ECEN 403
Electrical Design Laboratory I
GlycoTrem: Functional Model Report

www.GlycoTrem.com

Helali, Skander
skander.helali@qatar.tamu.edu

Dandan, Ghida
ghida.dandan@qatar.tamu.edu

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Mentor: Dr. Jim Ji

"An Aggie does not lie, cheat or steal or tolerate those who do."

Abstract

GlycoTrem consists of four integrated layers that can be further reduced into just two: the application layer and the processing layer. The application layer is the only one that the user would interact with, and the processing layer falls in the back-end of the system and is where all the computation and historical storage take place. Properly understanding the system's functionalities at this point in the project development process is crucial, especially since it allows for the visualization of the overall product before its realisation. Achieving this may be done through a functional modelling analysis which is what this report will touch on. Starting from the top-level one block form and then breaking it down to a detailed functional model, the components and functions that compose GlycoTrem will be extensively discussed, followed by design implementation and findings analysis.

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1 Introduction

Products are usually made up of several components or modules. These usually correlate to the device's functions, sub-functions, and behavior. A block representation of GlycoTrem with inputs and outputs, energy flows, and functional blocks that are clearly designed would help pave the way for a successful product design process.

2 Top-Level Functional Model

Representing a system in its top-level one block form allows to visualize the overall input-output relationship of the system's design. The following diagram shows the top-level condensed view of the system. The black-box can be split into two functional blocks that can be further broken down into more detailed functions and sub-functions.

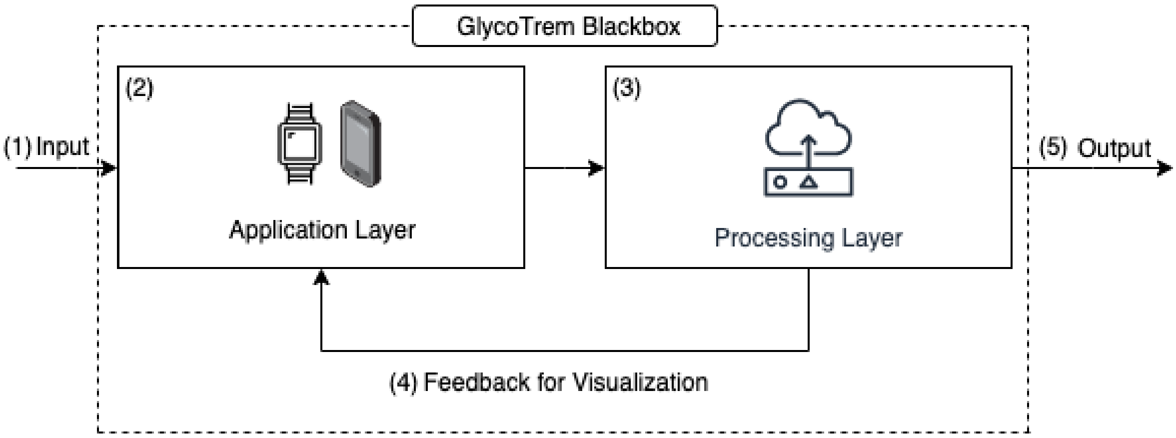

Figure 1: Top-Level View of GlycoTrem

The primary input of GlycoTrem's operation is the accelerometer data (x, y, and z axis coordinates - Element 1). This data is then fed into the "Application Layer (Element 2)" which is an abstraction of both the smartwatch and smartphone applications.

The output of this application layer is then fed into the "Processing Layer (Element 3)". This layer is similarly an abstraction of the dedicated server and database, the outputs here are then fed back into the application layer for visualization (Element 4). This feed-back loop does not alter or control the behavior of the system, it is simply data that the application layer can visualize after it was processed.

Some historical data and other information that is produced by the processing layer is stored in the database as represented by the output (Element 5).

These abstractions will be broken down into smaller and more detailed components later on. This will also highlight the hidden inputs and outputs within the blocks represented above in the top-level view of GlycoTrem's design.

3 Detailed Functional Model

The two major blocks that can be broken down into more detailed sub-functions are the second and third elements of the top-level view shown in Figure 1. In the interest of clarity, these blocks will be detailed separately. They will then be all combined in a comprehensive and detailed functional model representation.

3.1 Application Layer

The application layer consists of both the smartphone and smartwatch applications. The user only interacts with these two layers. Their primary purpose is to handle the transmission of unprocessed data, visualizing processed data, and alerting in case of hypoglycemic events.

3.1.1 Main Functions

The raw accelerometer data is the primary input of this layer. This is received by the smartwatch application. The processed data received from the server is relayed to the smartphone application which is responsible for visualizing this information.

