

Research on the Portable Biochemistry Blood Glucose Monitoring and Control System for Diabetics

林建銘、陳俊達

E-mail: 9224491@mail.dyu.edu.tw

ABSTRACT

- vi - Recently, many professions have studied much about Diabetes Mellitus. The experiments showed us that the Diabetes Mellitus could control well by blood glucose which can avoid some diseases such as Diabetic retinopathy, Kidney failure and Diabetic neuropathy. The central idea of the dissertation applied to design the construction between controller and observer in terms of Separation Principle. And the theoretical core will basic on H (Full-Information). The purpose is to deal with various and complicated physical situation and situation of body cause from outside environment. Then, the observer used to estimation the unmeasurable Insulin. Finally, the constitution of biochemistry blood glucose monitoring and control system is necessary for this we can discuss about reasons of the phenomenon of pathology and result from experiment. In addition, we can estimate the practice of experiments. All the system hopes to supply more comfortable, safely, simple methods to control blood glucose for Diabetic.

Keywords : Diabetes Mellitus, Separation Principle, H Full-Information, uncertain, disturbance, observer

Table of Contents

目錄 封面內頁 簽名頁 授權書.....	iii	中文摘要.....	iii
.....v 英文摘要.....	vi	誌謝.....	vi
.....vii 目錄.....	viii	圖目錄.....	viii
.....x 表目錄.....	xi	符號說明.....	xi
.....xii 第一章 緒論.....	1		
1.1 前言.....	1	1.1.1 糖尿病介紹.....	2
研究動機與目的.....	3	1.3 文獻回顧.....	4
文綱要.....	5	第二章 胰島素與血糖反應之數學模型.....	7
數學模型介紹.....	7	2.2 數學模型之模擬分析.....	12
模擬分析之結果與討論.....	12	2.2.1 模擬分析之結果與討論.....	12
第三章 理論分析與模擬.....	21	3.1 全訊息控制器.....	21
3.1.1 控制器模擬結果之討論.....	28	3.1.2 等效觀測器.....	29
3.1.2.1 等效觀測器模擬結果之討論.....	32	3.2 回授控制器.....	32
3.2.1 回授控制器模擬結果之討論.....	34	3.2.2 以等效觀測器為基礎之全訊息控制器.....	35
之模擬結果.....	35	第四章 血糖量測原理與檢測儀器.....	43
血糖量測原理.....	43	4.2 胰島素量測原理.....	46
4.3 血糖檢測儀器之發展.....	46	第五章 可攜式糖尿病患生化血糖監控系統之設計.....	51
生化血糖監控系統.....	51	5.2 硬體架構.....	53
結論與未來研究方向.....	57	6.1 結論.....	57
未來研究方向.....	58	參考文獻.....	59
圖目錄 圖1.1 人體血糖與胰島素作用情形.....	2	圖2.1 非線性模型-改變胰島素注射量之模擬結.....	15
.....15		圖2.2 線性化模型-改變胰島素注射量之模擬結果.....	16
.....17		圖2.3 非線性模型-延長胰島素注射時間之模擬結.....	17
.....17		圖2.4 線性化模型-延長胰島素注射時間之模擬結果.....	18
.....19		圖2.5 非線性模型-針對不同的血糖標準值之模.....	19
.....19		圖2.6 線性化模型-針對不同的血糖標準值之模.....	20
.....36		圖3.1 控制器-針對不同的胰島素初始值之模.....	36
.....36		圖3.2 控制器-針對不同的血糖初始值之模.....	37
.....38		圖3.3 等效觀測器-改變設計參數之模.....	38
.....38		圖3.4 等效觀測器-對照實驗數據之模.....	39
.....40		圖3.5 回授控制器-針對不同的胰島素初.....	40
.....40		圖3.6 回授控制器-針對不同的血糖標準值之模.....	41
.....42		圖3.7 以等效觀測器為基礎之全訊息.....	42
.....42		圖4.1 GLUCO WATCH之構造示意圖.....	48
.....49		圖4.2 二條活性電極試紙.....	49
.....49		圖4.3 三條活性電極試紙.....	50
.....52		圖5.1 生化血糖監控系統之建.....	52
.....52		圖5.2 胰島素注射器模擬胰臟分泌胰島素之狀態圖.....	52
.....53		圖5.3 硬體架構流程圖.....	53
.....53		圖5.4 步進馬達驅動放大器之電路模組.....	54
.....55		圖5.5 胰島素注射器之示.....	55
.....55		表目錄 表2.1 最小模型之參數規格表.....	13
.....13		表3.1 控制器設.....	13

