Glucose Value Prediction Model Documentation

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1 Introduction

For patients with Type 1 Diabetes (T1D) and have access to their real-time glucose values, the most important part of the treatment is how they are alerted when their blood sugar is spiking or diving. A healthy range for the glucose values is 70 - 180 mg/dL. We, as the Machine Learning Group, are aiming to build a model that predicts the future glucose levels, so that the patients can be alerted beforehand when their glucose values are about to be out-of-range.

2 Data

We got sets of Dexcom sensor data from Patient K for multiple months, along with a set of Medtronic pump data that keeps track on her insulin activities. In the Medtronic pump data, we got the following variables:

1) **Carb intake** (g): Manually input by the user during meal-time and snack-time.

2) **Insulin intake** (U): Calculated by the pump device with given glucose value and the amount of Carb intake at the time; can be adjusted by the user

3) **Carbohydrate Ratio** (g/U): Ratio for 1 Unit of insulin covers how many grams of Carbohydrate; changes during the day and shifts over certain days (see Figure 1)

4) **Insulin Sensitivity** (mg/dL per U): Ratio for 1 Unit of insulin contributes to how much drop on the glucose value; changes during the day and shifts over certain days (see Figure 1)

5) **Blood Glucose Target** (mg/dL): Manually input by the user for the range of ideal glucose values

Carbohydrate Ratio (g/U)

TIME	Ratio
0:00	10.0
6:00	5.5
11:30	4.0
14:00	7.5
18:00	6.5
21:00	9.0

Insulin Sensitivity (mg/dL per U)

TIME	Sensitivity
0:00	55
6:00	70
9:00	60
12:00	50
15:00	60

Blood Glucose Target (mg/dL)

TIME	Low	High
0:00	110	110

Figure 1: variation of Carbohydrate Ratio, Insulin Sensitivity on a one-day scale; value for Blood Glucose Target is fixed

6) **Basal** (mg/dL): Minor amount of insulin that reacts continuously during the day (see Figure 2)

Basal	
Maximum Basal Rate	2.00 U/Hr
Temp Basal Type	Percent of Basal

Standard (active)

24-Hour Total	10.700 U

TIME	U/hr
0:00	0.425
3:00	0.400
4:00	0.625
9:00	0.400
12:00	0.475
14:00	0.225
20:00	0.600

Pattern A

24-Hour Total	--

TIME	U/hr
--	--

Pattern B

24-Hour Total	--

TIME	U/hr
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Figure 2: Information for Basal type and rate

3 Model

With all the data and variables provided, we tried to relate them together with an equation. We assumed that the Carb Intake will rise the glucose value, while the Insulin Intake and the countinous Basal Intake will bring the glucose value down to the Blood Glucose Target in a 4-hour active period.

The assumed relationship among all the variables is illustrated in the following equation:

$$CurGluVal + \frac{Sens}{CarbRatio} * Carb - Insulin * Sens - Basal * 4 * Sens = Target,$$

where CurGluVal = Current Glucose Value; Sens = Insulin Sensitivity; CarbRatio = Carbohydrate Ratio; Carb = Carb Intake; Insulin = Insulin Intake; Basal = Basal Rate; Target = Blood Glucose Target.

We tested the equation with a single data-point at 6/27/2016 15:56:00 from Patient K's data sets. At the moment, her Current Glucose Value = 237; Carb Intake = 50; Insulin Intake = 7.90; Carbohydrate Ratio = 7.5; Insulin Sensitivity = 60; Basal Rate = 0.225; and Blood Glucose Target = 110:

$$237 + \frac{60}{7.5} * 50 - 7.9 * 60 - 0.225 * 4 * 60 = 109$$

Since the Target Glucose Value is set to be 110, the relative error is less than 1%. We want to further test our equation with a series of real-time data, so we constructed a Python script that reads from our database, loop the data-points, and generate prediction values.

4 Code

Along with this documentation, we include our database and Python script in this repository. The database contains real-time Glucose Values and Pump Data from Patient K.

In our script, we loop the data points from the database; whenever there is a Carb Intake activity, we start to generate predicted Glucose Values 15-min ahead based on the Current Glucose Value with upward and downward slopes derived from the equation model.

$$UpwardSlope(/min) = \frac{\frac{Sens}{CarbRatio} * Carb}{4 * 60}$$

$$DownwardSlope(/min) = -\frac{Insulin * Sens - Basal * 4 * Sens}{4 * 60}$$

Because the insulin intake will be active 15 minutes after the injection, we assume that the Carb intake will rise the Glucose Values in the 15-min period with the upward slope. When the Insulin Intake kicks in, it will be effective with the continuous Basal intake, bringing the Glucose Value down with the downward slope.

The predicted Glucose Values are stored in a .csv file for further investigation.