Software Design Document

for

Diabetic Patient Monitoring

Version 2.0 approved

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Medtronic / Alex Zhong

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## Revision History

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1. Introduction

1.1 Purpose
The purpose of this document is three-fold:
   a) Completely define a full set of requirements for the this project
   b) Completely define the design for this project.
   c) Define and partially implement feasible modules for this project

1.2 Intended Audience and Reading Suggestions
This document is intended for future Medtronic developers and CSULA senior design students.

1.3 System Overview
The purpose of this project is to obtain insight on glucose level based on activity level, and find any correlation between them. In addition, to come up with a solution to predict glucose levels primarily using FitBit metrics in order to reduce reliance on expensive sensors. In doing so we will dynamically process data and display information to patients or authorized people.
2. Design Considerations

2.1 Assumptions and Dependencies

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<th>Dependency</th>
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2.2 Goals and Guidelines

- Finding insight/relationship between physical activity and glucose levels and visualizing results
- Investigating the possibility of predicting continuous glucose level based on physical activity and blood glucose samples

2.3 Development Methods

This project is being conducted using Agile development. The development process is formal with document and code reviews.

- Time series Research
- API Gateway and API endpoint creation

*Data Manipulation/Machine Learning Process*

- Back-end Python Machine Learning Structure and Code
- Data preprocessing and data cleaning
  - Store raw glucose and fitness data
  - Store trained data set
- Sample data feature extraction
  - Prepare data for machine learning algorithm
- Feature selection and dimensionality reduction
- Knowledge extraction/ data analytics, deriving insights
- Data testing and training
- Continuous data processing
3. Architectural Strategies

The real time data stream will be handled by Apache Kafka, which will send the data stream to Apache Storm for data analysis using python data analysis libraries. Storm will send the analysis to a Flask front end for viewing by the end-user. Each module is a Microservice and can be run independently from each other Microservice. These microservices can be easily scaled.
4. System Architecture

4.1 - Level 0 DFD

4.2 - Level 1 DFD
4.2.1 Feature Extraction Engine

1.3 Feature Extraction Engine

Data Preprocessing and Cleaning → Feature Extraction → Dimensionality Reduction → Output

DB

4.2.2 - Prediction Engine

1.5 Prediction Engine

Training Data → ML Training → Predictive Model → ML Testing/Prediction → Output

Real Time Data

4.2.3 - Insight Engine

1.4 Insight Engine

BG Features → Physical Activity Features → Food Intake Features → Correlation and Statistical Analysis → Visual Representation and Pattern Analysis → Insights
4.3 - Database Schema

- **Cassandra DB0** (Simulation DB):
  - **time_series**:
    - PK: ts double
    - unique userid
    - metric_group text
    - metric_id text
    - patient_id int
    - value double
  - **nutrimo_data**:
    - PK: patient_id int
double
    - foodsource_type_name text
    - dish_preparation_type text
    - serving_amount double
    - display_name text
    - protein double
    - saturated_fatty_acids double
    - trans_fatty_acids double
    - carbs double
    - lipids double
    - energy double
    - sodium double
    - sugars double
    - fibers double
  - **insight_data**:
    - PK: ts double
    - patient_id int
    - insight_id int
    - patient_id int
    - insight_voucher
    - X_metric_id text
    - Y_metric_id text
    - X_metric_val float
    - Y_metric_val float

- **Cassandra DB1** (Insight and Real Time DB):
  - **time_series**:
    - PK: ts double
    - unique userid
    - metric_group text
    - metric_id text
    - patient_id int
    - value double
  - **generated_features**:
    - PK: patient_id int
    - activity_log_data
    - activity_id int
    - activity_parent_id int
    - calories int
    - description text
    - distance int
    - has_start_time Boolean
    - has_stop_time Boolean
    - is_favourite Boolean
    - log_id int
    - name text
    - steps int
    - activity_data double
  - **sleep_log_data**:
    - PK: patient_id int
    - start_time double
    - awake_count int
    - awake_duration int
    - awakings_count int
    - duration int
    - efficiency int
    - is_main_sleep Boolean
    - minutes_after_wakeup int
    - minutes_asleep int
    - minutes_to_fall_asleep int
    - minutes_awake int
    - restless_count int
    - restless_duration int
    - time_in_bed int
  - **personal_data**:
    - PK: patient_id int
    - age_range int
    - age int
    - sex text
    - pedometer text
    - years_on_insulin int
    - age_onset int
    - diagnosis float
    - diabetes_type int
4.4 - Detailed descriptions

Major functional subunits shown in the DFDs in the previous subsections, are described in detail below. The section numbering below corresponds to DFD diagrams in section 4.2.

1.1 Static FitBit Data

FitBit analytics are received from a static directory in production.

1.2 Real Time Data Feed

This module handles the real time data. This includes continuous glucose readings, food intake, and manual glucose readings.

   1.2.1 - Database for storing Raw Data as DataPackets
   1.2.2 - Real Time Data Feed
   1.2.3 - Cassandra Database shall be used to store incoming data as DataPackets
   1.2.4 - Apache Kafka shall receive data stream from fitbit
   1.2.5 - Apache Kafka shall receive data stream from SG
   1.2.6 - Apache Kafka shall create a producer for streaming to Apache Storm
   1.2.7 - Apache Storm shall split the stream by feature
   1.2.8 - Apache Storm shall send processed data to Feature Extraction Engine (1.3)

1.3 Feature Extraction Engine

The feature extraction engine will extract features, use feature selection and dimensionality reduction. These extracted features will be sent to modules 1.4 and 1.5.

   1.3.1 - Data shall be received from Apache Storm.
   1.3.1 - Python script shall analyze and sort data
   1.3.2 - Pandas shall handle features of real time data
   1.3.3 - Database shall store extracted features

1.4 Insight Engine

The insight engine will make insights.

   1.4.1 - Python script shall find features to develop insights from the real time data
   1.4.2 - Pandas shall handle good values for correlations of different features.
   1.4.3 - Database shall store insights for use with Flask.
1.5 Prediction Engine
The prediction engine shall take training data, and use it to produce a predictive model. It then uses the predictive model on real time data to produce predictions.

1.5.1 - Data shall be received from Apache Storm.
1.5.2 - RNN shall be implemented using TensorFlow to create predictions
1.5.3 - Database shall store predictions.

1.6 Front End
The front end will display all of our results after our insight and prediction data is put together.

1.6.1 - Gentelella Flask shall display webpages
1.6.2 - ChartsJs shall display charts
1.6.3 - Data is streamed from the Prediction Engine
1.6.4 - Data is streamed from the Insight Engine
5. Policies and Tactics
The team shall use SCRUM developing methods

5.1 Technology in current RTD Framework

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<td>Apache Kafka</td>
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<td>Apache Storm</td>
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<td>Apache Cassandra</td>
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<td>Python</td>
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<tr>
<td>Flask</td>
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<td>Flask Gentelella</td>
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<tr>
<td>Charts.js (gentelella)</td>
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<td>Amazon Web Services</td>
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Appendix A: Glossary

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<th>Abbreviation</th>
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<td>SDD</td>
<td>Software Design Document</td>
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<tr>
<td>BG</td>
<td>Blood Glucose Level</td>
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<td>CGM</td>
<td>Continuous Glucose Monitoring</td>
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<td>SG</td>
<td>Sensor Glucose Data from Real Time Glucose Monitor</td>
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<td>RNN</td>
<td>Recurrent Neural Network</td>
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<td>API</td>
<td>Application Programming Interface</td>
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