MODEL-BASED INTEGRATION OF INSAR AND LIDAR FOR CANOPY STRUCTURE

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1. INTRODUCTION AND OBJECTIVES

In this work we present a model-based approach to sensor fusion that produces detailed information on vegetation structure and aboveground biomass for terrestrial ecology studies related to the carbon cycle and biodiversity. We integrate lidar data with polarimetric and interferometric SAR data in a joint optimization framework using a combination of physics-based and empirically derived sensor models. While both radar and LIDAR data have been used separately for deriving vegetation parameters, it is widely accepted that a single data modality cannot produce a comprehensive set of these parameters, but rather a combination of data types that are sensitive to different aspects of vegetation structure are needed [1]. The SAR models to be used in the estimation algorithm described here are derived from explicit physical models of radar scattering from forested ecosystems, while the lidar models are derived using a mix of empirical training data sets and physical waveform-based analyses.

2. APPROACH

Many parameter estimation approaches including those proposed for data fusion rely on empirically based models. As the dimension of the data space increases through using multiple sensors, the quantity of required training data to estimate parameters within a traditional regression framework also increases. Alternatively, here we will utilize a Bayesian approach whereby we assume that the prior probability reflects the slow-varying structure of vegetation over the landscape and substitute results from our physics-based radar models validated using field data for the likelihood function in the estimation model.

LIDAR models for vegetation structure are almost exclusively empirical and based on parameters extracted from point cloud or more recently from waveform data [2, 3]. Fusion approaches for SAR and LIDAR typically utilize vegetation height derived from LIDAR to constrain parameter estimation in SAR models. We will decompose LIDAR waveforms and obtain structural characteristics for multi-level canopies from the resulting estimates. The estimated value of the vegetation structure variables in a multisensor environment will then be obtained via an iterative optimization procedure, which also provides an error-measure for the estimate [1]. For multisensor fusion problems, both the input and output variables can be multidimensional, corresponding to the measurements of the individual sensors and the forest structure parameters, respectively. Estimating all forest parameters jointly will provide the opportunity for much better model estimates and hence much better forest structure parameter estimates.

We will use the La Selva biological station for our study. This 1600 ha field station is located in northern Costa Rica. In addition to its rich biological resources, this site hosts an advanced laboratory for Geographic Information Systems (GIS) and remote sensing, over which a comprehensive set of LVIS lidar and polarimetric and interferometric SAR data have been acquired in the recent past.

3. RESULTS AND CONCLUSIONS

The fusion framework is implemented in two modes: 1) dense coverage by both LIDAR and SAR data and 2) sparse coverage by LIDAR and coverage of extended areas by SAR data. In the first case, better estimates of vegetation heights may be achieved from a combination of LIDAR and SAR acquired over the same area. Vegetation heights predicted using parameters obtained from the fusion model optimization process will be integrated using a multiresolution approach [4]. However, if coverage by LIDAR is sparse within the SAR acquisition, it will be necessary to extrapolate information derived from the LIDAR.

This work will provide a foundation for fusion of physically based models of vegetation structure in a multi-sensor environment. We address both the case of common coverage and that of sparsely overlapping coverage by LIDAR and SAR. Outcomes will be directly applicable to demonstrating the potential utility of this multi-sensor configuration to spaceborne mission concepts such as DESDynI. Results will be shown and evaluated in terms of accuracy and computational requirements.

4. REFERENCES

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