ABSTRACT

Type 1 diabetes mellitus is a chronic and incurable disease that affects millions of people all around the world. Its main characteristic is the destruction (totally or partially) of the beta cells of the pancreas. These cells are in charge of producing insulin, main hormone implied in the control of blood glucose. Keeping high levels of blood glucose for a long time has negative health effects, causing different kinds of complications. For that reason patients with type 1 diabetes mellitus need to receive insulin in an exogenous way.

Since 1921 when insulin was first isolated to be used in humans and first glucose monitoring techniques were developed, many advances have been done in clinical treatment with insulin. Currently 2 main research lines focused on improving the quality of life of diabetic patients are opened. The first one is concentrated on the research of stem cells to replace damaged beta cells and the second one has a more technological orientation. This second line focuses on the development of new insulin analogs to allow emulating with higher fidelity the endogenous pancreas secretion, the development of new noninvasive continuous glucose monitoring systems and insulin pumps capable of administering different insulin profiles and the use of decision-support tools and telemedicine. The most important challenge the scientific community has to overcome is the development of an artificial pancreas, that is, to develop algorithms that allow an automatic control of blood glucose.

The main difficulty avoiding a tight glucose control is the high variability found in glucose metabolism. This fact is especially important during meal compensation. This variability, together with the delay in subcutaneous insulin absorption and action causes controller overcorrection that leads to late hypoglycemia (the most important acute complication of insulin treatment).

The proposals of this work pay special attention to overcome these difficulties. In that way interval models are used to represent the patient physiology and to be able to take into account parametric uncertainty. This type of strategy has been used in both the open loop proposal for insulin dosage and the closed loop algorithm. Moreover the idea behind the design of this last proposal is to avoid controller overcorrection to minimize hypoglycemia while adding robustness against glucose sensor failures and over/under- estimation of meal carbohydrates. The algorithms proposed have been validated both in simulation and in clinical trials.