Uppsala Universitet

Master Thesis

Single Cell learning in Paramecium

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A thesis submitted in fulfillment of the requirements for the degree of Master of Science

in the

Department of Immunology, Genetics & Pathology

UPPSALA
UNIVERSITET

26th of August 2024

Declaration of Authorship

I, Kian Esfandiari, declare that this thesis titled, Single Cell learning in Parameciumand the work presented in it are my own. I confirm that:

- This work was done wholly or mainly while in candidature for a research degree at this University.
- Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated.
- Where I have consulted the published work of others, this is always clearly attributed.
- Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work.
- I have acknowledged all main sources of help.
- Where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself.

Signed:

Date:

"*Progress in science depends on new techniques, new discoveries and new ideas, probably in that order.*"

Sydney Brenner

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Abstract

Fürth lab

Department of Immunology, Genetics & Pathology

Master of Science

Single Cell learning in Paramecium

by Kian Esfandiari

This is the abstract

Acknowledgements

Integer id risus vel lorem laoreet commodo lobortis quis purus. Cras cursus leo vel dui laoreet pulvinar. Nunc tincidunt metus et ante fermentum lacinia. Proin quam magna, tristique ut viverra at, dapibus eget elit. Quisque eu leo id nisi semper laoreet at ac nulla. Fusce volutpat, metus sed dictum mattis, nisl elit dapibus velit, non porttitor urna urna vel diam. Praesent tortor nulla, rutrum ac magna a, tempor sagittis enim. Praesent pharetra ipsum libero, eu malesuada libero blandit ut. Sed sed venenatis ligula, nec convallis turpis. Nulla iaculis felis eros, eget pharetra lorem cursus quis. Nunc iaculis lobortis magna at malesuada. Nullam elementum elit at urna congue aliquam.

Table of contents

List of Figures

List of Tables

List of Abbreviations

LAH **L**ist **A**bbreviations **H**ere
WSF **W**hat (it) **S**tands **F**or

List of Symbols

a	distance	m
P	power	W (J s^1)
ω	angular frequency	rad

For Elsa

Chapter 1

Introduction

1.1 Main Section 1

![**CuAAC syntesväg.** schematisk figur som visar hur 3'ändan av en oligonukleotid märks in med en fluorophore. **a)** Panel a visar detta. **b)** Panel B visar detta.]

Vi jämförde två grupper. Den första gruppen, X, hade större längd (M = 29.58 cm, SD = 8.65 cm) än den andra gruppen Y (M = 6.25 cm, SD = 10.52 cm). Denna skillnad var också statistiskt säkerställd (t = 17.12, df 190.87= , $P < 10^{-4}$).

1.2 Cell densitet

Vi jämförde cell densitet.

Det var signifikant skillnad mellan 0.125 och 0.25 filution (t = -2.95, df 4.19= , P = 0.04), men inte mellan 0.125 och 0.0625 (t = 1.35, df 4.06= , P = 0.25)

1.3 Welcome and Thank You

Welcome to this LaTeX Thesis Template, using the LaTeX typesetting system and Quarto and based on the LaTeX thesis template MastersDoctoralThesis version 2.0 downloaded from LaTeXTemplates. This LaTeX document class was authored by Vel (vel@latextemplates.com) and Johannes Böttcher based on a style file by Steve R. Gunn from the University of Southampton (UK), department of Electronics and Computer Science.

Det har visat sig i literaturen att formamid påverkar smälttemperaturen (Tm) av oligonukleotider (Blake and Delcourt 1996; Fuchs et al. 2010).

1.4 A Short Math Guide for LaTeX

If you are writing a technical or mathematical thesis, then you may want to read the document by the AMS (American Mathematical Society) called, `A Short Math Guide for \LaTeX{}". It can be found online at [AMS](http://www.ams.org/tex/amslatex.html under the`Additional Documentation" section towards the bottom of the page.

1.4.1 Common LaTeX Math Symbols

There are a multitude of mathematical symbols available for LaTeX and it would take a great effort to learn the commands for them all. The most common ones you are likely to use are shown on this page.

You can use this page as a reference or crib sheet, the symbols are rendered as large, high quality images so you can quickly find the LaTeX command for the symbol you need.

