Cardiff University

CM3203 - One Semester Individual Project (40 credits)

Initial Plan

LiDAR Data Analysis

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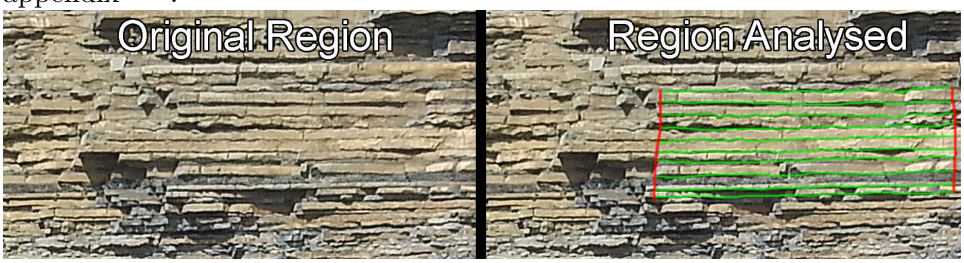
0.1 Project Description

For my dissertation I plan to continue work I initially started in a CUROP project implementing LiDAR data analysis. In this project we achieved some initial success at identifying different layers of a cliff face (idea illustrated below) in a LiDAR captured point cloud. We found strong candidate points on the cliff face by calculating some basic cost values based on the point's neighbourhood's properties (referred to as local descriptors), then we found the optimal path through points using path finding techniques (referred to as global optimisation).

Figure 1: Mockup results of cliff face with horizontal layers. For a greater overview of the previous project please look at the resources supplied in the appendix[1, 2].



With the supervision of Dr. Yukun Lai (Computer Science) and in collaboration of Dr. Tristram Hales (Earth Sciences), I plan to extend our work to improve the accuracy of the current system created during my CUROP. We hope to achieve this by using a higher quality scan of the cliff face with a refined and extended algorithm.

There have been a few implementations of Terrestrial Laser Scanning (TLS) technology for automated cyclostratigraphic analysis (the study of cyclic changes in sedimentary successions)[3]. One such implementation found success using a combination of TLS intensity along with calcimetry (the measurement of calcium carbonate and magnesium carbonate in a sediment sample) and lithofacies (the description of a sediment sample's physical characteristics).[4] In terms of TLS, the study's cyclostratigraphic interpretation showed 'the presence of strong cyclicities that are compatible with the expected Milankovitch (a theory describing the effects of changes in the Earth's movements on the weather) frequencies'[5].

This case proves that good results can be achieved with the automated cyclostratigraphic analysis. We have taken a different approach to identify the different sediment layers in a LiDAR capture of a cliff face, and in my dissertation we plan to continue this work.

Yukun, Tristram, and I had previously discussed the problems with the previous system. The system failed to identify many layers on the cliff face, to improve this we agreed that a higher density point cloud and a better algorithm would help. To achieve this we aim to capture a higher detail scan of the cliff face as well as improving the system's local descriptors and global optimisation algorithms. Another problem with the system was it's lack of automacy, this affected how well it could identify layers on different point clouds. To address this I plan to improve the semi-automacy of the system by implementing machine learning for parameter optimisation.

0.2 Aims & Objectives

The end goal is to achieve greater degree of accuracy using the new system over the old one.

Since we have already developed a basic system my primary aim will be to iteratively improve the ground-works as well as implement machine learning. To achieve this I shall take the following steps:

- Critically Analyse Previous System
  - Identify flaws in the previous system's design, this will be done by comparing the results attained by the previous system with the results we expect it to achieve, and analysing the algorithms used to produce those results (local descriptors & global optimisation function).

- Improve Local Descriptors & Global Optimisation
  - Local descriptors should help discriminate neighbourhoods of points at the boundary of a layer in the point cloud. Global optimisation should select points which follow the same layer boundary.

- Implement Learning for Parameter Optimisation
  - Make the new system operate in a semi-automatic manner with minimal input from the user.

0.3 Legal & Ethical

According to Cardiff University's Research Ethics Committee site my project does not require REG approval, since the project does not involve any form of interview, observation, questionnaire, or access to publicly unavailable personal data.[6] I have also confirmed with my supervisor that an ethical approval is not necessary.