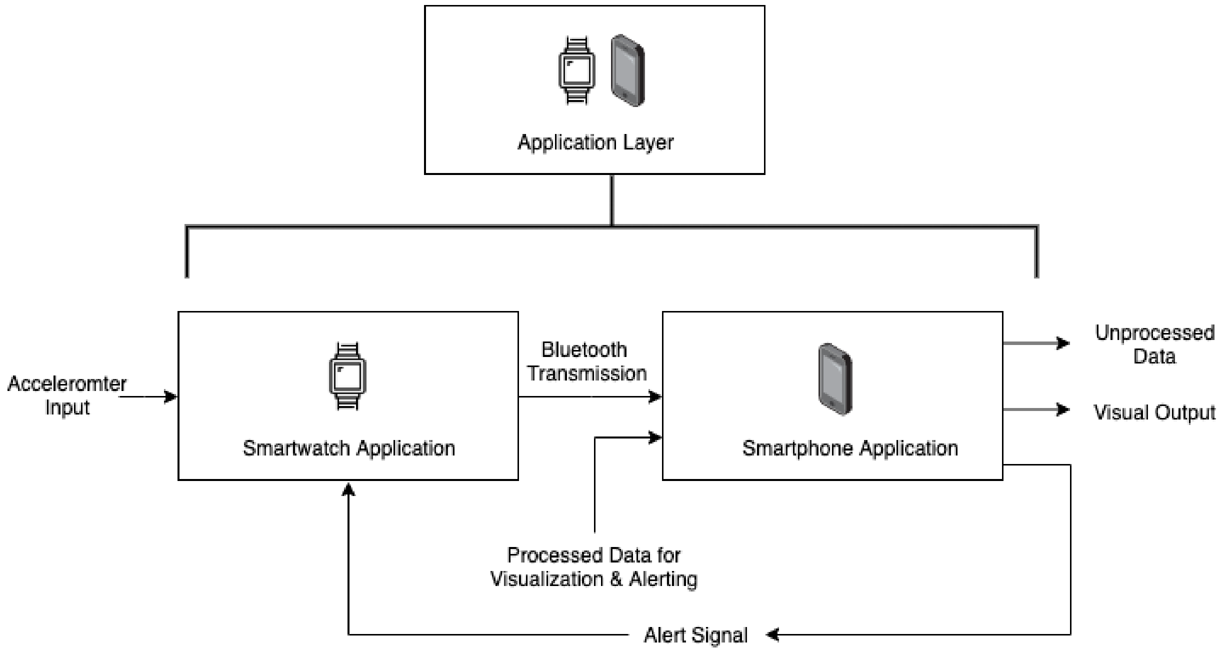

Figure 2: Detailed View of Application Layer

3.1.2 Sub Functions

Within this block, the smartwatch is responsible for continuously transmitting raw accelerometer data using Bluetooth to the smartphone application. On the other hand, the smartwatch application is responsible for sending this raw data unaltered to the processing layer. Additionally, the smartwatch application is responsible for issuing an alerting signal to the smartwatch when hypoglycemic events are detected and received from the server.

3.2 Processing Layer

The processing layer consists of the database and dedicated server. These handle the bulk storage and the computationally intensive calculations needed to identify hypoglycemic events.

3.2.1 Main Functions

This layer is responsible for the primary function of GlycoTrem which is the identification of hypoglycemic events. The database server receives the unprocessed accelerometer data and relays it to the dedicated server. The dedicated server performs calculations and analysis on this data and relays it back to the database server for long term storage. In addition, the dedicated server outputs the processed data (hypoglycemic events) to the application layer as outlined previously. In essence, the primary input of this layer is the unprocessed accelerometer data, while the primary outputs are the hypoglycemic events.

