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7CCSMPRJ

Individual Project Submission 2024 - 2025

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Degree Programme:	MSc. Advanced Computing
Project Title:	GluCORRECT - Harnessing Artificial Intelligence to scrutinize Hypoglycemia in hospitalised patients with diabetes to classify, anticipate and analyse hypoglycemic episodes [Knowledge Exchange Project with NHS England]
Supervisor:	Dr. Rita Borgo
Word Count:	==== Word count goes here ====

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Signature: Signature **Date:** August 1, 2025

Department of Informatics
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7CCSMPRJ Individual Project

GluCORRECT - Harnessing Artificial Intelligence to scrutinize Hypoglycemia in hospitalised patients with diabetes to classify, anticipate and analyse hypoglycemic episodes [Knowledge Exchange Project with NHS England]

Name: **Siddharth Kishor Samarth**
Student Number: K24012370
Course: MSc. Advanced Computing

Supervisor: Dr. Rita Borgo

This dissertation is submitted for the degree of MSc Advanced Computing.

Acknowledgements

I would like to express my sincerest gratitude towards my project supervisor, Dr. Rita Borgo, for her invaluable advice and consistent direction throughout the course of this project. Her mentorship and ideas have been instrumental in shaping the development of this work, leading to its successful completion.

I am also deeply thankful & appreciative of my industry advisor, Dr. Piya Sen Gupta, for providing the dataset that has served as the foundation of this work. Her contributions have significantly enhanced the practical relevance and quality of this project.

Ultimately I would like to thank my friends and my parents, especially my dad, without whose sacrifices I would not be where I am today.

The content of “Abstract” is in “\contents\abstract.tex”

Abstract

Project Variant: Variant 4 - Develop a weighted score and design score to predict risk of a hypoglycaemic episode before it occurs.

It is well known that hypoglycemia as well as hyperglycemia are common adverse events in patients who are on blood sugar control medication, and they are also one of the most frequently cited causes of hospital admissions in people with diabetes. National quality improvement programmes from the Healthcare Quality Improvement Partnership (HQIP) and reviews of ambulance call-outs have shown that ***lack of awareness*** by both patients and their attendants is associated with a dramatically increased rate of complications, amongst other factors. Guy's and St. Thomas' NHS Foundation Trust (GSTT) have found, after departmental investigation, that hypoglycemic episodes (also called "hypos")

This analytical study serves as a foundation and proof-of-concept to aid GSTT in pre-emptively reducing hypoglycemia and its episodes within hospitalised patients, by utilising statistics & machine learning techniques. I go on to identify the significant factors responsible for hypoglycemia within the dataset provided, and explore how they can be utilized to devise a risk score, to classify patients based on their risk of hypoglycemia, and in conclusion, exhibit my findings with potential ways of applying them in practise in hospitals.

All abbreviations and symbols used in the report must be listed and defined in alphabetic order.

Nomenclature

GSTT	Guy's and St Thomas' NHS Foundation Trust
HQIP	Healthcare Quality Improvement Partnership
"Hypo" or "Hypos"	Hypoglycemic episode(s)
"Inpatient"	Referring to the the fact that a patient is required to stay overnight in order to be treated (in case of surgeries or long term care / observation for example)
NCAPOP	National Clincal Audit & Patient Outcomes Programme
NDA	National Database Audit
NDISA	National Diabetes Inpatient Safety Audit
NHS	The publicly funded healthcare system of the United Kingdom, the National Health Service.

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a	The number of angels per unit area
A	The area of the needle point
c	Speed of light in a vacuum inertial frame
h	Planck constant
LMI	Linear Matrix Inequalities
N	The number of angels per needle point

Contents

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List of Tables

1 Introduction

Hypoglycemia is a condition that occurs when the human body's blood glucose (sugar) level drops below the normal healthy range of 4.0 to 6.0 mmol/L. For the purposes of this project, severe hypoglycemia has been defined as a blood glucose of 2.2 mmol/L or lower. With glucose being the body's main source of energy, hypoglycemia is a concern as it can disturb brain and bodily functions.