1.5 About this Template

This LaTeX Thesis Template is originally based and created around a LaTeX style file created by Steve R. Gunn from the University of Southampton (UK), department of Electronics and Computer Science. You can find his original thesis style file at his site, here: http://www.ecs.soton.ac.uk/~srg/softwaretools/document/templates/.

Steve's `ecsthesis.cls` was then taken by Sunil Patel who modified it by creating a skeleton framework and folder structure to place the thesis files in. The resulting template can be found on Sunil's site here: http://www.sunilpatel.co.uk/thesis-template.

Sunil's template was made available through LaTeXTemplates where it was modified many times based on user requests and questions. Version 2.0 and onwards of this template represents a major modification to Sunil's template and is, in fact, hardly recognisable. The work to make version 2.0 possible was carried out by Vel (vel@latextemplates.com) and Johannes Böttcher.

1.6 What this Template Includes

1.6.1 Folders

- Appendices – this is the folder where you put the appendices. Each appendix should go into its own separate qmd file. An example and template are included in the directory.
- Chapters – this is the folder where you put the thesis chapters. Each chapter should go in its own separate qmd file.
- Figures – this folder contains static figures for the thesis, i.e. figures that are not generated by code in the chapters.

1.6.2 Files

- example.bib – this is file that contains all the bibliographic information and references that you will be citing in the thesis for use with BibTeX. You can write it manually, but there are reference manager programs available that will create and manage it for you. Zotero is popular and integrates with RStudio IDE if you use that.
- MastersDoctoralThesis.cls – this is the class file that tells LaTeX how to format the thesis.
- pdf in docs folder – this is your typeset thesis.
- Frontmater folder – this has the files for the various front matter elements.

1.7 Bibliography and Citations

Citations will be added and formatted automatically for you.

If you use the RStudio IDE, then you can link Zotero to RStudio and Quarto will find your citations for you when you enter `@`. This is in the visual editor mode. Make sure to search for videos on how to do this as using Zotero libraries will make your citation and bibliography management much much easier.

In the text use `@smith2000` to produce Smith (2000) add use `[@smith2000, @jones1999]` to produce (Smith 2000; Jones 1999). See the natbib cheatsheet for how to do other types of formatting for your in text citations. The bibliography style (`classoption: "authoryear"`) is used for the bibliography and is a fully featured style that will even include links to where the referenced paper can be found online.

1.7.0.1 A Note on bibtex

The bibtex backend used in the template by default does not correctly handle unicode character encoding (i.e. "international" characters). You may see a warning about this in the compilation log and, if your references contain unicode characters, they may not show up correctly or at all. One solution to this is to use the biber backend instead of the outdated bibtex backend. This is done by finding this in `tex/in-header.tex`: `backend=bibtex` and changing it to `backend=biber`. Google a bit to find information on this.

See the Quarto manual for full examples and instructions.

1.7.1 Typesetting mathematics

If your thesis is going to contain heavy mathematical content, LaTeX will make it look beautiful, for HTML or PDF output.

The Not So Short Introduction to LaTeX should tell you everything you need to know for most cases of typesetting mathematics. If you need more information, a much more thorough mathematical guide is available from the AMS called, A Short Math Guide to LaTeX.

1.8 In Closing

Good luck and have lots of fun!

This guide was written originally by

Sunil Patel: http://www.sunilpatel.co.uk}{www.sunilpatel.co.uk

and Vel: http://www.LaTeXTemplates.com

and heavily shortened and adapted for Quarto by Eli Holmes.

Chapter 2

Method

2.1 Main Section 1

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$$\int_{A_i} \lambda(\boldsymbol{\mu}) \tag{2.1}$$

$$\int_{A_i} \lambda(\mathbf{x}) \tag{2.2}$$

2.1.1 Subsection 1

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2.1.2 Subsection 2

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2.2 Main Section 2

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Chapter 3

Results

3.1 Main Section 1

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$$\int_{A_i} \lambda(\boldsymbol{\mu}) \tag{3.1}$$

$$\int_{A_i} \lambda(\mathbf{x}) \tag{3.2}$$

3.1.1 Subsection 1

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3.1.2 Subsection 2

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3.2 Main Section 2

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pellentesque justo a massa fringilla non vestibulum metus vestibulum. Vestibulum in orci quis felis tempor lacinia. Vivamus ornare ultrices facilisis. Ut hendrerit volutpat vulputate. Morbi condimentum venenatis augue, id porta ipsum vulputate in. Curabitur luctus tempus justo. Vestibulum risus lectus, adipiscing nec condimentum quis, condimentum nec nisl. Aliquam dictum sagittis velit sed iaculis. Morbi tristique augue sit amet nulla pulvinar id facilisis ligula mollis. Nam elit libero, tincidunt ut aliquam at, molestie in quam. Aenean rhoncus vehicula hendrerit.

