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Closed-Loop Control of Blood Glucose

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To Jehovah God, my parents and siblings
Frederick

To my wife Yasmin and two daughters Melissa and Rochelle
Tyrone

Preface

Diabetes is a disease that is now regarded an epidemic in the world and a significant effort is directed towards finding better ways to manage diabetes. Keeping blood glucose levels as close to normal as possible, leads to a substantial decrease in long term complications of diabetes and can bring significant cost reductions associated with the disease. Traditionally, managing diabetes has been through intermittent monitoring of blood glucose and then administering an appropriate dose of insulin into the blood stream. This method of intermittent monitoring and administration of insulin cannot ensure blood glucose remains at near normal levels at all times and therefore, there is considerable interest in managing diabetes on a continuous basis.

The development of artificial organs/apparatus that regulate human's blood glucose level has been in progress since 1960. The aim was to measure blood glucose level ex vivo and then injecting an appropriate amount of insulin to the hyperglycaemic patient, thereby correcting the high glucose level. This aim of closing the "loop" is still being challenged by technological barriers even today, and progress are being made constantly both in overcoming the challenges and understanding more about the workings of glucose-regulatory system.

The purpose of this book is to introduce the field of closed-loop blood glucose control, in a simple manner, to the reader. This includes the hardware and software components that make up the control system (see Chapter 2). The hardware components involved the different types of glucose sensor (invasive, minimally-invasive and non-invasive) and the different types of insulin. The software component represents the approaches that translate a given blood glucose reading to an appropriate insulin rate (see Chapter 4). Some of these approaches applied mathematical sciences to model the underlying system and formulate mathematical solutions. Examples of how mathematical models are formulated as well as the control algorithms that stem from mathematical exercises are given, where possible.

This book also attempts to describe, from functional level, the basic physiology of blood glucose regulation during fasting and meal (see Chapter 3). The physiological changes in diabetic and critically ill patients are also described.

This would help in understanding the nature of the glucose-regulatory problem that we are facing and tackling. Finally, an example design of a closed-loop hardware using commercially-available equipment is given (see Chapter 5).

The ultimate goal in closed-loop control of blood glucose is not just finding the optimal insulin rates that can effectively reduce the high blood glucose, but to infuse it in such a way that the blood glucose level can mimic the body's natural excursion.

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