Spurious Drop-out Detection In Subcutaneously Implanted Continuous Glucose Monitors

Quan Shen*, S. Joe Qin†

Continuous glucose monitoring (CGM) is of importance for the management and control of diabetes mellitus, which is a prevalent chronic disease of no cure as yet. CGM can continuously inform diabetic people of the status of their glucose and warn of actual or impending hypo- or hyperglycemia. In the past decades, biosensors have been developed for CGM, among which the implanted wired enzyme biosensor [1] has advantages of consistency and accuracy [4, 3] over other subcutaneously implanted sensors.

It is found in the experiments of subcutaneously implanted sensors that there are some spurious drop-outs which do not reflect the true glucose level and will cause problems in subsequent glucose calibration and lag correction. These spurious drop-outs are usually very fast and abrupt. Our objectives are to (1) detect spurious drop-outs online for a single glucose sensor signal, since in practice only one subcutaneously implanted glucose monitor is carried by one person; (2) detect different sizes of spurious drop-outs; and (3) detect drop-outs as quickly as possible.

In this paper, we propose an online spurious drop-out detector based on the discrete wavelet transform (DWT) [2], a signal processing technique which can effectively extract the signal component at a specific frequency range and a specific time region with scaled

*Department of Chemical Engineering, The University of Texas at Austin, Austin, Texas 78712, USA. Email: quanshen@che.utexas.edu

†The Mork Family Department of Chemical Engineering and Materials Science, University of Southern California, Los Angeles, CA 90089, USA. Email: sqin@usc.edu

and shifted wavelets. Because of its multiscale feature, DWT is very useful in detecting singularities of a single sensor signal. In our study, the finest five level details ($D_1 \sim D_5$) are found to have the ability to capture the spurious drop-outs in the glucose signal. The online detection scheme is designed in a recursive way. At each new time point, a moving window is reconstructed. Then DWT is applied on the glucose data inside the window to extract the finest five level details and calculate D_c=sum(D_1:D_5). If D_c exceeds its confidence interval (CI), an abrupt drop-out is warned, which will be confirmed as a spurious drop-out or otherwise by a rule-based evaluator. The rule-based evaluator is a Boolean valued composite measure based on the boundaries, minimum, width of the drop-out, normal signal variations around the drop-out, etc. This evaluator is to exclude normal fast changes such as a real glucose rise after a meal.

The subcutaneously implanted wired enzyme glucose biosensor has been commercially available to diabetic people. In this study, we apply the proposed online spurious drop-out detection method to glucose data from non-diabetic pigs. The results demonstrate effectiveness of the proposed method.

References

[1] A. Heller, *Implanted electrochemical glucose sensors for the management of diabetes*, Annual Reviews of Biomedical Engineering **1** (1999), 153–175.

[2] R. M Rao and A. S. Bopardikar, *Wavelet transforms: Introduction to theory and applications*, Addison Wesley Longman Inc, 1998.

[3] R. L. Weinstein, S. L. Schwartz, R. L. Brazg, J. R. Bugler, T. A. Peyser, and G. V. McGarraugh, *Accuracy of the 5-day freestyle navigator continuous glucose monitoring system: comparison with frequent laboratory reference measurements.(emerging treatments and technologies)*, Diabetes Care **30** (2007), 1125–1130.

[4] D. M. Wilson, R. W. Reck, W. V. Tamborlane, M. J. Dontchev, C. Kollman, P. Chase, L. A. Fox, K. J. Ruedy, E. Tsalikian, and S. A. Weinzimer, *The accuracy of the freestyle navigator continuous glucose monitoring system in children with type 1 diabetes*, Diabetes Care **30** (2007), 59–64.