COAL: Coal and Open-pit surface mining impacts on American Lands

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Abstract

Mining is known to cause environmental degradation, but software tools to identify mining impacts are lacking. Researchers studying this problem possess large imaging spectroscopy and environmental quality data sets as well as high-performance cloud-computing resources. This project provides a suite of algorithms using these data and resources to identify signatures of mining and correlate them with environmental impacts over time.

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1 Purpose and Goals

Our project is COAL: Coal and Open-pit surface mining impacts on American Lands. The purpose of our project is to create a suite of algorithms that will identify metrics to identify and classify minerals, identify mining activity based on those minerals, correlate effects on the environment with mining, and analyze those effects over time.

The deliverables for this project are an API that contains the algorithms for the previously mentioned image processing and correlation tasks that is contained in a GitHub repository, autogenerated API documentation using Sphinx, and a website. The website will contain information about the project and its development as well as links to the GitHub repository and API documentation as well as developer profiles (which also link to our individual GitHub repositories) and background research papers.

We intend for our suite of algorithms to be used by environmental data scientists, people involved in environmental regulation, and anyone else with an interest in mineral identification and hyperspectral imagery.

2 Week by Week Summary

2.1 Weeks One and Two

Weeks one and two were dedicated to introducing the class and submitting our choices for what project(s) we wanted to work on. We did not know each other during these weeks, so in the context of this project, they were uneventful.

2.2 Week Three

During week three we had our first official meeting with all three team members and our client, Dr. Lewis John McGibbney from the Jet Propulsion Laboratory. We discussed background information on the problem and introduced ourselves. We went over the goals of the project, preferred tools, and the specific deliverables. We also got started on our first draft of the Problem Statement assignment. Our client set up an organization on GitHub to host our code as well as any third-party projects we contribute to [1]. We also set up a wiki for our weekly updates [2].

2.3 Week Four

After managing prerequisites in the previous week, during week four we became familiar with our project and gained an understanding of the expectations for the coming year. Our client provided some basic literature for us about mining and imagery, and we previewed some introductions about AVIRIS. We also scheduled initial meetings with our TA during which we set up our goals for the term. We also began to work on the Requirements Document.

2.4 Week Five

During week five we turned in the final draft of the Problem Statement on Friday and turned our attention to the Requirement Document, which is more like a to-do list for us. Our client mentioned that we need a website so that we can update our progress online as the project continues. After our client meeting, Taylor created a skeleton for our website using GitHub pages. We also met with our TA to discuss our progress on the documents. On Friday we finished the rough draft of the Requirement Document.

2.5 Week Six

We got feedback on our Problem Statement that was turned in during week five. The main criticism was that it described the problem from the client's rather than the developers' perspective. Heidi and Taylor met with Dr. Winters and agreed to submit another problem statement, dubbed our "Student Problem Statement," by the end of the term. Taylor volunteered to draft this document. Heidi generated a basic Sphinx documentation skeleton and committed it to the GitHub repository. Heidi and Taylor revised the Requirements Document based on some basic feedback given by our TA Vee, most of which consisted of having requirements that could easily be broken up into multiple parts.

2.6 Week Seven

In week seven Taylor and Xiaomei met to print literature and to review Git. The team began work on the Technology Review and continued to research material provided by the client. The Technology Review proved to be difficult as it was at this point that we began to discuss most of the "how" of our project. We all had to read up on a lot more literature regarding hyperspectral imagery and mineral identification and classification. Heidi posted questions about some of the literature to the group mailing list.

2.7 Week Eight

We revised our initial draft of the Technology Review during week eight. In addition, we outlined our Design Document and set up meeting times for the next two weeks in the library during a canceled lecture. During the meeting with the client, Taylor discussed options for a development server. Taylor also posted comments and questions about the research papers we are reading to the group mailing list.

2.8 Week Nine

During week nine we added more content to the Design Document. Because of the holiday, we had only a few working days. We decided to meet on Monday of that week to at least get started on the design document while we were all together in person. We agreed to strive for having most of it done by the next Monday. During the Thanksgiving holiday Xiaomei added content to the skeleton of our website on GitHub pages including links to our GitHub main page, course website, and literature, as well as an initial Bootstrap theme [3].

2.9 Week Ten

During week ten we completed our design document and submitted it to the client. We did not quite meet the goal of having our first draft done by Monday, but we did get it in on time. Taylor provided a Beamer slideshow template which the team used to generate slides. Taylor added graphics to the slides, and every team member recorded audio to accompany each slide. Xiaomei's laptop microphone proved to be the highest quality, so we used hers for over half the slides. We ran out of time and recorded remaining slides on our respective machines. During our meeting with the client we reviewed our progress during the term and began planning for future terms.