Hypoglycemia is common in diabetics, especially those taking insulin, but it can occur in non-diabetics as well. Symptoms are rapid and successive, including feeling dizzy or sweating, shaking, feeling tired or weak and disorientated, unable to find one's bearing.

What is especially significant though, besides quick to appear symptoms, is that hypoglycemic episodes are dreadfully anxiety provoking, with practically every patient's main concern being if people around them would have the proper awareness of the necessary measures to take to resolve an episode should one occur. Even though remedial action is relatively simple (to provide the patient with sugary foods / liquids or solutions to restore blood glucose), it can lead to loss of consciousness & memory, seizures, cardiac arrhythmias and even death if not taken speedily.

Across GSTT, there are 0.5 million point of care glucose tests (POCT) carried out annually. GSTT possesses blood glucose / ketone data over the course of 1 year (Apr 2022-2023) with additional linked data including demographics, dates of admission and discharge, measurements including weight, blood pressure, HbA1c, renal function & POCT. There is another kind of record they use called an 'inpatient record', and it was identified that the inpatient record misses approximately 10% of glucose data due to operator error, as compared to the POCT glucose feed which contains more data. We would like to resolve this, while also analysing the available data in order to assist GSTT in detecting blood sugar related conditions, making measureable improvements to diabetic healthcare.

As evidenced by the National Diabetes Inpatient Safety Audit (NDISA) [insert reference], it has been recognized that severe hypoglycemia (blood glucose levels 2.2mmol/l) and recurrent severe hypoglycemia have been occurring relatively frequently at Guy's and St. Thomas Hospitals (here onwards referred to as GSTT). The NDISA forms part of the National Database Audit (NDA), and it maintains that "The prevalence of diabetes continues to increase. In England between 2017-18 and 2021-22 prevalence of type 1 diabetes went up from 248,240 to 270,935 and the prevalence of type 2 and other diabetes from 2,952,695 to 3,336,980", as of 2022.

1.1 Aims and Objectives

1.1.1 Dissertation Length

The dissertation should be less than 15000 words.

1.1.1.1 Dissertation Length 2

Refer to KEATS for suggested structure

1.1.1.1.1 More subsections

1.2 Background and Literature Survey

It gives an overall picture about the work with a clear review of the relevant literature. The background of the project should be given. What have been done to deal with the problem should be stated clearly. The pros and cons of various existing algorithms and approaches should be stated as well. Differences between your proposed method and the existing ones should be briefly described. It is important to make sure that the discussion is structured and coherent; the key issues are summarised; key and relevant references are used critically analysed and the literature is covered comprehensively.

The following links may help on literature review:

- **IEEE Xplore digital library** (http://ieeexplore.ieee.org/): a resource for accessing IEEE published scientific and technical publications (You must be with King's network to get access to the digital library)
- **ScienceDirect.com** (**ScienceDirect.com** http://scienceDirect.com): an electronic database offering journal papers not published by IEEE (You must be with King's network to get access to the database)

1.3 Insert More Sections if Necessary

The content of “Background” is in “\contents\background.tex”

2 Background theories & Literature Survey

Various kinds of different prediction models have already been devised and developed for predicting hypoglycemia. Yi Wu and others have systematically compared, and evaluated the applicability of models in clinical practice in a paper in Biological Research for Nursing[1] where it was found that the major predictors were age, HbA1c, history of hypoglycemia, and insulin use. Lin Yang, Zhiguang Zhou have carried out similar research in the Frontiers in Public Health journal[2] uncovering risk factors that could possibly lead to hypoglycemic events, after employing various data driven models based on ML techniques such as neural networks, autoregressive / ensemble learning and such.

In silico proof of concept studies like the one from Zecchin[3] have also been researched to investigate how continuous glucose monitoring short-term glucose prediction algorithms could be exploited to recognise the run up to hypoglycemic episodes, allowing the patient to take appropriate countermeasures to mitigate events. They found that there was a significant reduction in both the time spent in a hypoglycemic event as well as the number of hypoglycemic events.

