The Title Of Your Project

**October 2024**

**By**

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**Word count: XXXX**

This document is a suggested template for your guidance. You don’t have to stick to it precisely. It may not suit your particular project. Modify it if you need to – but please discuss with your supervisor before making substantial changes to the organisation and content. Make sure you write about the all the required elements mentioned in the assignment specification.

Paragraphs in red, like this one, are instructions and extra information. You must delete them before submitting your report.

This template document has a number of paragraph styles predefined. If you use them (‘Heading 1’, ‘Heading 2’ and ‘Heading 3’) and don’t alter them, then your report will automatically have properly numbered paragraphs and your table of contents will be automatically generated with the right page numbers. Use ‘Normal’ as the style for general text paragraphs in your document. If you don’t know how to use paragraph styles in Word, now is a good time to learn.

On this page (and I *really* hope this is obvious) you must replace the words “The Title Of Your Project”, “Your Full Name Here” and “202XXXXXX” with the correct information. You’d be surprised how often people forget to do this. Don’t be one of them.

You must also replace “XXXX” with the actual word count (excluding acknowledgements, abstract, table of contents, references and appendices) of your document after you have deleted all the red bits.

This table of contents (TOC) is automatically generated by Word, based on paragraphs with styles of ‘Heading 1’, ‘Heading 2’, ‘Heading 3’ and ‘Unnumbered Heading’. It will automatically update with the correct page numbers when you load the document, but you can force it to do so at any time by right-clicking on it (the whole TOC will turn grey) and selecting “Update Field” or pressing F9.

If you manually edit the table of contents, you may find that either your changes will get overwritten or it will no longer update automatically. It’s a pain to keep a table of contents up to date manually, so you are advised not to edit it!

Delete these red paragraphs!

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# Project background and purpose

## Introduction

In this project, a software tool will be developed to tackle the multi-objective optimization problem of Multiple Sequence Alignment (MSA) - a common analysis task in Bioinformatics. The tool will aim to produce high-quality alignments of biological sequences in a time-efficient manner.

## Objectives

### 1.2.1 Primary Objectives

**1. Perform Multiple Sequence Alignment in a Time-Efficient Manner**

The produced software should be able to align a typical testcase of 6 protein sequences within 10 seconds on a university desktop computer. The resulting alignment of sequences must conserve the original sequence content and identifiers given as input.

**2. Assess the Viability of a Single-State Approach for Iterative Alignment**

To address their underrepresentation in recent studies, a single-state metaheuristic algorithm such as 'Simulated Annealing' should be implemented and assessed in its ability to guide an effective optimization process for MSA. A single-state form of the software could be contrasted against a population-based approach or assessed relative to an external tool such as Clustal Omega.

**3. Support Established Bioinformatics File Formats**

The alignment tool should be able to read biological sequences from an established file format such as FASTA. Likewise, the tool should support an established file format for outputting sequence alignments, such as FASTA, PHYLIP or NEXUS. The user should be able to specify the input source and output destination as command-line arguments.

**4. Consistently Produce High-Quality Alignments of Sequences**

As assessed in a case study using structural benchmarking, the alignment tool should demonstrate the ability to consistently produce alignments of a comparable quality to established software packages such as Clustal Omega and MUSCLE. (TODO: add that this is informed by experts)

### 1.2.2 Secondary Objectives

**5. Output a Set of Alignments Offering Compromises Between Objectives**

Keeping step with recent research, the software should leverage multiple objective functions to guide the pareto-optimization process. As output, the tool should produce a non-dominated set of at least 5 alignments that represent different compromises between the objectives.

**6. Support Batch Alignment of Multiple Files**

The alignment tool should support the alignment of a series of input files from a specified directory. The user should be able to specify a source and destination directory using command-line arguments. The software should work through each input in sequence and output the resulting alignments to the destination directory.

**7. Indicate Progress in Aligning Sequences**

As the software may need to process a set of sequences for multiple seconds at a time, the software should display a clear indicator of how much progress has been made on the current alignment. For example, the program could present a progress bar using ASCII characters.

## Scope

This project will entail the development of software that performs the specialist task of Multiple Sequence Alignment (MSA). The alignment tool will be developed using an agile methodology and leverage metaheuristic algorithms to tackle the MSA problem. A series of experiments will be undertaken with the goal of improving each successive iteration of the software – to be released at intervals alongside details of its performance on benchmark testcases.

The project should conclude with a comparative case study, comparing the performance of developed tool against established alternatives such as MAFFT, Muscle and ClustalOmega.

Despite being a key feature of some sequence alignment packages such as ClustalX, the development of a rich graphical user interface (GUI) lies outside the scope of this project. Instead, emphasis is placed on producing high-quality alignments in a time-efficient manner.