If we collect more cliff data with the LiDAR scanner we will be using it in a public place, which is legally acceptable according to the Met Police: 'Members of the public and the media do not need a permit to film or photograph in public places'[7]. With respect to the safety of individuals in the public space the laser product classification is Class 1, which means it is considered 'safe under all conditions of normal use.'[8, 9]

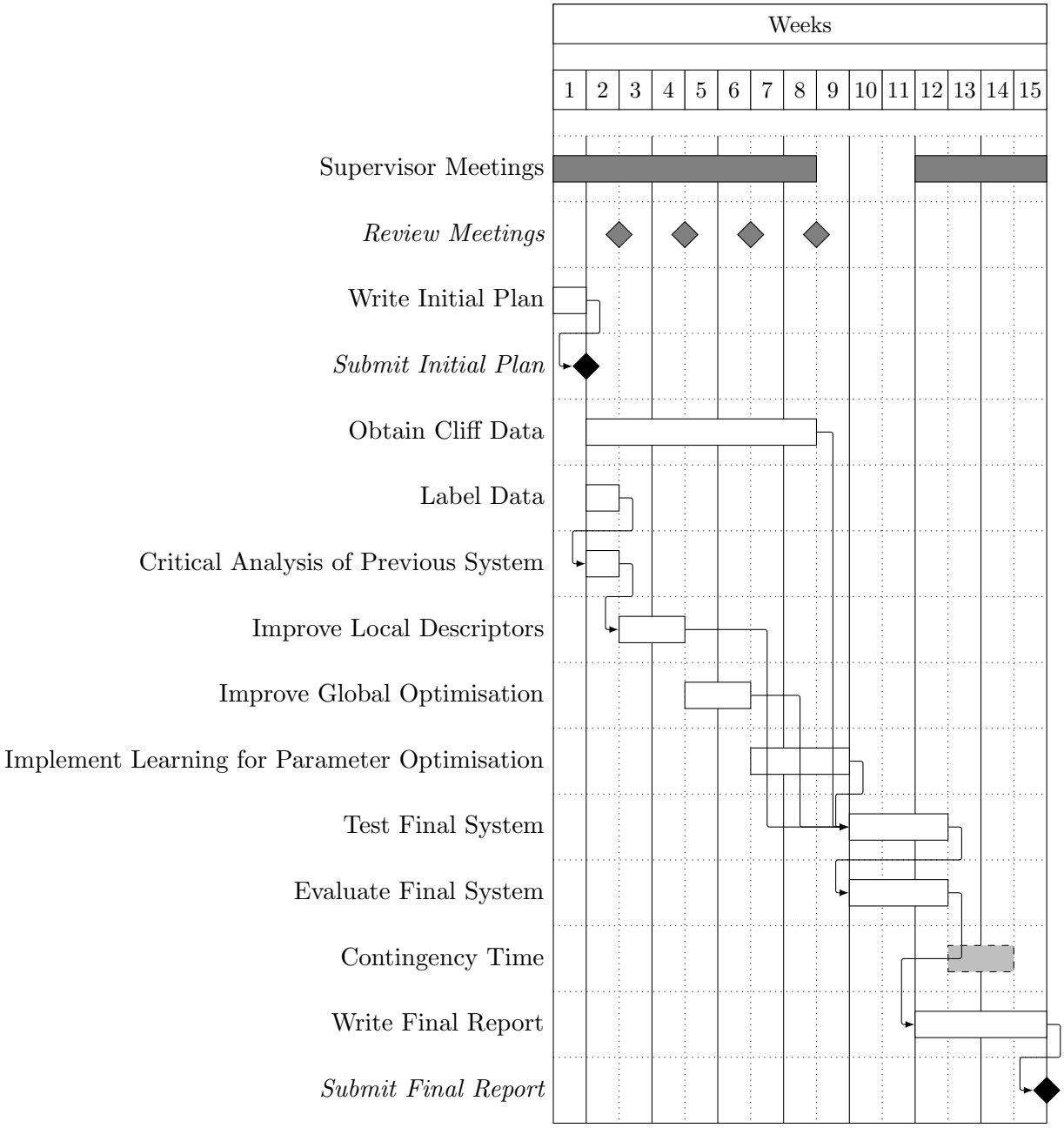
0.4 Work Plan

0.4.1 Notes on Deliverables

In terms of the deliverables for this project we consider it unnecessary to produce an interim report. So other than this initial plan, I shall submit one more report by the dissertation deadline (6th May). The final report will contain a thorough comparison between the old and new system, this will comprise of a description of the changes made and their collective impact as well as a description of the steps taken to achieve these results.

