# *GluGo2.0*
# Concept Brief

## 1. Summary in Brief

**Name of Organization:** GluGo2.0

**Name of Key Contacts/Team Members:**

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**Organization or business logo:**

**Due date for the completion of the project:** December 3rd

**Timeline:**
October 3rd (1st sprint), October 31st (2nd sprint), November 19th (3rd sprint), December 3rd (pitch)

**Brand or brand name:** GluGo2.0

**Budget/financial numbers if available:** N/A

## 2. Introduction/Abstract/Opening Statements

According to the American Diabetes Association (ADA), about 40,000 people receive a type 1 diabetes diagnosis (T1D) each year in the United States [1]. While diabetes management technology has made leaps and bounds since the invention of artificial insulin, the demand for the next improvement in the existing diabetes management technology is still very high. Organizations like The Nightscout Project are facilitating efforts to hack continuous glucose monitors (CGMs), so that parents of children with T1D can get smartphone and smartwatch notifications if their child has a blood sugar spike or crash. Dexcom, one of the three major CGM producers [2], released the G6 sensor, the first CGM that can communicate with an insulin pump [3]. Such aspirations toward an “integrated system” require algorithms that can predict future glucose trends. With that in mind, our company’s goal is to utilize machine learning and time series analysis to develop an *accurate*, *personalized*, and *low-maintenance* glucose prediction algorithm. There are a number of systems that currently utilize such algorithms [4]. But many have a one-size-fits-all approach. We seek an algorithm that will learn about *you*, adapting to the specificities of *your* life. Many of the other algorithms are also high-maintenance, requiring manual entry of carbohydrate intake, for example. We seek an algorithm that minimizes the need for human oversight.

## 3. Audience/Target Market

The target market for this product will be middle class women under 65 with type 1 diabetes. We’re designing our algorithm with the explicit goal of adaptability, and personalization. There is room for this market to expand and include any person with type 1 diabetes. However, the dataset on which we are currently developing the model consists of only women. We may be able to expand our dataset later in the semester. But for now, women with type 1 diabetes will benefit from this predictive technology. Our target is also restricted by social and economic factors. The audience we are appealing to would need to already own a CGM

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[1] http://www.diabetes.org
[2] The other two are Abbott and Medtronic. Read more here: https://integrateddiabetes.com/choosing-a-cgm-3-heads-are-better-than-one/
[3] https://www.fda.gov/newsevents/newsroom/pressannouncements/ucm602870.htm
[4] https://www.tandemdiabetes.com/products/t-slim-x2-insulin-pump

and an insulin pump. Both technologies, along with artificial insulin [5], are very expensive without health insurance. And because integrated diabetes management technology is so new, there will certainly be a lag between the production of these systems, and their incorporation into healthcare plans. Finally, elderly diabetics are less likely to use a CGM or pump, sometimes opting instead to use manual glucose sensors and syringes.

## 4. Background/Purpose/Need/Rational

Before the successful extraction of animal insulin in 1921, Type 1 Diabetes was a death sentence [6]. Patients either died from hypoglycemia, complications associated with blood sugar highs, or starvation (strict low-carb diets). And the first insulin pump looked more like a backpack than a pager [7]. Artificial human insulin wasn't invented until 1978. The modern T1D management paradigm of discrete insulin pumps and continuous glucose monitors sounds pretty cushy by comparison. Yet, managing type 1 diabetes today amounts to waging a war against your own body. T1D management requires constant forethought and vigilance, and even the most successful experience fluctuations in blood sugar never seen in a non-diabetic. The consequences of diabetes mismanagement are still life threatening. A nighttime blood sugar low is deadly, and the complications associated with frequent blood sugar highs are be life-threatening in the long run. Furthermore, patients who suffer from type 1 diabetes frequently wake up during the night to control their glucose level in order to keep their glucose level from dropping to a life-threatening range.

Managing glucose level is a difficult challenge in part due to the complexities of the human body. Insulin sensitivity, a measure of how efficiently the body uses insulin, is affected by time of day, exercise, and sleep. Current insulin pumps generally deliver two types of insulin; bolus insulin (generally fast acting) which is given before meals, and basal insulin (generally slow acting), which is given constantly. Successful diabetics are constantly reevaluating the formulas they use to calculate the appropriate bolus insulin to cover their carbohydrate intake, due to potential changes in how their body utilizes insulin to breaks down carbs.