3 Project Status

So far, we have a skeleton for the Sphinx documentation and a basic website hosted on GitHub pages. We have also done a lot of background reading on mineral identification, processing AVIRIS data, and image processing methods

that were provided by our client on a weekly basis in a shared Google Drive folder. We also identified a Python library we are interested in using to process the AVIRIS data known as Spectral Python [4]. Our client tested out Spectral and originally had issues with compatibility when trying to process AVIRIS-NG data (as opposed to data taken from the original AVIRIS instrument), but the issue has been resolved [5].

We are in the process of acquiring computing resources to facilitate our development. We would like to configure a shared development server with tools necessary to edit, debug, and test our code in a consistent environment. We would also like to execute our code on high-performance systems such as supercomputing facilities available through NASA. We are investigating resources at both Oregon State University and the Jet Propulsion Laboratory and will be configuring the systems when they are available.

When we return from Winter break we will begin a detailed literature review. We will then use the remaining time in Winter and Spring terms to develop the components of our application. We think the mineral identification, feature extraction and classification, and identifying mining steps will be fairly achievable in those ten weeks. The correlation with environmental effects and plotting those over time will likely be carried over into the beginning of Spring term, as that is the area we have researched the least so far and is dependent on all of the previous steps.

4 Challenges

The first challenge we came across was finding meeting times and locations that worked for all three members of our team as well as our client. Our client is located in California so we naturally had to do video conferences, but we preferred to meet in person on our end to have time to meet and discuss documents and any other pertinent details before and after the video conferences. Taylor commutes from Salem and preferred to meet on Tuesdays and Thursdays, Xiaomei took 19 credits this term and was very busy, and Heidi's classes were during most of the times Xiaomei and Taylor were free. We agreed to meet Thursdays from 14:00-15:00. There were a couple of weeks where we had to reschedule due to our client being busy, but for the most part this was a good time for us and provided an opportunity to discuss documents with our client before we turned them in. We will have to find new meeting times next term to accommodate changes in our schedules.

Balancing writing the documents required for CS 461 and the research our client provided to us was also a challenge. The documents for this course tended to be long and dense, so we did not get to finish them when we met in person. This meant we had to do most of our collaborative work remotely, which was not ideal. At the same time, we had many research papers to read and videos to watch about image processing and mineral identification and classification. We often came across situations where we had to prioritize the document writing over research.

5 RETROSPECTIVE

Successes	Challenges	Changes
We were able to improve our understanding of the background information on image processing, AVIRIS, and mineral identification and classification.	We wish to meet in person more frequently.	We will set aside more time to meet during the week. Ideally, this will be in library study rooms.
We got a good idea of the team's strengths and weaknesses and were able to allocate responsibilities accordingly.	Team members had occasional technical difficulties during video conferences.	We will attempt to meet in person during rescheduled meetings to improve computer and network reliability.
We were able to submit completed drafts for each of the writing assignments.	Contributions were not made equally by all team members on every document.	We will acknowledge our respective contributions and aspire to allocate work fairly while meeting course and client expectations.
We maintained a consistent line of communication with our client.	We need to obtain access to a suitable development environment for when we start working on the bulk of the code.	Our client is currently looking into accessing supercomputing for our future development and we are looking into any applicable resources OSU may have available regarding a shared development server.
Collaborative editing using Overleaf eased the document-writing process.	We need to agree upon style guidelines, if any, to use when writing TeX, HTML, and Python.	We will discuss with our client at our next meeting (12/8/16) whether we want to use PEP8 or something different.
The website was successfully hosted on GitHub pages.	The website needs to be updated to contain all of the content desired by the client.	The team will add the missing content and links as soon as possible.
Setting up Sphinx went smoothly with no issues.	We currently have little source code from which to generate documentation.	We will develop our source code and ensure that it is well-commented so that useful API documentation can be generated.
The project has kept our interest and its goals have inspired our progress.	The research and development is challenging and time-consuming.	We will invest as much time as is necessary to make this project a success within the time allotted.

REFERENCES

[1] https://github.com/capstone-coal
[2] https://github.com/capstone-coal/coal/wiki/Updates
[3] https://capstone-coal.github.io/
[4] https://github.com/spectralpython/spectral
[5] https://github.com/spectralpython/spectral/issues/55