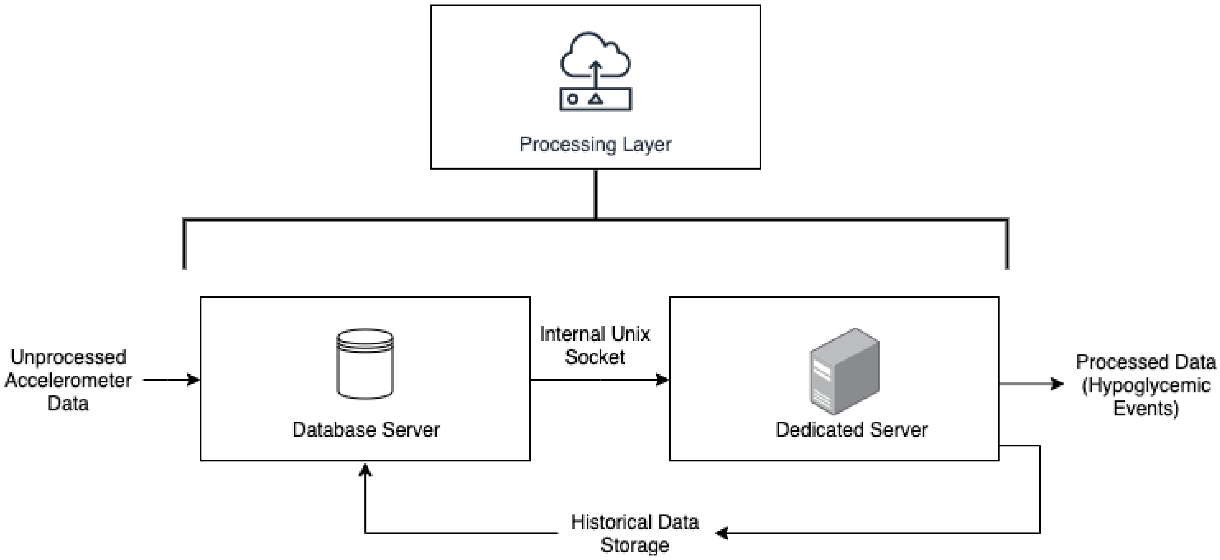

Figure 3: Detailed View of Processing Layer

3.2.2 Sub Functions

The database server is expected to archive and keep a record of historical processed data for each patient. This database is responsible for retrieving this information on-demand if requested from any other layer in GlycoTrem's design. In addition, the database is tasked with relaying the unprocessed data to the dedicated server through an internal UNIX socket [1] (since both servers are containers on the same physical machine).

3.3 Overall Detailed Model

By combining the functional blocks defined in Figures 2 and 3, the following over-all model is obtained in Figures 4 and 5. The model was rendered in left-to-right and top-down formats for clarity.