While a number of studies have explored metaheuristic approaches for MSA, this project aims to address the underrepresentation of single-state methods in recent research. Further, the project offers opportunity to explore novel combinations of objective functions to guide the optimization process.

## Deliverables

What artefacts (hardware and/or software) or results will the project deliver? How will you decide whether the project has met its objectives? Be clear and specific.

Delete the red paragraphs and replace this one with your content (use the “Normal” paragraph style).

## Assumptions

This work is predicated on the assumption that the performance of alignment software as assessed via structural benchmarking is indicative of the tool's real-world performance at Multiple Sequence Alignment (MSA).

As described by Thompson et al. (2001), structural benchmarks are designed to offer a comprehensive evaluation for sequence alignment software. Today, their use is prevalent in the literature. In a review of 45 recent papers, structural benchmarking was found to be the most popular quality measure for MSA (Ibrahim et al., 2024).

# Project rationale and operation

## Project benefits

What benefits will a successful project bring, and to whom? Note that this is about the project’s content and purpose, not the fact that you are doing a project for your degree.

Delete the red paragraphs and replace this one with your content (use the “Normal” paragraph style).

## Project operation

How will you operate the project? Will you use a particular methodology for it and for any software or other development? How will you measure the success of your choice?

Delete the red paragraphs and replace this one with your content (use the “Normal” paragraph style).

## Options

What options are available to you for the tools, techniques and design parameters of your project? How will you evaluate them and make the best selection?

Delete the red paragraphs and replace this one with your content (use the “Normal” paragraph style).

## Risk analysis and mitigation

What risks might affect the outcome of your project or its stakeholders? How severe are they, and what steps will you take to mitigate against them? Present these as shown in the lectures.

Delete the red paragraphs and replace this one with your content (use the “Normal” paragraph style).

## Resources required

What special resources will you need for the project (you need not list standard software and hardware)? Are any non-standard? Are they already available? What effect will it have if they are not available or are delayed, and how would you manage that?

Delete the red paragraphs and replace this one with your content (use the “Normal” paragraph style).

## Ethical and legal considerations

Does conducting your project raise any ethical issues? You do not need to consider the ethical consequences of implementing it after your project is complete – that will be done in the Final Report – but you should consider any potential impact during the project. This is in addition to the ethical checklist assignment. You should also consider if there are likely to be any legal issues – are there laws you need to take account of (e.g. the GDPR or the Computer Misuse Act) and which might have an effect on your project?

Delete the red paragraphs and replace this one with your content (use the “Normal” paragraph style).

## Commercial considerations

What will your project cost to undertake? Could you market the end result? What would your potential market be, and who are the competitors? It may be that you have no intention of commercialising your work, but you should still consider the possibilities.

Delete the red paragraphs and replace this one with your content (use the “Normal” paragraph style).

# Project methodology and outcomes

## Initial project plan

## Tasks and milestones

Present a realistic task list for the entire project, broken down to a suitable level of detail. Indicate milestones against which progress can be monitored. Make sure you include all the deliverables you mentioned earlier.

Delete the red paragraphs and replace this one with your content (use the “Normal” paragraph style).

## Schedule Gantt chart

Present a Gantt chart showing a schedule for all tasks, milestones and deliverables. Show dependencies amongst tasks. If you are intending to use SCRUM or other agile methods, be sure to go to the lectures involving project planning. Your time plan should cover the entire period of your project (and will therefore include the PDD preparation as a task and the PDD itself as a deliverable). Gantt charts work better in landscape format, so rotate yours or add a landscape format section to the document. Don’t be tempted to simply paste a wide image into a page. It needs to be readable if printed out at normal size.

Delete the red paragraphs and replace this one with your content (use the “Normal” paragraph style).

## Project control

How will you manage the project day-to-day? How will its performance be monitored? How will you judge if it has been successful?

Delete the red paragraphs and replace this one with your content (use the “Normal” paragraph style).

## Project evaluation

How will you evaluate the project’s artefacts and overall outcomes? What user evaluation will you do? Do not underestimate the importance of this, and include clear details of how you will do the evaluation. Remember that if you intend to test your outputs on people, you must declare this in your ethics review.

Delete the red paragraphs and replace this one with your content (use the “Normal” paragraph style).

# References

List any sources you have used for your background and introduction here. Make sure you use the proper referencing format.

Delete the red paragraphs and replace this one with your content (use the “Normal” paragraph style).

# Appendix a

You may use one or more appendices (label them “Appendix a” “Appendix b” and so on), to add useful reference information which may be relevant to other sections of the report. Do not use appendices simply as a way of writing more than will fit into the main document word count. If you don't need any appendices, then delete this whole section

Delete the red paragraphs and replace this one with your content (use the “Normal” paragraph style).