As this is a Knowledge Exchange Project (KEP) with NHS England I have been provided a real world dataset from GSTT. Medical data is difficult to obtain, and it rarely fits a research objective without needing much modification.

The content of "Main results" is in "\contents\introduction.tex"

The chapter reports the contributions of your work. For example, it could contain the following sub-sections to summarise the contribution of the project such as Theoretical Development, Analysis and Design, Implementation and Experimental Work, Results, Observation and Discussion.

3 Objectives, Specification and Design

It recalls the objectives in a more detailed way to justify the development of a set of requirements and specifications, and identify a coherent set of issues to be addressed. It explains in detail the design and how the design can achieve the project aim (solve the problem).

4 Methodology and Implementation

It presents and justifies the methodology used to deal with the problem and describes in detail the implementation procedures. The background theory presented in the previous chapter can be recalled to support the proposed implementation. The originality, novelty and contribution are to be demonstrated with the discussion of the strengths and limitations.

5 Results, Analysis and Evaluation

It summarises the results obtained from the proposed design and methodology. The way to obtain the results should be described in detail. Analysis and evaluation have to be performed. Comparisons should be made. It should justifies if the project aims, objectives, requirements and specifications have been achieved.

6 Legal, Social, Ethical and Professional Issues

A chapter gives a reasoned discussion about legal, social ethical and professional issues within the context of your project problem. You should also demonstrate that you are aware of the Code of Conduct & Code of Good Practice issued by the British Computer Society (BSC) (`https://www.bcs.org/membership/become-a-member/bcs-code-of-conduct/`) for computer science project and Rule of Conduct issued by The Institution of Engineering and Technology (IET) (`https://www.theiet.org/about/governance/rules-of-conduct/`) for engineering project. You should have applied their principles, where appropriate, as you carried out your project. You could consider aspects like: the effects of your project on the public well-being, security, software trustworthiness and risks, Intellectual Property and related issues, etc.

7 Others

This section is for demonstration of equations, figures, tables, which is not required for the report.

7.1 Maths

$$\frac{\mathrm{d}S_t}{S_t} = r\mathrm{d}t + \sigma\mathrm{d}W_t, \qquad S_0 > 0, \tag{7.1}$$

The equation $\sigma = ma$ follows easily [1].

7.2 Glossary and acronyms

Latexlinuxs and other Unix operating systems are better then Windows because they support lvmformula out of the box [2].

A ref is missing here

7.3 Figures

Here is an example [3] of how to insert a picture:

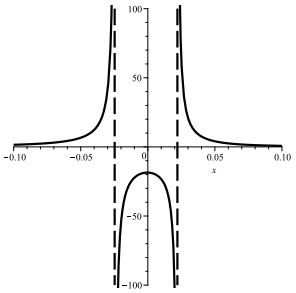

Figure 1: This is the caption for the figure.

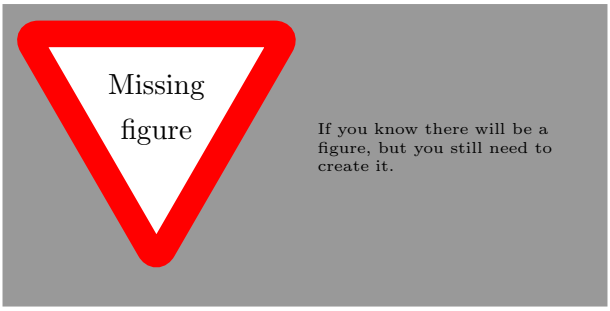

Figure 2: This is the caption for the figure which is not even present.

