Synergy: In-Silico Functional Verification of Artificial Pancreas Control Algorithms

University of Colorado, Boulder

Rensselaer SCHOOL OF ENGINEERING

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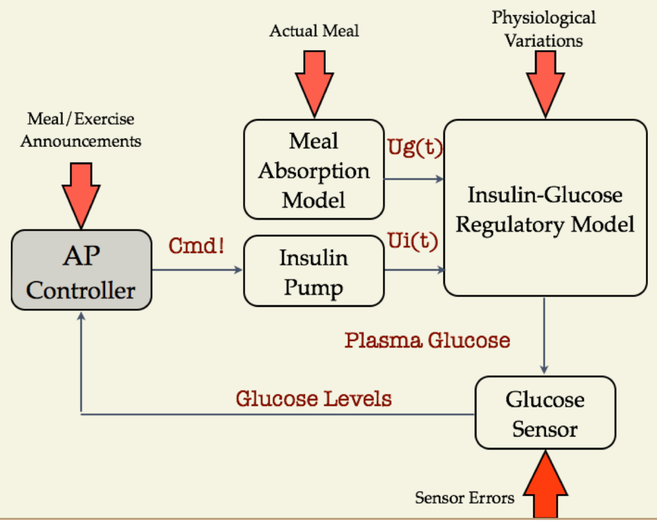
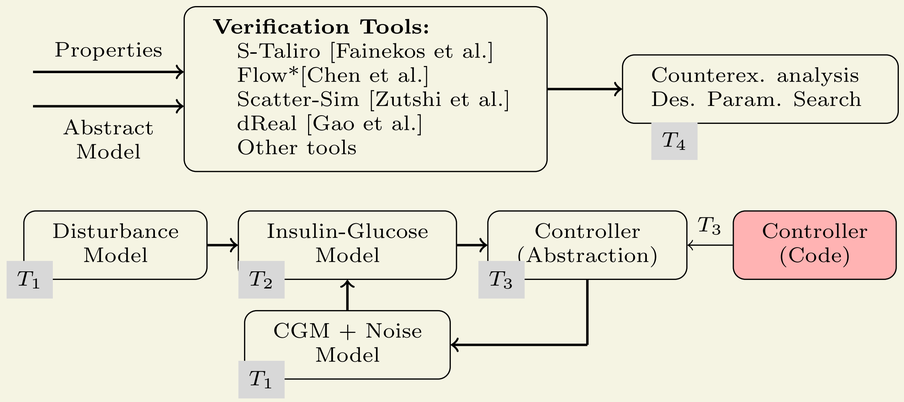
The artificial pancreas (AP) is a set of increasingly sophisticated devices and algorithms that will automate the delivery of insulin to patients with type-1 diabetes. While the AP concept promises to alleviate the burden posed by the self-management of blood glucose levels, it also poses significant risks arising from a combination of external disturbances such as patient meals, physical activity, sensor errors, network delays and physiological variations. We are investigating modeling and verification frameworks that allows designers of AP control algorithms to automatically evaluate their designs against a large number of disturbance patterns. The project will investigate disturbance modeling techniques from data, delay-differential models of insulin-glucose dynamics, control code abstraction and techniques for explaining verification results to clinical researchers and control engineers.



Components of an *in-silico* closed-loop Artificial Pancreas System



Overview of verification framework

Verification Framework	
Input:	Control algorithm (Matlab syntax) + Specification
Output:	*Post-processed* violations.
Time Bnd:	$27 - 30$ hrs (initialization + run-in)

Properties	Description
NoHypo	BG is always above hypoglycemia threshold
NoHyper	BG is always below hyperglycemia threshold
Alarm	Controller must always alarm when insulin stopped
Warning	Controller must provide adequate and timely warning of device failure and hypoglycemia.
MeanBG	Mean blood glucose must be within limits.
InsulinLimits	Controller must respect limits on insulin delivered.

Task	Description
T1	Disturbance Modeling from data
T2	Delay Differential Modeling
T3	Verification with software in the loop
T4	Processing of Verification Results

Disturbance Modeling

Clinical/Survey data-based disturbance modeling.
Goal: Inference of non-determinstic automata models from sequence data.

Delay-Differential Modeling

Insulin-Glucose response is governed by numerous continuous delays
Goal: Incorporate delay-differential models with fewer state variables into verification loop.

Verification with Software-In-Loop

Goal: Integrate static analysis techniques for software with flowpipe construction tools.

Post-Processing Verification Results

Goal: Help visualize/prioritize verification warnings to help clinicians/engineers understand and deal with warnings.

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