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B A C H E L O R ' S T H E S I S

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Eidesstattliche Erklärung

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Contents

1	Introduction	1
2	T-Cells, Calcium Concentration	3
2.1	Components of a T-Cell	3
2.2	Activation	3
3	Data	5
3.1	Structure of Data	5
3.2	How it was generated	5
3.2.1	Measuring Calcium Concentration	5
3.2.2	Processing	6
4	Optimization Algorithm	7
4.1	Algorithm Name	7
5	Results	9
6	Conclusion	11

1 Introduction

2 T-Cells, Calcium Concentration

Lymphocytes form a key component of the immune system. T cells are one type of lymphocyte and are responsible for responding to pathogens, allergens and tumors. Different subtypes of t cells exist, that fulfill various responsibilities. They are transported throughout the body via the lymphatic system and blood.[Kumar2018]

Precursor cells are formed in the bone marrow. Once they are transported to the thymus they undergo maturation and selection to become t cells. Each cell forms receptors, called t cell receptors (TCR), that respond to one particular out of many ($10^6 - 10^9$) possible short pieces of proteins, called peptides. These peptides are attached to the major histocompatibility complex (MHC) present on antigens and antigen presenting cells (APC). Important aspects of the selection are ensuring that the t cells react to foreign MHCs, but not to those present on the body's own cells.[Ashby2024]

In positive selection cells in the thymus present peptides on their MHC. If a t cell is unable to bind, it will undergo apoptosis, a type of cell death. T cells which were able to bind receive survival signals. Negative selection verifies that t cells will not attack the body's own cells. This is done by only selecting t cells which only bind moderately to the peptides presented, as a strong bond suggests that these t cells would have a high likelihood of being reactive to own cells.[Hagel2018] If a t cell passed both the positive and negative selection it is transported to the periphery.

There are multiple types of peripheral t cells. Native t cells respond to new antigens. Cytotoxic t cells kill cells with a MHC compatible with their TCR. Helper T cells activate other parts of the immune response. Memory t cells shorten the reaction time when the same antigen is encountered again at a later point in time. Suppressor t cells moderate the immune response.[Ganong1997]

2.1 Components of a T-Cell

calcium storage, membrane, APC docking point

2.2 Activation

When a native t cell encounters an APC that is compatible, a bond is formed between the TCR on the t cell and the peptide-MHC complex on the APC. This recognition can be triggered by less than ten molecules of foreign substance and is therefore described as near perfect. Sufficiently long contact is necessary between the APC and the t cell in order for the t cell to activate. The role of contact time in t cell activation is modelled by Morgan et.al.[morgan2023].

Through Ca^{2+} signaling the t cell may be activated.

what does activation mean? how are the calcium levels affected?

3 Data

calcium concentration shows activatedness of t cells (reference chapter t cells), relatively easy to measure

3.1 Structure of Data

what format is the data in? which columns are present + datatypes

Name	Data Type	Description
x	float64	Position of cell in pixels along the horizontal axis
y	float64	Position of cell in pixels along the vertical axis
frame	int32	Number of frame, with frame rate of 1 frame per second
mass short	float64	Brightness of cell in 340nm channel
bg short	float64	Background in 340nm channel
mass long	float64	Brightness of cell in 380nm channel
bg long	float64	Background in 380nm channel
ratio	float64	Calculated as mass short divided by mass long
particle	int32	Identification for each particle

Table 3.1: Description and data type of all columns present in the data matrix.

3.2 How it was generated

experimental setup, what types of t cells where used?, apc layer, explain steps in experiment

- Date: 18/12/23
- Cells: Jurkat wt labelled with Fura-2
- Sample: PDMS coated with OKT3 (positive control)
- Imaging: SDT3, ratiometric Ca imaging, 340nm & 380 nm, Total cycle time 1000ms (-; 1 frame per sec in sum/ratio image)
- pixel size: 1.6 um / px

3.2.1 Measuring Calcium Concentration

how is the calcium concentration measured? different wavelengths and then ratio between them, show example video frame

3.2.2 Processing

tracking of particles (in sum of two images), numbering them, removing bad ones (too out of focus, too short)

4 Optimization Algorithm

objective, mathematical formulation of problem

4.1 Algorithm Name

algorithm description

pseudo code for algorithm

[proof of convergence, if applicable]

5 Results

6 Conclusion