DEPARTEMENT OPTIQUE ET TECHNIQUES ASSOCIEES (DOTA)

Automatic mapping of urban tree species based on multi-source remotely sensed data

Soutenance de thèse – Josselin Aval

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Résumé
With the expansion of urban areas, air pollution and heat island effects are increasing, leading to state of health issues for the inhabitants and global climate changes. In this context, urban trees are a valuable resource for both improving air quality and promoting freshness islands. On the other hand, canopies are subject to specific conditions in the urban environment, causing the spread of diseases and life expectancy decreases among the trees. This thesis explores the potential of remote sensing for the automatic urban tree mapping, from the detection of the individual tree crowns to their species estimation. This is an essential preliminary task for designing the future green cities, and for an effective vegetation monitoring. Based on airborne hyperspectral, panchromatic and Digital Surface Model data, the first objective of this thesis consists in taking advantage of several data sources for improving the existing urban tree maps, by testing different fusion strategies (feature and decision level fusion). The nature of the results led us to optimize the complementarity of the sources. In particular, the second objective is to investigate deeply the richness of the hyperspectral data, by developing an ensemble classifier approach based on species specific classifiers. The features are built owing to vegetation indices selection, specific for each species. Finally, the first part highlighted to interest of discriminating the street trees from the other structures of urban trees. In a Marked Point Process framework, the third objective is to detect trees in urban alignment. Through the first objective, this thesis demonstrates that the hyperspectral data (especially the VNIR) are the main driver of the species prediction accuracy. The decision level fusion strategy is the most appropriate one for improving the performance in comparison the hyperspectral data alone, but slight improvements are obtained (a few percent) due to the low complementarity of textural and structural features in addition to the spectral ones. The ensemble classifier approach developed in the second part allows the tree species to be classified from ground-based spectral references (leaf and canopy levels), with significant improvements in comparison to a standard feature level classification approach. Finally, the street trees can be mapped thanks to the proposed model integrating contextual features (alignment and similar heights). This work could be extended to the phenological monitoring of urban vegetation and the analysis of the state of health.
Mots clés : Urban, Tree, Remote sensing, Hyperspectral, Panchromatic, Digital Surface Model, Object-based, Fusion, Ensemble classifier, MPP, Vegetation indices.