Automated Insulin Delivery for Type 1 Diabetes

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Abstract:
Pursuit of a closed-loop insulin delivery system that automatically controls the blood glucose of individuals with type 1 diabetes has intensified during the past decade. Here we discuss the recent progress and challenges in the major steps towards a closed-loop system. Continuous insulin infusion pumps have been available for over two decades, but ''smart pump'' technology has made the devices easier to use and more powerful. Continuous glucose monitoring (CGM) technology has improved and the devices are more widely used. Low glucose alarms can warn of impending hypoglycemia, but individuals often sleep through these alarms; this motivated the development of low glucose suspend systems, which turn-off the insulin pump for a period of time to reduce the risk of overnight hypoglycemia.

A number of closed-loop systems are under development; most manipulate only insulin, while others manipulate insulin and glucagon. Meals and exercise cause ''disturbances'' to blood glucose, and we discuss techniques that our group has developed to detect and predict the effect of meals and exercise. In this presentation we provide an overview of contributions that our team has made in improving hypoglycemic alarms, predictive low glucose suspend systems (PLGS) and fully closed-loop control using a multiple model probabilistic predictive control (MMPPC) approach. To get to the clinical trial stage takes a lot of effort and collaboration among many individuals and oversight committees, and we briefly discuss the regulatory processes involved. We include our experiences in over 5000 nights of outpatient trials for a PLGS system, and our fully closed-loop studies involving 45 patients.

Biography:
B. Wayne Bequette is a Professor of Chemical and Biological Engineering and Technical Manager for the Northern Regional Manufacturing Center of the Department of Energy Clean Energy Smart Manufacturing Innovation Institute (CESMII) at Rensselaer Polytechnic Institute, where his research efforts are focused on the modeling and control of biomedical and chemical process systems. He serves as Board Secretary for the American Automatic Control Council (AACC) and as President of the Computer Aids for Chemical Engineering (CACHE) Corporation. Dr. Bequette is a founding member of the Editorial Board of the Journal of Diabetes Science and Technology, and serves on the Editorial Board of Industrial & Engineering Chemistry Research. He is a Fellow of IEEE, AIChE and the American Institute of Medical and Biological Engineers (AIMBE), and was inducted into the Arkansas Academy of Chemical Engineers.

Dr. Bequette received his BS from the University of Arkansas, and his PhD from the University of Texas, both in chemical engineering. He is the author of Process Control: Modeling, Design and Simulation (2003); and Process Dynamics: Modeling, Analysis and Simulation (1998), both published by Prentice Hall. His extracurricular activities include bicycling and pole-vaulting (where competition in the Master's Division denotes age rather than skill level).