“Engineering the Artificial Pancreas”

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Type 1 diabetes mellitus (T1DM) is a chronic autoimmune disease affecting approximately 35 million individuals world-wide, with associated annual healthcare costs in the US estimated to be approximately $15 billion. Current treatment requires either multiple daily insulin injections or continuous subcutaneous (SC) insulin infusion (CSII) delivered via an insulin infusion pump. Both treatment modes necessitate frequent blood glucose measurements to determine the daily insulin requirements for maintaining near-normal blood glucose levels.

More than 30 years ago, the idea of an artificial endocrine pancreas for patients with type 1 diabetes mellitus (T1DM) was envisioned. The closed-loop concept consisted of an insulin syringe, a blood glucose analyzer, and a transmitter. In the ensuing years, a number of theoretical research studies were performed with numerical simulations to demonstrate the relevance of advanced process control design to the artificial pancreas, with delivery algorithms ranging from simple PID, to H-infinity, to model predictive control. With the advent of continuous glucose sensing, which reports interstitial glucose concentrations approximately every minute, and the development of hardware and algorithms to communicate with and control insulin pumps, the vision of closed-loop control of blood glucose is approaching a reality.

In the last 10 years, our research group has been working with medical doctors on clinical demonstrations of feedback control algorithms for the artificial pancreas. In this talk, I will outline the difficulties inherent in controlling physiological variables, the challenges with regulatory approval of such devices, and will describe a number of process systems engineering algorithms we have tested in clinical experiments for the artificial pancreas.

Biography

Frank Doyle is the *John A. Paulson Dean* of the School of Engineering and Applied Sciences at Harvard University, where he also is the *John A. & Elizabeth S. Armstrong Professor.* Prior to that he was the Mellichamp Professor at UC Santa Barbara, where he was the Chair of the Department of Chemical Engineering, the Director of the UCSB/MIT/Caltech Institute for Collaborative Biotechnologies, and the Associate Dean for Research in the College of Engineering. He received a B.S.E. degree from Princeton, C.P.G.S. from Cambridge, and Ph.D. from Caltech, all in Chemical Engineering. He has also held faculty appointments at Purdue University and the University of Delaware, and held visiting positions at DuPont, Weyerhaeuser, and Stuttgart University. He has been recognized as a Fellow of multiple professional organizations including: IEEE, IFAC, AIMBE, and the AAAS. He is the President for the IEEE Control Systems Society, and is the Vice President of the International Federation of Automatic Control. In 2005, he was awarded the *Computing in Chemical Engineering Award* from the AIChE for his innovative work in systems biology, and in 2015 received the *Control Engineering Practice Award* from the American Automatic Control Council for his development of the artificial pancreas. His research interests are in systems biology, network science, modeling and analysis of circadian rhythms, and drug delivery for diabetes.