DEVELOPING A PORTABLE BLOOD GLUCOSE METER USING RAMAN SPECTROSCOPY TECHNIQUE

by

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A Dissertation Submitted in Partial Fulfillment of the Requirements for the Degree of Doctor of Engineering in Data Science and Artificial Intelligence

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ABSTRACT

Self-monitoring of blood glucose (SMBG) is essential for diabetics to monitor their glycemia (the concentration of sugar or glucose in the blood). By measuring glycemia continuously, the treatment and patient lifestyle can be adjusted according to the report. The solution would be a wearable device that collects blood glucose continuously throughout the day. However, building a complete non-invasive one is challenging. Multiple techniques employing non-optical and optical methods have been studied. One technique that showing to be promising for this task is Raman Spectroscopy due to its low sensitivity to water and temperature, and great specificity. Fortunately, researchers have shown that glycemia can be measured by observing the light scattering such as the Raman Spectroscopy technique. With this method, it is possible to develop portable blood glucose meter equipment that is not only non-invasive but also a continuous method. Our portable equipment has an accuracy comparable to the clinical glucose meter of choice with an error of less than $\pm$ 0.83 mmol/L. The portable aspect enables continuous sampling throughout the day. With our equipment, continuous non-invasive SMBG is possible. Not only this will help to improve the treatment plan for diabetics but also enables individuals to monitor their glycemia which in turn may improve their diet selection.

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CHAPTER 1
INTRODUCTION

1.1 Background of the Study

Diabetes is now in the top three leading causes of death and disability in the United States (*About Chronic Diseases | CDC*, 2022). *Diabetes* (2022) states that there are 422 million people who are affected by diabetes throughout the globe. This number has been rising for the past three decades and there is a global agreement to stop this trend by 2025. Although there is no cure for this condition, controlling glycemic can help the patient to live 5 to 8 years longer (Vashist, Zheng, Al-Rubeaan, Luong, & Sheu, 2011).

1.2 Statement of the Problem

However, today glucose meter requires a blood sample to be drawn by pricking the patient's finger (Pratley et al., 2018). This invasive method causes both pain and risk of infection to the patients. Therefore, glycemic is not measured as often as recommended (Enter & von Hauff, 2018; Jintao, Liming, Yufei, Chunyan, & Han, 2017; Reach, 2008). Therefore, we want to have a non-invasive self-monitoring blood glucose (SMBG) method which will enable continuous measurement.

A recent study has shown that Raman Spectroscopy is a viable technique to measure glycemic. By selecting the measuring site and employing the machine learning technique, the root-mean-square error (RMSE) can be as low as 0.26601 mmol/L (Li et al., 2019). As a result, Raman Spectroscopy is selected as a measuring technique.

1.3 Objectives

Our objective is to develop a portable self-monitoring blood glucose meter. To achieve this, we separate the project into three studies.

Study 1: Confirm the parameters

1. Reproduce the Introduce your main objective first in one sentence, followed by a bulleted list of specific objectives, left aligned. 1. Follow a 0.5-inch Tab setting. 2. Add more here.

1.4 Organization of the Study

Start your paragraph here.

CHAPTER 2
TITLE

Write your introductory paragraph/s to give an overview of the chapter (except for Chapter 1). Limit this section to two paragraphs. Follow the appropriate structure of writing paragraphs. Paragraphs should have at least four sentences (8 lines). Paragraphs with more than 6 sentences (12 lines) must be split into two paragraphs. Maintain one blank line between paragraphs.

2.1 Heading, Level 2

This section presents some guidelines on how to create and format tables and figures following the APA Style with some examples. Every table and figure should serve a purpose. A table or figure can be referred to in the text by its number [e.g., As shown in Table 2.1…, as can be seen in the results of the testing (see Figure 2.1)]. Avoid writing "the table above" or "the figure below" as the position of a figure or table might change during the writing process.

Tables and figures can be generated in different ways using many programs. Table 2.1 presents the format of a table following the APA style. Align all tables and figures with the left margin and place a table or figure after a paragraph where it is first mentioned. Separate the paragraph and the table or figure title by a double-spaced blank line. Titles should be brief, clear, and explanatory.

Repeat the column headings on the second page of the table (see Table 2.1). Separate

Figure 2.1

Doge.

Note. Additional notes goes here.

this paragraph from the table by a double-spaced line. Tables and figures can be placed at the start or end of a page. Fit the table or figure between the margins and in one page.

As there is very little space left for the table on this page, present the table on the next page. You can add more content in this section. The description should be as close to the table or figure as possible. (There should be one blank double-spaced line between the last line of the paragraph and the table or figure number, and between the table / figure number and the title.)

You can cite stuff in references.bib like this (Author, 2024). y is as follows.

$$y = mx + b \tag{2.1}$$

2.2 Heading, Level 2

Add a short introductory sentence/s here.

2.2.1 Heading, Level 3

Start your paragraph here. Table 2.2 presents a sample of a qualitative table with variable descriptions. Separate the paragraph and the table or figure title by a double-spaced blank line. Titles should be brief, clear, and explanatory. Check the Language Center website for more examples.

2.2.2 Heading, Level 3

(1 space between the last line of this section and the next Level 2 heading)

2.3 Heading, Level 2

As for figures, the figure title should also be written in italics below the figure number (in bold) separated by a double-spaced blank line as shown in Figure 2.1. The size and density of the elements in a figure must be considered when deciding on the font size and spacing. Continue with the paragraph here.

Continue with the paragraph here. The table or figure should be as close to the description as possible or when it is first mentioned. Fit the tables and figures between the margins. (There should be one blank double-spaced line between the previous paragraph and the figure number, and between the figure number and the title.)

Table 2.1

An example table in latex.

Methods	Metric
Method A	153.3
Method B	2.4

Note. Add notes here.

CHAPTER 3

METHODOLOGY

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