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LESTO: an Open Source GIS-based toolbox for LiDAR analysis

Silvia Franceschi, Andrea Antonello, and Giustino Tonon
University of Bolzano, Science Technologies, Bolzano, Italy

During the last five years different research institutes and private companies stared to implement new algorithms to analyze and extract features from LiDAR data but only a few of them also created a public available software. In the field of forestry there are different examples of software that can be used to extract the vegetation parameters from LiDAR data, unfortunately most of them are closed source (even if free), which means that the source code is not shared with the public for anyone to look at or make changes to.
In 2014 we started the development of the library LESTO (LiDAR Empowered Sciences Toolbox Opensource): a set of modules for the analysis of LiDAR point cloud with an Open Source approach with the aim of improving the performance of the extraction of the volume of biomass and other vegetation parameters on large areas for mixed forest structures.
LESTO contains a set of modules for data handling and analysis implemented within the JGrassTools spatial processing library. The main subsections are dedicated to 1) preprocessing of LiDAR raw data mainly in LAS format (utilities and filtering); 2) creation of raster derived products; 3) flight-lines identification and normalization of the intensity values; 4) tools for extraction of vegetation and buildings.
The core of the LESTO library is the extraction of the vegetation parameters. We decided to follow the single tree based approach starting with the implementation of some of the most used algorithms in literature. These have been tweaked and applied on LiDAR derived raster datasets (DTM, DSM) as well as point clouds of raw data. The methods range between the simple extraction of tops and crowns from local maxima, the region growing method, the watershed method and individual tree segmentation on point clouds.
The validation procedure consists in finding the matching between field and LiDAR-derived measurements at individual tree and plot level. An automatic validation procedure has been developed considering an Optimizer Algorithm based on Particle Swarm (PS) and a matching procedure which takes the position and the height of the extracted trees respect to the measured ones and iteratively tries to improve the candidate solution changing the models' parameters.
Example of application of the LESTO tools will be presented on test sites. Test area consists in a series of circular sampling plots randomly selected from a 50x50 m regular grid within a buffer zone of 150 m from the forest road. Other studies on the same sites take as reference measurements of position, diameter, species and height and proposed allometric relationships. These allometric relationship were obtained for each species deriving the stem volume of single trees based on height and diameter at breast height.
LESTO is integrated in the JGrassTools project and available for download at www.jgrasstools.org. A simple and easy to use graphical interface to run the models is available at https://github.com/moovida/STAGE/releases.