Chaotic dynamic analysis and nonlinear control of blood glucose regulation system in type 1 diabetic patients

In this paper, chaotic dynamic and nonlinear control in a glucose-insulin system in types I diabetic patients and a healthy person have been investigated. Chaotic analysis methods of the blood glucose system include Lyapunov exponent and power spectral density based on the time series derived from the clinical data. Wolf's algorithm is used to calculate the Lyapunov exponent, which positive values of the Lyapunov exponent mean the dynamical system is chaotic. Also, a wide range in frequency spectrum based on the power spectral density is also used to confirm the chaotic behavior. In order to control the chaotic system and reach the desired level of a healthy person's glucose, a novel fuzzy high-order sliding mode control method has been proposed. Thus, in the control algorithm of the high-order sliding mode controller, all of the control gains computed by the fuzzy inference system accurately. Then the novel control algorithm is applied to the Bergman's mathematical model that is verified using the clinical data set. In this system, the control input is the amount of insulin injected into the body and the control output is the amount of blood glucose level at any moment. The simulation results of the closed-loop system in various conditions, along with the performance of the control system in disturbance presence, indicate the proper functioning of this controller at the settling time, overshoot and the control inputs.

Keywords: Chaos, Glucose-Insulin Blood System, Lyapunov exponent, Sliding Mode Controller, Fuzzy Logic

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