SILESIAN UNIVERSITY OF TECHNOLOGY

Abstract

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Doctor of Philosophy

Unmixing of Hyperspectral Images: Where Artificial Intelligence Meets Earth Observation

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This doctoral thesis focuses on improving the analysis of hyperspectral images by addressing key challenges across the entire machine learning workflow, from data preparation to model deployment. The research begins by tackling the problem of biased model evaluation, often caused by spatial correlations in hyperspectral imagery. A rigorous data splitting and validation strategy is introduced to prevent information leakage between training and test sets, ensuring fair and trustworthy assessment of model performance.

The next part of the work investigates how the size of the training dataset influences the accuracy and reliability of material abundance estimations. Through systematic experiments, this study highlights the sensitivity of deep learning models to the availability of labeled data, offering valuable insights for designing robust models in data-scarce environments.

Building on these foundations, the thesis benchmarks state-of-the-art deep learning methods for hyperspectral image analysis and proposes new model architectures designed to improve unmixing accuracy. These include deep ensemble techniques, graph convolutional neural networks combining spectral and spatial features as well as attention modules, and a flexible band selection method that reduces data complexity without compromising performance.

Finally, the research addresses the practical challenge of deploying these advanced models in real-world settings, particularly on resource-limited platforms such as satellites. To support this, the thesis explores model quantization techniques that significantly reduce computational demands, making it possible to run complex deep learning models efficiently on edge devices.

Together, these contributions form a complete, end-to-end framework for hyperspectral image analysis — from data preparation and feature selection to model development, evaluation, optimization, and deployment. This work not only advances the scientific understanding of hyperspectral unmixing but also delivers practical tools and methods for operational Earth observation applications.