計之參數規格表.....	28	表3.2 等效觀測器設計之參數規格表.....	32	表3.3 回授控制
制器之參數規格表.....	34	表5.1 步進馬達性能規格表.....	54	符號說明 大
寫粗體字母為矩陣，如A、B、C...等等 小寫粗體字母為向量，如x、y、w...等等 小寫希臘字母為純量，如、...等等				

REFERENCES

- 【1】 <http://www.doh.gov.tw> 台灣行政院衛生署 【2】 戴東原, “糖尿病講座”, 健康世界出版社, 1993. 【3】 G. Sparacino and C. Cobelli, “A Stochastic Deconvolution Method to Reconstruct Insulin Secretion Rate After a Glucose Stimulus,” IEEE Trans. Bio. Eng., Vol. 43, pp. 512-529, 1996. 【4】 Liang-Wey Chang, “A Robust Observer Design for Biomedical System,” Biomedical Engineering, pp. 61-68, 1995. 【5】 F. Chee, T. Fernando and P.V. Heerden, “Simulation Study on Automatic Blood Glucose Control,” IEEE Trans. Bio. Eng., 【6】 Karl Heinz Kienitz and Takashi Yoneyama, “A Robust Controller for Insulin Pumps Based on H-Infinity Theory,” IEEE Trans. Bio. Eng., Vol. 40, No. 11, pp. 1133-1137, 1993. 【7】 Chatchai Neatpisarnvanit and John Robert Boston, “Estimation of Plasma Insulin From Plasma Glucose,” IEEE Trans. Bio. Eng., Vol. 49, No. 11, pp. 1253-1259, 2002. 【8】 M. Berger and D. Rodbard, “Computer Simulation of Plasma Insulin and Glucose Dynamics After Subcutaneous Insulin Injection,” Diabetes Care, Vol. 12, pp. 725-736, 1989. 【9】 R.N. Bergman, D.T. Finogood and M. Ader, “Assessment of Insulin Sensitivity in Vivo,” Endocrine Review, Vol. 6, 【10】 C. Cobelli and A. Mari, “Validation of Mathematical Model of Complex Endocrin-Metabolic System, A Case Study on a Model of Glucose Regulation,” Med. Bio. Eng, Vol. 21, pp. 390-399, 1983. 【11】 鄭炎煒, “血糖控制系統的參數評估”, 國立台灣大學電機工程研究所碩士論文, 1994. 【12】 E. Salzsieder, G. Albrecht, V. Fischer and E.J. Freyse, “Kinetic Modeling of the Gluco-regulatory System to Improve Insulin Therapy,” IEEE Trans. Bio. Eng., Vol. 32, pp. 846-855, 1985. 【13】 M.D. Maria Collazo-Clavell, “Mayo Clinic on Managing Diabetes,” 2001. 【14】 楊憲東、葉芳柏, “線性與非線性H 控制理論”, 全華科技圖書, 1997. 【15】 黃鴻鈞, “血糖量測與胰島素注射裝置作業技術規範”, 教育部醫學工程科技教育改進計畫, 1999. 【16】 <http://www.amiramed.com/> 【17】 <http://www.cellrobotics.com/> 【18】 J.A. Tamada, S. Garg and L. Jovanovic, “Noninvasive Glucose Monitoring-Comprehensive Clinical Results,” JAMA, Vol.282, pp. 1839-1844, 1999. 【19】 DC. Klonoff, “Non Invasive Blood Glucose Monitoring,” Diabetes Care, Vol. 20, pp. 433-437, 1997. 【20】 <http://www.spectrx.com/> 【21】 <http://www.cygn.com> 【22】 J.A. Tamada, Matthew Lesho and M.J. Tierney, “Keeping Watch on Glucose,” IEEE Spectrum, pp. 52-57, 2002. 【23】 <http://www.minimed.com/> 【24】 JH. Silverstein and AL. Rosenbloom, “New Developments in Type 1 (Insulin Dependent) Diabetes,” Clin Pediatr, Vol. 39, pp. 257-266, 2000. 【25】 楊台鴻, “人工器官”, 臺北市:教育部, 2000.