic forces, it will stick to the laser points that belong to the ground (Elmqvist, 2002).

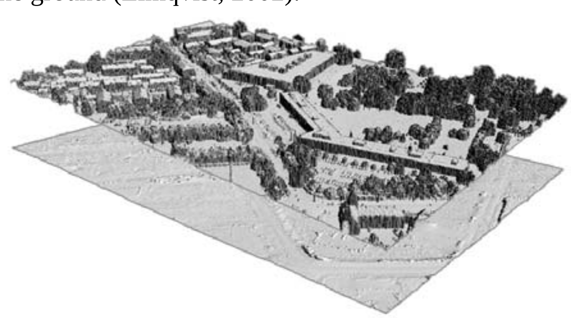

Figure 2: Ground modelling.

The remainder of the laser points (ie the points which are not classified as “ground”) can then be segmented into a number of classes. With our methods it is possible to separate eg. ground, vegetation, buildings, roads, lamp posts and power lines. For all these classes, further data processing can be performed to extract more feature parameters. For vegetation we have developed methods for identifying the position, width, height and in many cases even the species of individual trees (Persson & Holmgren 2002), see Figure 3. The tree identification method has been verified using a ground truth dataset in collaboration with the Swedish University of Agriculture in Umeå.

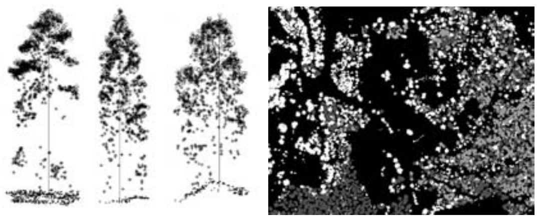

Figure 3: Laser point distribution within trees (left), tree species classification (right)

For each segment that is classified as building, i.e. the building footprint, the elevation data is used to extract planar roof faces. Next, the relationships between the roof faces are analysed. Topological points are inserted where the face's neighbours change. Sections between these points are defined as intersections, edges or both. A topological analysis is performed, where new points may be added and positions of points may be adjusted. In order to obtain building models with piecewise linear walls, the noisy edge sections are replaced by straight lines estimated using the 2D Hough transform. New points are also inserted at the intersections between the straight lines. Using these structures, 3D models of the buildings can be constructed, as illustrated in Figure 4 below.

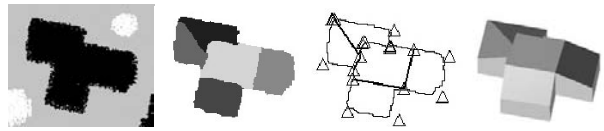

Figure 4: Building reconstruction process: Classification, data point extraction, topological analysis, 3D model.

The output form all methods can be integrated in eg. commercial terrain database generation packages or in GIS applications to create a synthetic representation of the environment (Ahlberg & Söderman, 2002). This is illustrated in Figure 5.

The data processing methods mentioned in this paper are automatic. This is a necessary requirement since the long term goal is to create an automated process from data collection to high resolution environment models.

Future work includes improved classification and further refinement of the data processing methods.

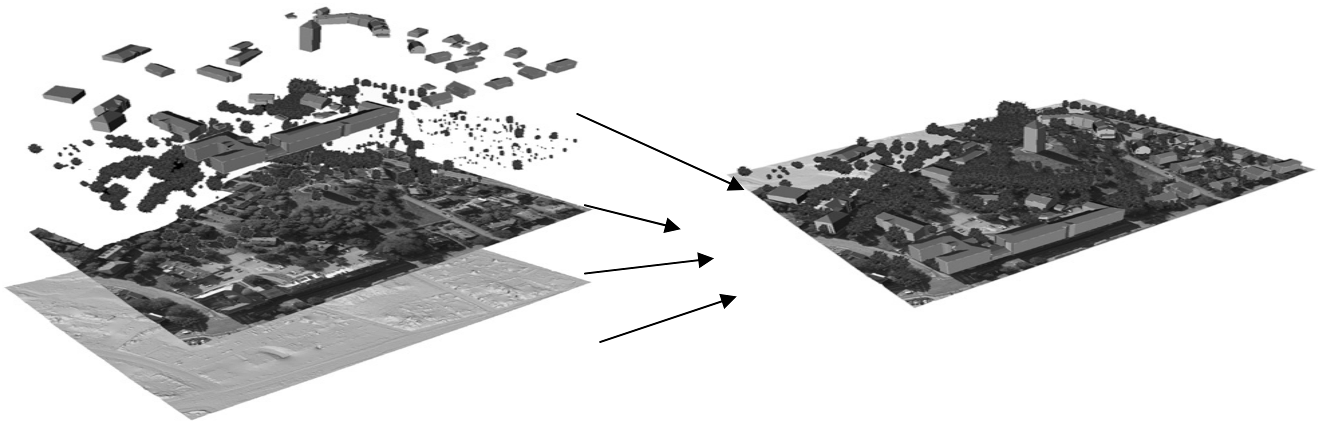

Figure 5: Extracted terrain features, an orthophoto mosaic and a DTM are integrated to create an environment model.

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