PhD project, fully funded in Rennes

Title: MASSIV-RIVER: Classification of massive 3D topo-bathymetric airborne lidar data in fluvial environments

Keywords: machine learning, remote sensing, image processing, big data, lidar, rivers

The universities of Rennes 1 and Nantes own a state of the art airborne topo-bathymetric lidar currently unique in France (800 k€). Traditional airborne lidar systems use a NIR laser (1064 nm) that measure in 3D topographic features, vegetation and buildings but cannot penetrate water. This new system, thanks to a second laser using a 532 nm wavelength, can penetrate water and measure shallow bathymetry in aquatic environments (5 to 10 m depth) at the same time that the surrounding topography. Because of the very high acquisition rate of the two lasers, ground resolution of 20 pts/m² with a vertical precision better than 10 cm can be obtained. This offers tremendous potential for fundamental research on fluvial environments (e.g., river morphodynamics, aquatic ecosystems...) and applied research (e.g., flooding risk mapping, dyke inspection, navigability...). While the acquisition technology is mature, the sheer volume of 3D data produced by the instrument (typically 10 billions points for 50 km of rivers) and the geometrical complexity of fluvial environments makes -apparently- simple tasks such as water surface detection, channel bank mapping or aquatic vegetation mapping extremely complex. The objective of this phd project is to create new processing algorithms to lift this bottleneck and automatically classify complex, massive topo-bathymetric lidar data of fluvial environments.

To this end, the phd student will develop new algorithms using not only the 3D data point as it as traditionally been done for topographic lidar, but also use the entire backscattered laser signal that is also recorded during the flight (Full Waveform Lidar data). The backscattered signal offers greater insights into the physical characteristics of the target illuminated with the laser and will be used to improve the classification success and to extract optical characteristics of the water in relation to turbidity. The student will have the opportunity to develop his work using the largest topo-bathymetric river surveys currently available.

Using 3D point clouds, and 3D backscattered signal, the student will develop new classification algorithms based on a multi-scale approach recently developed in our team (Brodu and Lague, 2012).
The PhD student will also explore the combination and assimilation of 2D hydrodynamic simulations on lidar data to account for hydraulic connectivity and extrapolate the data in places where the water was too deep for a backscattered signal to be measured. His work will also be applied during his PhD to another type of complex data (multibeam sonar+ mobile terrestrial lidar) acquired by colleagues at the University of Southampton (a 3-6 months stay in UK is planned).

The algorithms developed in this project will be implemented in existing open source platforms, and tested on other types of natural environments and 3D data. At the end of his PhD, the candidate is expected to have a unique set of skills that will allow him to continue an academic career, or to work in the private sector where the topo-bathymetric lidar only starts to be used.

**Required skills:** advanced training in machine learning (algorithm development) and remote sensing, image processing, proficient in programming (ideally C++), excellent communication skills in English. Candidates with an expertise in signal processing could also be considered. No previous knowledge on fluvial environments or lidar technology is needed. Speaking French is not mandatory.

**Host department:** Geosciences Rennes/IRISA. The PhD candidate will work with specialists of lidar acquisition and fluvial environments (D. Lague, J. Leyland (Southampton)), and specialists of remote sensing and machine learning (Th. Corpetti (IRISA/LETG), S. Lefevre (IRISA)).

**Host teams:** Quantitative Geomorphology (Geosciences Rennes, Univ. Rennes 1) & OBELIX team (IRISA, Univ Rennes 1)

The Quantitative Geomorphology team is specialized in the application of terrestrial and airborne lidar to study earth surface processes, and in particular extreme events (floods, landslides,...). It combines data acquisition in France and New-Zealand with the development of innovative 2D numerical models of landscape evolution. It consists of physicists, geologists, hydrologists and remote sensing specialists. It has numerous international collaboration (UK, New-Zealand, US) and is in charge of operating the topo-bathymetric lidar instrument.

The Obelix team of IRISA ([www.irisa.fr/obelix](http://www.irisa.fr/obelix)) is specialized in analysis and processing of images, machine learning and data mining, coupling between data and physical models, big data processing and tool development for decision making. Its developments in computer science, signal processing and mathematics are applied to remote sensing of the environment.

**Phd Advisors:** Dimitri Lague (Senior Researcher, CNRS, geophysicist specialist of Lidar and numerical modelling of river evolution), Thomas Corpetti (Senior Researcher, CNRS, remote sensing and machine learning), Sebastien Lefevre (Professor, IRISA/Univ. Vannes, remote sensing and machine learning)

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**Start date:** October 2016, **duration:** 3 years, **salary:** 1350 €/month

**Deadline for application:** 30 June 2016

**Administrative requirements:** the candidate must own a master degree (master 2 in France) or equivalent at the beginning of the PhD.
