COAL AND OPEN-PIT MINING IMPACTS ON AMERICAN LANDS (COAL): A PYTHON LIBRARY FOR PROCESSING HYPERSPECTRAL IMAGERY

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ABSTRACT

COAL is a Python library for processing hyperspectral imagery from remote sensing devices such as the Airborne Visible/InfraRed Imaging Spectrometer (AVIRIS-C & AVIRIS-NG). COAL was originally developed as a 2016 – 2017 Senior Capstone collaboration between scientists at the Jet Propulsion Laboratory (JPL) and computer science students at Oregon State University (OSU). COAL aims to provide a suite of algorithms for classifying land cover, identifying mines and mining activity and other geographic features, and correlating them with environmental data sets e.g. hydrologic features such as streams and watersheds. COAL is Free and Open Source Software with the pycoal Python toolkit and Science Data System licensed under the terms of GPL v2.0 and Apache License v2.0 respectively.

Index Terms— imaging spectroscopy, open source software, coal, mining, land cover

1. INTRODUCTION

Mountain-top Mining (MTM) is a method of open surface mining with the primary aim of exploring and exploiting coal seams present within the land and solid earth on mountaintops. Amongst other surface mining activities, MTM is known to be an extremely destructive mining procedure historically known to affect, in particular, the U.S.A. spatial boundaries of the Southern Appalachians (Eastern Kentucky, West Virginia and very small sections of Virginia and Tennessee). MTM is known to have caused irreparable damage to mountain landscapes and significant immediate and longer-term damage to key streams and watersheds. Larger afield, the rest of the U.S.A has some extensive surface mining in various places for exploitation of resources such as gravel/sand, various metals, other minerals and radioactive materials, etc. Several studies have provided important scientific understanding related to the local [1], regional and state-level [2] [3] impacts of such environmentally destructive practices, however a similar understanding on the national [4] and continental levels are very much lacking. The COAL project – **C**oal and **O**pen-pit surface mining impacts on **A**merican **L**ands – has successfully delivered (i) a suite of Python algorithms, packaged into a command line toolkit, for processing hyperspectral imagery from remote sensing devices such as the Airborne Visible/InfraRed Imaging Spectrometer (AVIRIS) to identify, classify, characterize, and quantify (by reporting a number of key metrics) the direct and indirect impacts of MTM and related destructive surface mining activities across the continental U.S (and further afield) and (ii) a Science Data System (COAL-SDS) for cataloging, archival, resource and workflow management of COAL data processing activities. This paper details (i) and (ii) above and concludes with future work detailing ongoing utilization of a NSF-funded XSEDE high performance computing (HPC) grant to further improve, validate and document COAL algorithms, execution runtime performance and geospatial output results.

2. CORE TOOLKIT FUNCTIONALITY

The following subsections detail the core functionality of the pycoal Python toolkit [5]. All italicized API documentation below can be accessed at [6].

2.1. Mineral Classification

Mineral classification for land coverage, particularly for the study of minerology, is a common task within imaging spectroscopy as all minerals have unique spectral signatures. Samples of those spectral signatures are contained in spectral libraries e.g. ASTER [7], USGS [8], etc. Using publicly available orthocorrected, scaled reflectance AVIRIS images with unknown land cover and spectral signatures, pycoal provides a *MineralClassification* API to classify each pixel with the spectral angle mapper classification mechanism. Other classification options exist e.g. unsupervised K-Means, supervised Gaussian Maximum Likelihood, Mahalanobis Distance and Multi-Layer Perceptron. The output is a mineral classified file where each pixel is assigned to a particular class in the spectral library. The above right image of FIGURE 1 displays an example mineral classified image with the corresponding Red-Green-Blue (RGB) GIS product image displayed on the upper left. Pycoal provides utility functions to easily generate RGB images for any given AVIRIS flight line greatly simplifying manual visual data analysis of flight lines prior to further classification.
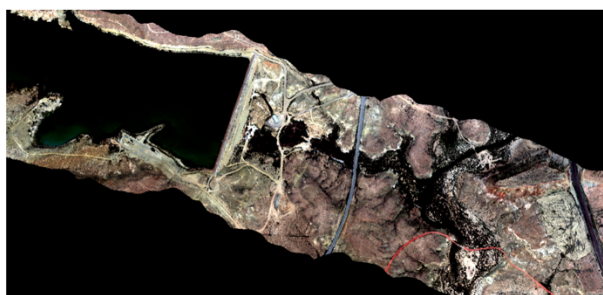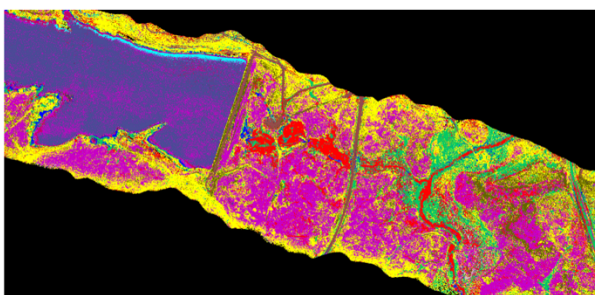
Figure 1: Visible-light image.
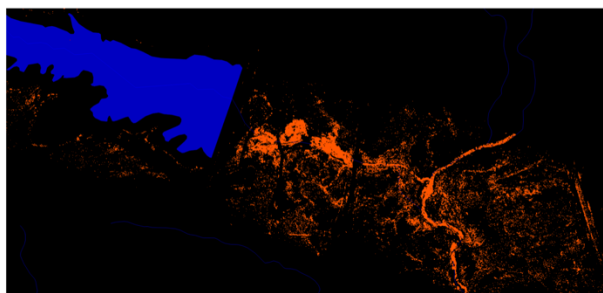
Figure 2: Mineral classified image.

Figure 3: Mining classified image.

Figure 4: Environmental correlation image.

FIGURE 1: COAL GIS PRODUCTS

2.2. Mining Identification

Through the *MiningClassificiation* API, pycoal enables configurable selection and use of certain classes of minerals as proxies for the presence of mining. Examples of such classes extracted from the USGS Spectral Library include *Schwertmannite*, *Renyolds_TnlSldgWet* and *Renyolds_Tnl_Sludge*. The lower left image of FIGURE 1 displays an example mining classified file where each pixel is identified as either corresponding to mining or not.

2.3. Environmental Correlation

The Pycoal *EnvironmentalCorrelation* API enables the ability to map identified mining activity in GIS applications and correlate them with water quality measurements. The lower right image in FIGURE 1 displays how we can determine whether water pollution is linked to mining and then use results to enhance environmental understanding.

3. FUTURE WORK

Through use of COAL-SDS we can already batch process past and present AVIRIS imagery and hence facilitate research with unique GIS data products. Our ongoing and future work involves continuation of COAL through the OSU Senior Capstone 2017-2018 program which will leverage the NSF-funded XSEDE Startup HPC Allocation to process the entire AVIRIS-C/NG archive.

4. ACKNOWLEDGEMENTS

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