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Adaptive Optimal Control and the Insulin Dependent Diabetic

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In some applications of mathematical modelling and control theory, several parameter sets may be known for individual cases and corresponding, relevant ranges of model parameters inferred from these. However, the effort involved in calculating such parameter sets may be too high or take too long to allow for the continuous updating required by the usual methods of adaptive control. This dissertation develops the mathematical framework necessary to formulate an adaptive, closed-loop optimal control algorithm for use in such situations.

The following mathematical techniques were adopted:

SYSTEM MODELLING: The use of a discretised set of coupled differential equations, analysed in terms of stability, sensitivity and validity.

SYSTEM CONTROL: The use of a discrete segments approach, a control "effect" assumption and a cost criterion to produce a closed-loop control algorithm. Adaptivity of the control is achieved by using representative parameter sets which are derived by the use of an especially constructed cost criterion and the method of steepest descents.

COMPUTER PROGRAMMING: Computer programs were devised to determine the representative parameter sets, to simulate a diabetic subject and to implement the insulin infusion algorithm.

The theory is then applied to provide adaptive, metabolic control for the insulin dependent diabetic. There are already a number of automatic insulin infusion devices which seek to maintain near normal glucose levels in insulin dependent diabetic subjects but they have generally been developed in a rather *ad hoc* manner and do not allow for the variations in glucose and insulin sensitivities that can occur in the course of daily life. The algorithm for insulin infusion used in this study has been developed with regard to a mathematical model of glucose/insulin dynamics and according to mathematical principles. It has been designed to adapt to changes in the glucose/insulin

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system caused by such factors as stress, exercise or infection and is presently available for clinical use. Once the technology of implantable glucose sensors is significantly improved, this algorithm could form the basis of a portable, automatic artificial beta cell.

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