Chapter 4

Discussion

4.1 Main Section 1

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$$\int_{A_i} \lambda(\boldsymbol{\mu}) \tag{4.1}$$

$$\int_{A_i} \lambda(\mathbf{x}) \tag{4.2}$$

4.1.1 Subsection 1

Nunc posuere quam at lectus tristique eu ultrices augue venenatis. Vestibulum ante ipsum primis in faucibus orci luctus et ultrices posuere cubilia Curae; Aliquam erat volutpat. Vivamus sodales tortor eget quam adipiscing in vulputate ante ullamcorper. Sed eros ante, lacinia et sollicitudin et, aliquam sit amet augue. In hac habitasse platea dictumst.

4.1.2 Subsection 2

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4.2 Main Section 2

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Appendix A

Arduino Shield PCB layout

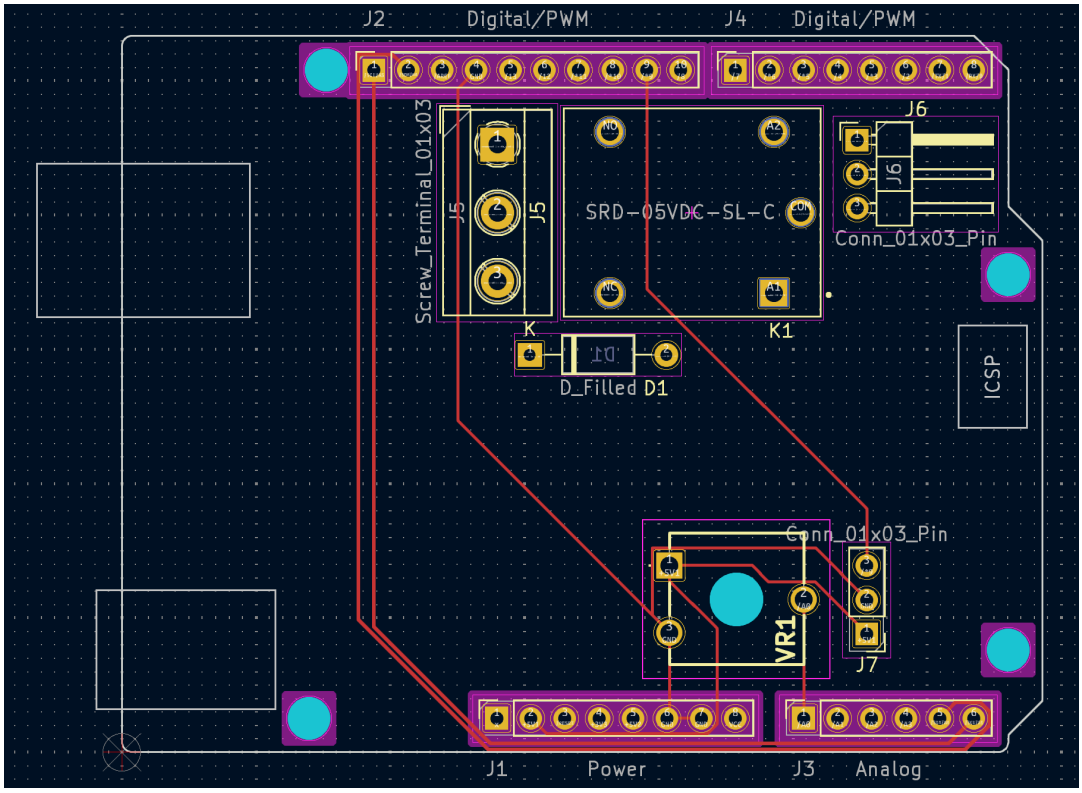

FIGURE A.1: **PCB layout in KiCad.** a figure of the PCB layout for the arduino shield made in KiCad.

Appendix B

Cell counting software

B.1 Automatic cell counting

B.2 Manual cell counting

References

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