0.4.2 Time Plan

Figure 2: Gantt chart of project plan



Supervisor Meetings

In a brief discussion with my supervisor we decided it would be appropriate to physically meet for updates every two weeks, with meetings during interim weeks if necessary. I have excluded meeting in weeks 9, 10, & 11 from the plan as it is unlikely either of us will be available during the Easter period, I have designed the subsequent tasks around this availability concern.

By having regular meetings with my supervisor I hope to be able to review my performance and have a clear idea of how achievable my goals are given my progress. There are some key points in which it will be critical to analyse my progress, specifically at the beginning and end of the implementation of some of my project aims.

I have marked the weeks where review meetings should be held. The rationale behind the chosen dates is that by the time of the meeting I should be coming to the end of the current step and should start thinking about moving onto the next step. There shall be a final review meeting just before the Easter holiday, this is not at the end of any significant milestone, but allows my supervisor and I to assess how my time over Easter will be best spent.

Write Initial Plan

The first week will be spent on initially planning the project, then producing a brief write-up summarising the project plan. At this point I have discussed the aims of the project with my supervisor to gain an understanding of the best approach to achieve my objectives, this has helped us build a project plan that should be achievable in a finite time. From this discussion I hope to be able to direct my efforts to find materials (e.g. research papers, blogs, etc.) that are relevant to the project.

Obtain Cliff Data

This will require me to organise a trip to the beach to acquire some more data, this will depend on the availability of the Earth Sciences department with their LiDAR equipment and myself. Though not imperative to the development of the system, we expect it could help improve results and provide more diverse test data.

Label Data

I shall capture some images of the cliff face and ask Dr. Hales to highlight the image with the lines he expects me to find in the system's response.

Critical Analysis of Previous System

The previous system will be scrutinised to produce a list of problems and steps to help solve them. The list will comprise of problems relating to the local descriptors and global optimisation algorithms.

Improve Local Descriptors & Global Optimisation

The next four weeks will be spent fixing the problems identified in the Critical Analysis phase. By the end of this time period I should have produced significantly better algorithms, when comparing results of the old and new systems.

Implement Learning for Parameter Optimisation

In addition to the previous system's basic functionality I plan to spend three weeks extending it by implementing machine learning code to optimise the parameters used to measure aspects of the cliff face.

Testing Final System

I shall ensure that all components of the system work as intended, this will provide a final opportunity to verify the correctness of my code. I plan to make a series of test cases that cover the breadth of a system to an appropriate level.

Evaluate Final System

By using a combination of the previous system's results and the expected results, I plan to evaluate whether the new system actually improves on the old one and see how well the results attained match up to the labeled data.

Write Final Report

I have allocated three weeks exclusively for writing the final report; this time period will be used to collate information into one cohesive report. The time available for the report will be contingent on minimising extra work caused by unforeseen problems in the project.

Bibliography

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[3] Wikipedia. 5 April 2015. *Cyclostratigraphy* [Online]. Available at: https://en.wikipedia.org/wiki/Cyclostratigraphy [Access: 27 Jan 2016].

[4] Franceshi, M. & Penasa, L. & Coccioni, R & Gattacceca, J. & Smit, J. & Casella, A. & Mariani, S. & Montanari, A. 15 December 2015. Terrestrial Laser Scanner imaging for the cyclostratigraphy and astronomical tuning of the Ypresian–Lutetian pelagic section of Smirra (Umbria–Marche Basin, Italy). *Journal of Palaeogeography, Palaeoclimatology, Palaeoecology.* Vol. 440. pp. 33-46

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