

The Next Generation of Artificial Pancreas Control Algorithms

Rodrigo E. Teixeira, Ph.D., and Stephen Malin, M.S.

Abstract

Creating a wearable artificial pancreas (AP) by closing the loop between a glucose sensor and an insulin infusion pump has the potential to significantly impact the complications associated with and improve the quality of life of diabetic individuals. Despite recent progress on glucose sensor and insulin infusion technologies, control algorithms built on the simple glucose value efferent and insulin dose afferent model are not efficient and reliable. Based on glucose regulatory mechanisms known to date, their impairment in the diabetic state, and fundamental principles of control theory, some corrections to the present course of research are proposed to facilitate the removal of this barrier. A greater emphasis on model predictive controllers or controllers that exploit a mathematical representation, or model, of the patient's own physiology is proposed. Whole-body physiologically based pharmacokinetics–pharmacodynamics-type models hold the best odds for enabling a successful closed-loop AP. However, two major improvements to the diabetes modeling state of the art are required to make them practical for daily care: integrating hypothalamus–pituitary–adrenal axis and gastrointestinal tract submodels. Although there are simple representations of these in current existence, large concerted efforts between experimentalists and modelers will be required to enhance their accuracy. Finally, changes in hardware that complements controller performance are suggested. For instance, the development of dual control inputs of insulin and glucagon could relax tolerances on controller accuracy.

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Author Affiliation: CFD Research Corp., Huntsville, Alabama

Abbreviations: (AP) artificial pancreas, (GIP) gastric inhibitory peptide, (GIT) gastrointestinal tract, (GLP-1) glucagon-like peptide 1, (HPA) hypothalamic–pituitary–adrenal axis, (MPC) model-predictive controller, (PB-PK-PD) physiologically based pharmacokinetics–pharmacodynamics, (PID) proportional-integral-derivative controller

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Corresponding Author: Rodrigo E. Teixeira, Ph.D., CFD Research Corp., 215 Wynn Drive, Huntsville, AL 35805; email address kikoteixeira@gmail.com