Road detection and characterization from LIDAR data

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Background

The National Road Database (nvdb.se) contains information about the whole Swedish road network. Data concerning speed limits, road standard and many other properties is stored in the database. Among other purposes, the information is useful for automatic route planning. The geographic information is based on GPS measurements. Usually the accuracy is sufficient, but the elevation ("z-coordinate") is notoriously difficult to measure. An accurate value of the road inclination is essential for estimating the energy consumption for a certain route.

The public roads are continuously monitored by the Swedish road administration using various methods, but the private roads are often monitored infrequently. The latter are typically gravel roads and constitute 80 percent of the total road network. They are essential for forestry's transportation of timber and machinery. The forestry sector has its own version of the national road database containing additional information relevant to forestry. Unfortunately, there is a lack of precision and even existence of information for large parts of the private road network. This default leads to inefficient route planning and faulty decisions in operational planning.

In 2009, The Swedish National Land Survey characterized Sweden's topography using airborne laser scanning (LIDAR). LIDAR data is basically an x-y-z point cloud, from which information about ground elevation and vegetation can be extracted using different algorithms. Data from the laser scanning is yet to be employed for large scale extraction of road properties.

Aim of the project

There are two primary goals of the project. The first one is related to energy efficient driving through accurate information about the road slope at every point of the road. The second goal concerns information about geometrical accessibility and bearing capacity during various seasons of the year. Combining large scale data from NVDB and the laser scanning, the idea is to identify the road from the point cloud dataset and then to compute accurate measures of:

Road grade (slope) - the longitudinal component of road gradient. The slope is necessary for accurate fuel consumption calculations.

Crossfall - the transversal inclination of the road. This is essential for water runoff and the bearing capacity of the road in wet conditions.

Road width. Information about road width is necessary for judging accessibility with long vehicle combinations.

Ditch depth. No single property affects road bearing capacity more than drainage. There is a strong correlation between ditch depth and the road's ability to withstand rainfalls and thawing.

Technical details

The project entails extraction of input from large LIDAR datasets. Figure 1 shows a small sample of a point cloud from laser scanning of a forested area with roads. Although the position of roads in principle can be found from NVDB, errors of several meters are common, and so it is not possible to

directly match a coordinate from the road database with points from the point cloud. Sometimes roads are also missing in NVDB. Points corresponding to the road surface must therefore be identified using some classification algorithm. The algorithm must be robust enough in order to treat thousands of kilometers of road without human intervention. Data from the laser scanning is generally accurate, but disturbances from vegetation and other obstacles are common. Also, it is sometimes difficult to distinguish the road surface from other flat areas. Since large areas of land are to be covered, the algorithm including data extraction, must be computationally efficient.

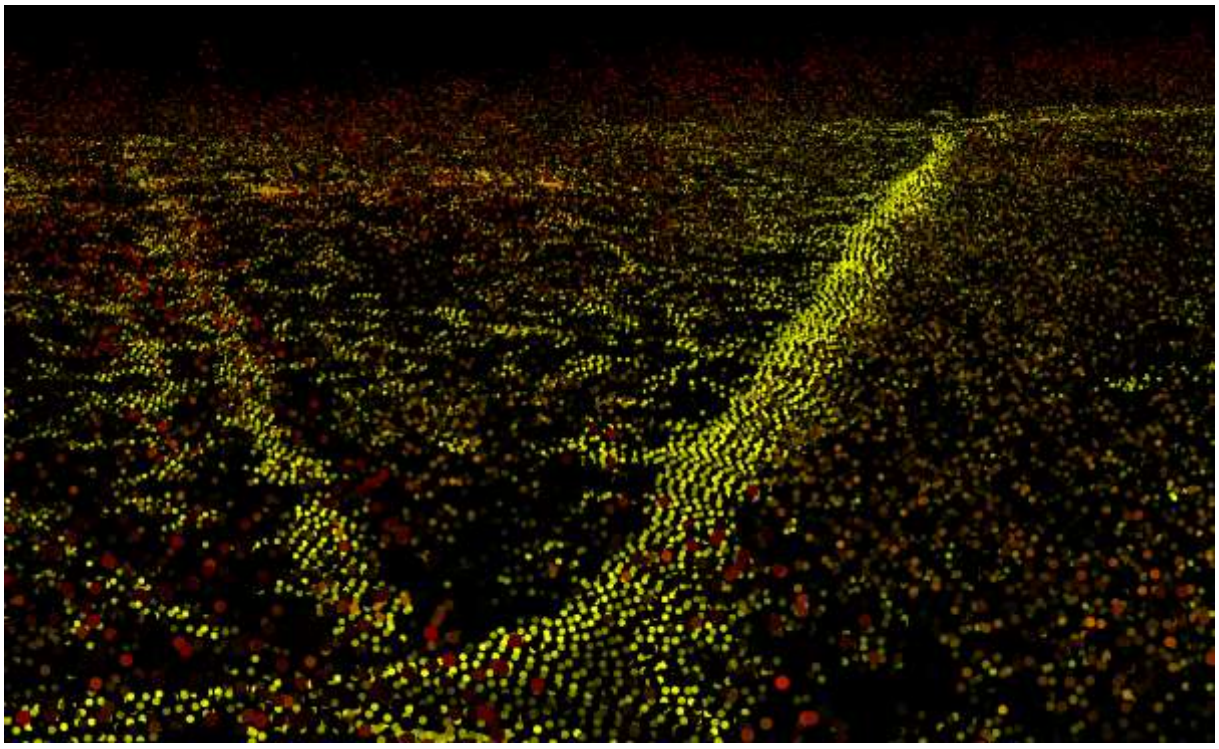

Figure 1. Point cloud example. Extending from the front and back to the right is a forest road. The structure extending back to the left is a power line. The color of the points corresponds to the reflection intensity. In this example, the road happens to come out as yellow, but owing to the surface properties the color may vary.

Outcome of the project

The project shall propose an algorithm that accomplishes road detection and is capable of quantifying road gradient, crossfall, width and ditch depth. Input data is a set of data files from the laser scanning along with data from NVDB. The algorithm can be implemented in Matlab or some other high-level language, as deemed necessary with respect to performance. Likewise, the project will investigate the hardware needs.