In 2006, Juvenile Diabetes Research Foundation launched a program called the Artificial Pancreas Project, which aims to design an automated blood-sugar management system that connects the CGM and insulin pump together. In theory, if the sensor can predict future glucose values, it will be able to alter the insulin dosing of the pump to avoid glucose highs and lows entirely. Due to the support from the foundation, there has been a recent explosion in research that predicts glucose concentration in the bloodstream. The integration of the CGM and pump, and the development of accurate glucose prediction are the two major innovations likely to define the next T1D management paradigm.

Even though more resources being put towards glucose prediction algorithms, the overall accuracy is not ideal. Based on a paper published in 2014, the accuracy of prediction at that time was only 23%. In 2017, the model used to predict glucose concentration had an accuracy of 85.14% for high glucose levels, 81.43% for normal glucose levels, and 93.46% for low glucose levels. One of our goals is to improve the accuracy of the model.

[5] https://www.npr.org/sections/health-shots/2018/09/01/641615877/insulins-high-cost-leads-to-lethal-rationing
[6] http://diabetesstopshere.org/2012/08/21/the-history-of-a-wonderful-thing-we-call-insulin/
[7] https://www.diabetes.co.uk/insulin/Insulin-pumps.html

The purpose of this project is to design a more *efficient*, *accurate*, and *personalized* prediction model for glucose level for female patients with type 1 diabetes. The improvement of glucose prediction algorithm in this project will be one of the steps towards achieving the ultimate goal of designing an automated blood-sugar management system that 1.25 million Americans can benefit from in the future.

## 5. Product or Service Detail/Description

Our goal is to develop an algorithm which could be implemented in an integrated, sensor-pump system. That is, an algorithm which accurately predicts future glucose values in real time, far enough out into the future that the pump can respond with an appropriate dose of insulin. Furthermore, we seek an algorithm that will be low maintenance for the user.

Our primary research subject will be a female diabetic (and Madeleine Clark Wallace Library Archivist), Kate Boylan. We will mainly focus on predicting her glucose highs (usually >200 mg/dL), and her lows (usually <70 mg/dL). It's important to note that our research is a continuation of the first iteration of Mark's *Startup: Machine Learning* course, which culminated in, among other things, a promising prediction model. We're particularly interested in testing highs, because the accuracy of the previous model is poor for high glucose values. The data will be collected through Tidepool, a database providing real-time glucose data. Unlike a simple linear regression model that a Wheaton student might learn in Introductory Statistics or Quantitative Research Methods, the analysis of time series is based on the assumption that successive values in the y-variable are correlated with each other based on time. Therefore, we will first identify patterns in the training set, including the trend (increasing, decreasing, or constant with respect to time) and seasonality (periodic patterns which repeat at a constant frequency). We will then test our model on a "test set", a different subset of Kate's data. We will train several prediction models using different machine learning algorithms. Finally, we will compare the test results to select the one that's the most *accurate*, *personalized*, and *low-maintenance*. After coming up with one prediction model for Kate, we will work to generalize our model with other datasets.

## 6. Project Activities/Action Plan/Approach/Timeline/Design Plan

Our timeline consists of three “sprints”:

- October 3rd
- October 31st
- November 19th

At the end of each of these sprints, our team is responsible for creating and displaying a properly tested demo of our current product. In order to accomplish this in time, our team has divided up to conquer separate tasks. These tasks currently include:

- Testing the current algorithm to verify its accuracy
    - Yun, Phuntso & David
- Developing Predictive Models using time series analysis and machine learning
    - Ethan & Xinru
- Accessing data from the Tidepool data frame and formatting it for model building/testing
    - Danny & Ari
- Working with and understanding the needs of our client Kate Boylan (all)
- Updating the GitHub repository (all)

On December 3rd our team will have to pitch our final product in order to “receive funding to continue this work”.

## 7. Summary/Conclusion/Attachments

T1D makes life a constant struggle for control over your body. Type 1 Diabetes used to kill you, now it usually just takes over your life. GluGo2.0 aims to develop an *accurate, personalized, and low-maintenance* prediction algorithm that will learn how to manage a patient’s diabetes, and help type 1 diabetics get back to their lives.