IMPERIAL

IMPERIAL COLLEGE LONDON

DEPARTMENT OF MATHEMATICS

SECOND-YEAR GROUP RESEARCH PROJECT

Title

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Supervisor(s):
Name of supervisor(s)

May 28, 2024

Abstract

Type your abstract here. The abstract is a summary of the contents of the project. It should be brief but informative, and should avoid technicalities as far as possible.

Contents

1 Introduction

The introduction should attempt to set your work in the context of other work done in the field. It should demonstrate that you are aware of what you are doing, and how it relates to other work (with references). It should also provide an overview of the contents of the project. You should highlight your individual contributions and any novel result: which of the calculations, theorems, examples, proofs, conjectures, codes etc. are your own?

2 Examples

Here is a section with a few useful examples.

Here is some filler text to show you what a few pages may look like. Nam dui ligula, fringilla a, euismod sodales, sollicitudin vel, wisi. Morbi auctor lorem non justo. Nam lacus libero, pretium at, lobortis vitae, ultricies et, tellus. Donec aliquet, tortor sed accumsan bibendum, erat ligula aliquet magna, vitae ornare odio metus a mi. Morbi ac orci et nisl hendrerit mollis. Suspendisse ut massa. Cras nec ante. Pellentesque a nulla. Cum sociis natoque penatibus et magnis dis parturient montes, nascetur ridiculus mus. Aliquam tincidunt urna. Nulla ullamcorper vestibulum turpis. Pellentesque cursus luctus mauris.

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Figure 1 This is an example of how you include a figure with a descriptive caption. This is an image of the South Kensington campus of Imperial College London on which we can recognize Queen's tower.

Module		
Module code	Module name	Number of students
	per gram	13.65
	each	0.01
Gnu	stuffed	92.50
Emu	stuffed	33.33
Armadillo	frozen	8.99

Table 1 Example booktabs table. Booktabs tables are nicer than regular ones. This site has a nice GUI for making LaTeX tables, and has a Booktabs option: https://www.tablesgenerator.com/

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risus porta vehicula. **This is how you would reference a table:** Table 1.

2.1 Section Example

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2.1.1 Subsection Example

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Note that you can reference chapters, sections, subsections and subsubsections. For example: Subsection 2.1.1!

2.2 Math Example

While math can be written inline like so $f(x) = \sum_{n=0}^{\infty} \frac{x^n}{n!}$, we often need to write stand-alone equations like so

$$\text{score}(x) = \left(\lambda_m \sum_{i=0}^{|\mathbf{m}|} \log \hat{p}_m(d(x, \mathbf{m}_i) \mid l_i) \right) + \left(\lambda_l \sum_{i=0}^{|\mathbf{l}|} \log \hat{p}_l(d(x, \mathbf{l}_i) \mid \mathbf{v}_i) \right) + \lambda_p \hat{p}_p(x) \tag{1}$$

To write equations over multiple lines (like systems of equation or equations too long to fit the page), one can use the *align* environment coupled to the *subequations* environment like so

$$\mathbb{P}(0 \rightsquigarrow -a) = D \int_0^{\infty} dt\, k_r e^{-k_r t} \int_0^t d\tau\, \partial_x u \big|_{x=-a}, \tag{2a}$$

$$\mathbb{P}(0 \rightsquigarrow b) = -D \int_0^{\infty} dt\, k_r e^{-k_r t} \int_0^t d\tau\, \partial_x u \big|_{x=b}. \tag{2b}$$

2.3 Theorem and Proofs

This section is directly taken from Overleaf. Please do consult the webpage for more information and discuss with your supervisors.

Theorems can easily be defined:

Theorem 2.1. *Let f be a function whose derivative exists in every point, then f is a continuous function.*

Theorem 2.2 (Pythagorean theorem)**.** *This is a theorem about right triangles and can be summarised in the next equation*

$$x^2 + y^2 = z^2$$

And a consequence of theorem 2.2 is the statement in the next corollary.

