Testing Land Coverage Classification Algorithms for Optimizing Flood Detection in Hyperspectral Image Data
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Summary
- We want to improve on existing algorithms for detecting water from satellite imagery in order to effectively monitor floods.
- Current methods are limited to using few spectral bands due to onboard computational constraints.
- Our methods utilizing all available spectral bands significantly outperform algorithms currently onboard the EO-1 satellite.
- We thus leverage existing cloud-based infrastructure to quickly process and classify large hyperspectral images with high accuracy.

Background
- NASA's Hyperion instrument on its Earth Observing-1 (EO-1) Satellite provides hyperspectral imagery, covering 242 spectral bands (from 0.4 to 2.5 µm).
- Standard scenes are 37 km x 42 km, amounting to 1.5 to 2.5 GB of data per scene.
- High spectral resolution creates a high-dimensional feature space, potentially allowing for high predictive performance.
- Reflectance values from hyperspectral images can thus be used to detect water.

Problem: Data Access and Limited Computational Ability
- Current onboard sensors are limited to using 3 of the 242 spectral bands for water detection.
- Hyperion scenes are difficult to access in large volumes for scientific processing.
- How do we quickly classify hyperspectral images using all 242 spectral bands?

Data Acquisition
- Project Matsu, a cloud-based collaboration with NASA, provides a framework for fast access to hyperspectral EO-1 images.
- We leverage Project Matsu's framework to access hyperspectral data, based on diverse types of surface materials (clouds, dry land, vegetation, water).

Image Pre-Processing
- Input data: raw radiance values per band per pixel.
- The radiance for each band is divided by its respective solar irradiance, then geometrically corrected for solar elevation/distance at observation time.
- Output data: at-sensor reflectance values per band per pixel.

Results: Model Comparison
- 60/20/20 training/test/validation set used to train and compare models.
- Compare models trained on all bands vs. models used onboard EO-1, resulting in 5% - 20% accuracy increase.

Results: Spectral Band Performance
- Feature ranking/selection can be used to determine optimal band selection.
- Many bands unused by onboard algorithms have high predictive performance.
- Bands used by onboard algorithms are suboptimal for flood detection; better band combinations can be chosen.

Conclusion
- Because of the efficient framework provided by Project Matsu, we get quick overnight characterization of possible flood scenes with greater accuracy (5% - 20% increase) than existing methods.
- Feature selection methods can be used to select optimal spectral band combinations for water detection without additional computational expense.
- Classification of hyperspectral images can potentially be used to accurately detect various types and mixtures of surface materials.

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Additional Info
To see the dataset used and a reproducible code tutorial, follow the QR code below, or visit benhuynh.github.io/waterdetection.html. The author can be reached at benhuynh@uchicago.edu.