Linear Control Systems
Master 1

Academic year of 2019-2020

LCS - HW1 - Control of blood sugar concentration

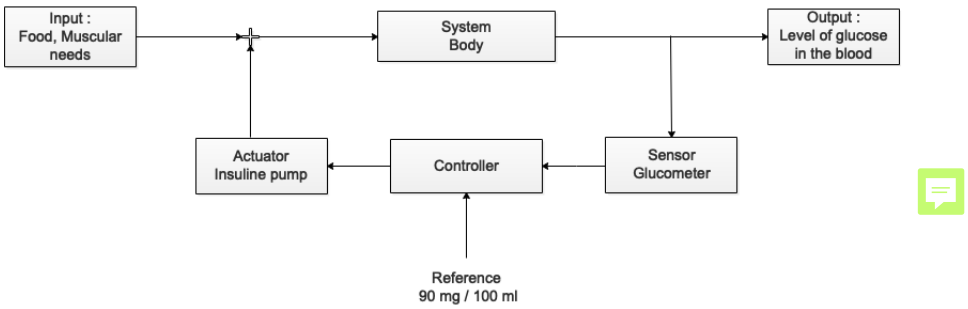
Work of Bareel Pierre-Yves, Gevaert Lou and Paquay Joachim

(s162827, s161603 and s154432)

1 Context

The amount of sugar in the blood is a perfect example of a regulated system. Indeed, the amount of sugar should be constant to provide energy to each cell of the organism but the levels are constantly changing according to the person activity (eating, exercising...). The body is thus able to maintain a constant level of sugar (about 90 mg per 100 mL of blood since it is between 1g/L and 1.4 g/L after a meal and between 0.63 g/L and 1g/L otherwise) by realising insulin when the sugar should be stored in the liver and glucagon when sugar should be released. These two hormones are delivered by the pancreas. The glucose can be delivered in the blood thanks to glycogenolysis (by the liberation of glucose from the glycogen of the liver when it receives glucagon) and gluconeogenesis (by the liver and the kidneys) but we will not go in to much detail about it and we will consider the body as an whole. The principal organs that consume glucose are the brain, the muscles, the kidneys, red blood cells and adipose tissues. This system is efficient for most people but not for patients suffering from type 1 diabetes and we will focus on that case. The controller will essentially act during hyperglycemia periods when the pancreas does not release enough insulin. In the case of hypoglycemia detected by the controller, we assume that the person would eat something to increase blood sugar.

2 Control problem diagram



3 Control problem description

— Utility of the controller : To avoid hypoglycemia that leads to shakiness, dizziness, hunger, headache and other unpleasant symptoms. Moreover, it helps to avoid hyperglycemia which causes among others, an increased thirst, headaches, trouble concentrating, blurred vision, fatigue and weight loss.

— System to be controlled : The entire body

— Inputs into the system : The quantity of insulin injected by the pump as well as glucose coming from food and used by the organism.

— Outputs of the system : Concentration of glucose in the blood.

— Reference : We want to keep the level of glucose between 0.9 g/L and 1g/L.

— Sensors : A glucometer. We want the measures to be continuous because it enables to visualize the evolution and not only a certain concentration at a particular moment. So, we will use a continuous glucose monitor that analyses the quantity of glucose in the interstitial fluids, which is proportional to the level of sugar in

the blood but there is a certain time lapse. In fact, after a meal, blood sugar will increase and glucose will then go, after 5-10 min to the interstitial fluids to supply the cells. By measuring glucose at this location, the sensor is non-invasive and is mainly used nowadays. We will assume to have one like that.

— Actuators : An insulin pump

— Constraints and Limitations : There is a time lapse between the injection of insulin and the delivery of glucose. The parameters of the models may vary from a patient to another.

4 Reference

— Abbes, I.B. (2013). *Développement d'un nouveau modèle dédié à la commande du métabolisme glucidique appliqué aux patients diabétiques de type 1. Supélec, France.*

— *Wikipedia (21/09/2019). Glucose meter Retrieved (28/09/2019) from* `https://en.wikipedia.org/wiki/Glucose_meter#Continuous_glucose_monitors`

— *Chase, J. G., Shaw, G. M., Lin, J., Doran, C. V., Hann, C., Robertson, M. B., Browne, P. M., Lotz, T., Wake, G. C., and Broughton, B. (2005). Adaptive bolus-based targeted glucose regulation of hyperglycaemia in critical care. Medical Engineering and Physics*