Corollary 2.2.1. *There's no right rectangle whose sides measure 3cm, 4cm, and 6cm.*

You can reference theorems such as 2.2 when a label is assigned.

Lemma 2.3. *Given two line segments whose lengths are a and b respectively there is a real number r such that $b = ra$.*

As you can see, theorems, corollaries and lemmas are italicised. Often, definitions are not:

Definition 2.1 (Fibration)**.** A fibration is a mapping between two topological spaces that has the homotopy lifting property for every space X.

This can be changed using the `\theoremstyle{}` command in the preamble.

It can be useful to have an unnumbered theorem-like environment to add remarks, comments or examples to a mathematical document. Here, you can do so by using the following environment:

Remark. This statement is true, I guess.

Finally here is an example of proof:

Lemma 2.4. *Given two line segments whose lengths are a and b respectively there is a real number r such that $b = ra$.*

Proof. To prove it by contradiction try and assume that the statement is false, proceed from there and at some point you will arrive to a contradiction. □

2.4 Algorithm Example

See Algorithm 1

2.5 Reference Example

Here is how you can cite papers which you have added in the `/bibs/bibliography.bib` file. You can cite single references as such [1] or multiple references like so [1, 2]. Here is a reference to a website [3].

Algorithm 1: Algorithm example

Input: $\mathbf{m}$, such that $\mathbf{m}_i$ is the position of the i'th monitor
$\mathbf{l}$, such that $\mathbf{l}_i$ is the position of the i'th landmark
$\mathbf{p}^m$, such that $\mathbf{p}^m_i$ is the ping latency from monitor i to the target
$\mathbf{p}^l$, such that $\mathbf{p}^l_i$ is the set of ping latencies to landmark i

Pre: Compute $\hat{p}_m(d \mid l)$, an estimator giving the likelihood of the target being distance d away from the monitor, given that the monitor records a latency of l to that target. Implemented by training a KDE using $\mathbf{p}^l$.
Compute $\hat{p}_l(d \mid v)$, an estimator giving the likelihood of the target being distance d away from the landmark, given a Canberra distance of v between the target and the landmark, using training targets.

Output: Most likely location of the target

Function *Likelihood(*x*,* $\mathbf{v}$*)*
  MonitorScore $\leftarrow \sum_{i=0}^{|\mathbf{m}|} \log \hat{p}_m(d(x, \mathbf{m}_i) \mid l_i)$;
  LandmarkScore $\leftarrow \sum_{i=0}^{|\mathbf{l}|} \log \hat{p}_l(d(x, \mathbf{l}_i) \mid \mathbf{v}_i)$;
  return MonitorScore + LandmarkScore
end
$\mathbf{v} \leftarrow \{\text{canberra\_distance}(\mathbf{l}_i, \mathbf{p}^m) \mid \mathbf{l}_i \in \mathbf{l}\}$
$\mathbf{C} \leftarrow$ Constraint-Based-Geolocation($\mathbf{m}$, $\mathbf{p}^m$);
$\mathbf{C_l} \leftarrow \{m \in \mathbf{m} \mid \mathbf{C} \text{ contains } m\} \cup \{l \in \mathbf{l} \mid \mathbf{C} \text{ contains } l\}$;
return argmax$_{x \in \mathbf{C_l}}$ Likelihood(x)

3 Background

4 Methods

5 Results

6 Discussion

7 Conclusion

The conclusion section is required but the previous sections (background, methods, results and discussion) are just examples of sections which may be useful.

Acknowledgments

Comment this out if not needed.

A First appendix

B Second appendix

References

[1] A. Einstein. Zur Elektrodynamik bewegter Körper. *Annalen der Physik*, 322(10):891–921, 1905.

[2] P. A. M. Dirac. *The Principles of Quantum Mechanics*. International series of monographs on physics. Clarendon Press, 1981.

[3] Wikipedia Contributors. Riemann hypothesis — Wikipedia, the free encyclopedia. https://en.wikipedia.org/wiki/Riemann_hypothesis, 2024. [Online; accessed 01-February-2024].