Internship Report: Forest Canopy and Ground Height Estimation using TomoSAR and Deep Learning Models

Intern: Sahar Mohamed
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Lab: EO Analytics, Salzburg University, Austria.

Supervisor: Dr. Karima Hadj-Rabah

Tasks

1. **Training a Tomographic SAR Neural Network (TSNN)**
   Trained a TSNN model to estimate forest canopy and ground heights in the Paracou region of French Guiana using TomoSAR data acquired as part of ESA's TropiSAR mission. The dataset was split into training, validation, and test sets. The model was also tested on unlabeled data to evaluate generalization. Modifications were made to the training process to improve performance.
2. **Literature Review and Performance Comparison**
   Reviewed recent articles and compared the efficiency of the TSNN model with state-of-the-art approaches from the literature.
3. **Development of Modified UNet Model (M-UNET)**
   Developed a modified UNet architecture named M-UNET to estimate canopy and ground heights from patches rather than single resolution cells. The proposed model was designed to better capture spatial context and was tested on unlabeled datasets lacking lidar data to assess generalization ability.
4. **Comparison with Traditional Methods**
   Compared deep learning methods (TSNN and M-UNET) with traditional spectral estimation techniques namely CAPON and MUSIC to evaluate relative performance.

Learning Objectives

My learning objectives were to gain a deeper understanding of Forest height estimation from tomographic SAR imaging and to develop deep learning models capable of estimating ground and top of the canopy heights without relying on lidar as from my BIP in Romania for Drones in environmental sciences , I realized how expensive and costly the lidar datasets besides the whole process and preparation to make the flight plan, charge batteries of drone, capture for only specific area and range in a limited time. This internship met those objectives by providing

practical experience with TomoSAR data, especially covariance matrices calculated using fully polarized SLC images (HH, HV, VV).

Training models like TSNN and M-UNET helped me understand how to handle complex SAR data and how it relates to physical forest structures. Additionally, comparing these models with traditional spectral methods broadened my knowledge of the strengths and weaknesses of different approaches.

Recommendations for Future Intern

- **Understand SAR Fundamentals:** Develop foundational knowledge about SAR technology, including different types, polarizations, and techniques.
- **Deep Learning Skills:** Gain experience in training neural networks, handling tensors, and properly splitting datasets for training, validation, and testing.
- **Forestry Knowledge:** Familiarize yourself with forest ecology, especially tropical forests, to better interpret model results on unseen data using domain knowledge and visual inspection.

Additional Notes

The internship emphasized the importance of thoroughly understanding SAR data formats, such as covariance matrices, and their physical significance. The combination of deep learning with traditional methods proved valuable in improving height estimation accuracy.