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or two side-by-side pictures:

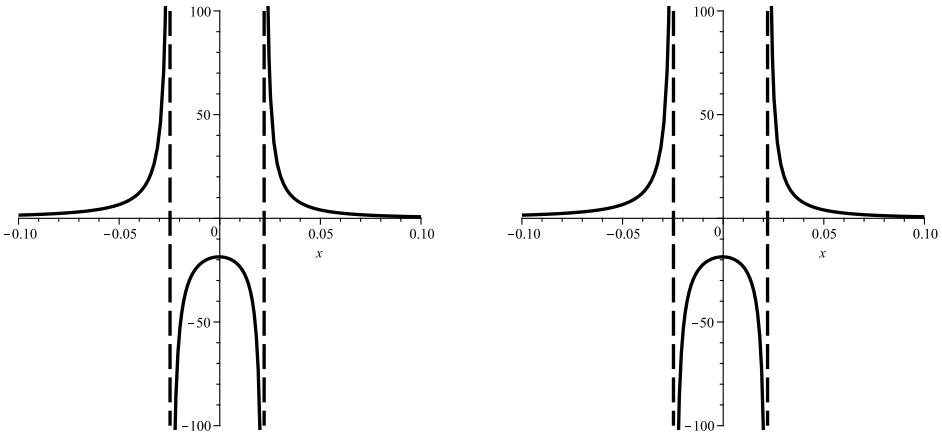

Figure 3: Another caption

7.4 Table

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This needs further explanation

Something	Someother	Thing
Seems	to be	good

Table 1: Random data for a table.

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8 More Others

8.1 What is calibration?

Here is an example of a matrix[4] in $A \in \mathcal{M}_n(\mathbb{R})$:

$$A = \begin{pmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & \vdots \\ a_{n1} & \dots & \dots & a_{1n}. \end{pmatrix}$$

8.2 Numerical methods for calibration

...

The content of “Conclusion” is in “\contents\conclusion.tex”

9 Conclusion

It is a chapter to sum up the main points and findings of the work; how you achieve the project aims and address the research questions; the contributions and results you have achieved. Future plan and development can be mentioned in this section as well. It is normally in one or two pages.

References

[1] J. Doe, *The Title*. PhD thesis, University of Mars, 2011.

[2] I. M. Johnstone, *Gaussian estimation: Sequence and multiresolution models*. Publisher, 2011.

[3] I. Johnstone and B. Silverman, "Ebayesthresh: R programs for empirical bayes thresholding," *Journal of Statistical Software*, vol. 12, no. 8, pp. 1–38, 2005.

[4] F. Inc., "Phage lambda: description & restriction map," November 2008.

The content of "Appendix" is in "\contents\app_1.tex"

A Appendix

Supplementary materials (such as source code, user menu, etc) could be included. Each appendix must be labelled (for example, Appendix A, Appendix A.1, Appendix A.2, Appendix B, Appendix B.1, etc.) and with heading. All Appendices must be referred in the text.

A.1 Points to Note

Please note the following points when you write your report:

- Consider the outline of the report. It is a good idea to start with the table of contents, which gives you an overall structure of the report.
- Show understanding of the topic and demonstrate the contribution of the work. 70% of the content of the report should be your own contributions and achievements.
- Always use your own words.
- The main report and any appendices must constitute one document.
- Pages must be numbered consecutively.
- Captions must be provided for all figures and tables.
- Equations (or important equations), figures and tables must be numbered.
- All figures and tables must be referred to in the text.
- Units of all variables must be provided.
- Numerical values (floating-point number) should be in 4 decimal places.
- Contractions should not be used.
- Check the punctuation of sentences. In particular, those sentences with equation. For example, if an equation is at the end of a sentence, a full stop should be used.
- All variables must be defined.
- Font face of variables throughout the report (in the text, equation, figures and table) must be consistent.
- Use proper headings for chapters, sections, subsections.

- Chapters, sections, subsections should be numbered and with the same numbering system throughout the report. It is suggested that vector and matrix variables should be in bold, scalar variables should be in italic.
- References must be used for materials used in the report that are not yours.
- A standard reference format must be adopted and be consistently applied through the report. General guidelines for reference format can be found on KEATS.
- Always backup your files.

B Review of stochastic calculus

B.1 Riemann integration

B.2 The Itô integral