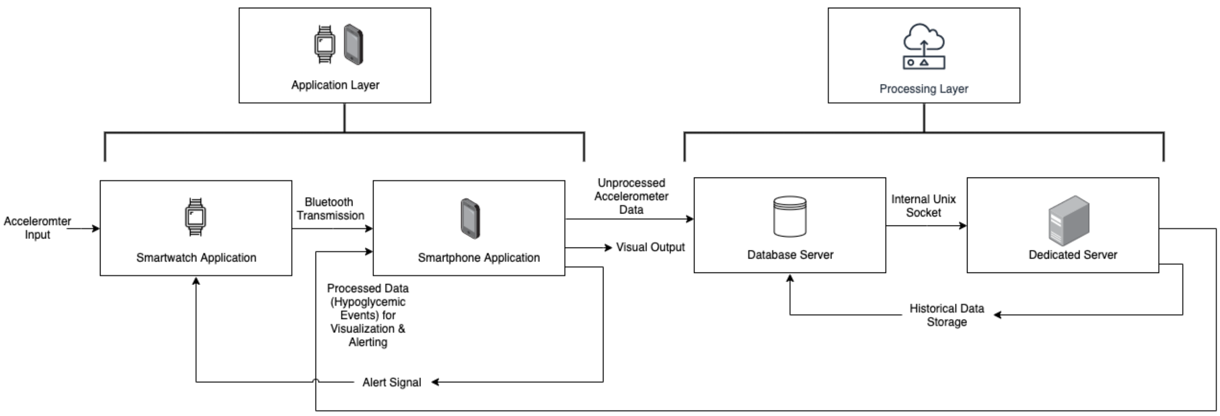

Figure 4: Detailed Overall View of GlycoTrem

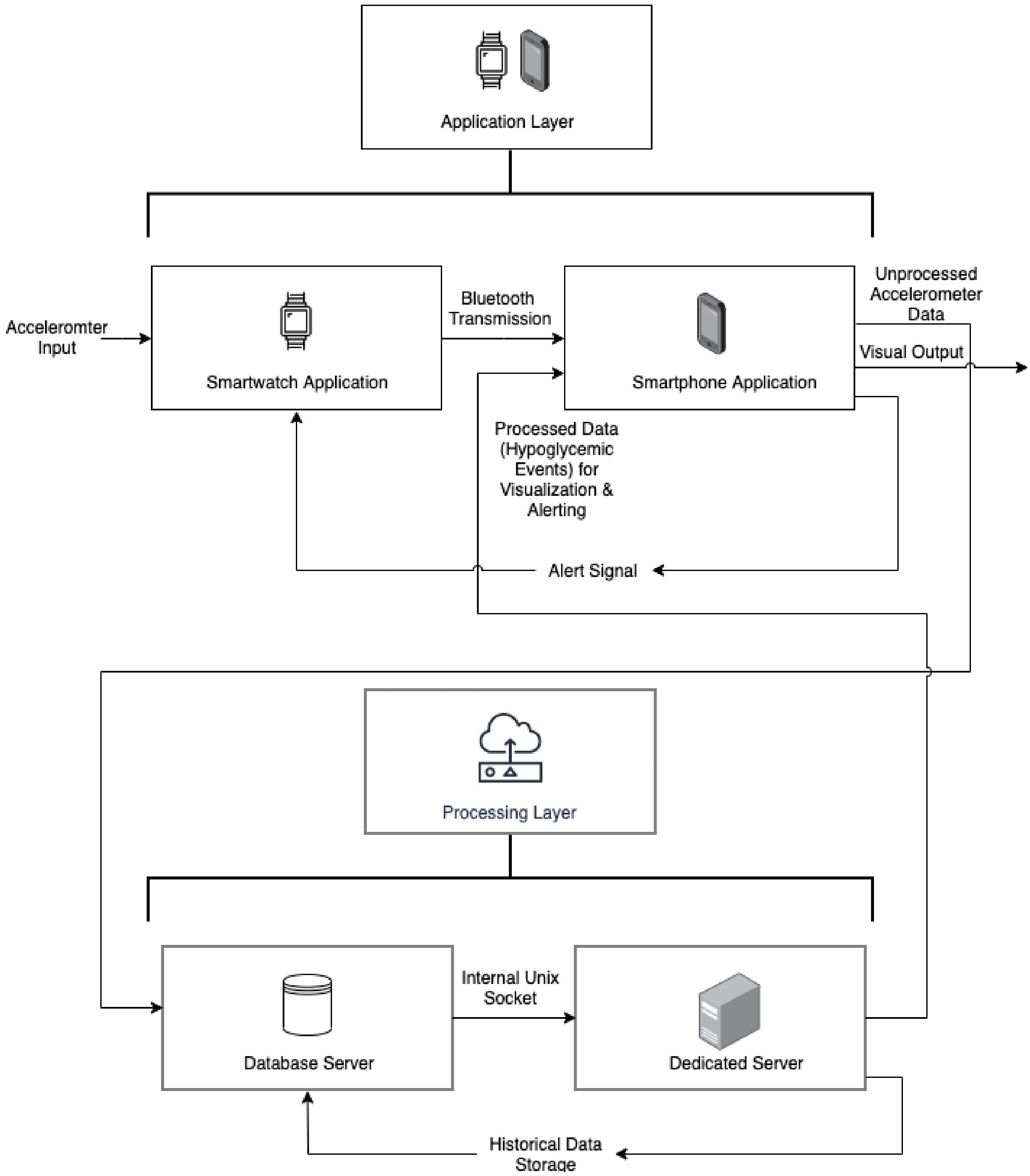

Figure 5: Top-Down Version of Detailed Overall View of GlycoTrem

As shown by Figures 4 and 5, the overall system outline contains one primary input which is the raw accelerometer data, and two primary outputs which are the hypoglycemic events and the visualized data form of the data from the smartwatch.

Inside the functional blocks, more internal inputs and outputs are clearly defined and their purpose is explained in their relevant sections. These were previously hidden in the black-box representation in Figure 1.

4 Material & Energy Flow

To reiterate, the system's input is simply the raw accelerometer data (x, y, and z coordinates) that is collected by the smartwatch application using the smartwatch's triple axis accelerometer. This data gets sent to the smartphone application, and from there it gets sent to the database and the dedicated servers for processing and storing. The dedicated server is also responsible of sending the processed data back to the smartphone application for visualization and alerting in case of a hypoglycemic event. This cycle briefly describes the complete data flow of the system.

In terms of energy consumption, for the users to be able to remain connected the servers, the smartphone is expected to be charged and have a functioning Internet connection. Furthermore, in order for GlycoTrem to undergo its planned data cycle, the accelerometer data needs to be continuously recorded by the smartwatch application and sent to the smartphone. This means that the smartwatch must be charged, worn, and connected to the smartphone via Bluetooth. Thankfully, smartwatches are becoming increasingly common-place and integrated in the daily charging routines of users.[2]

5 Design Implementation

The implementation of GlycoTrem's design requires a large quantity of accelerometer data from both healthy and diabetic patients in order to train the algorithm in the detection and extraction of hypoglycemic events.

In addition, a solution that allows low latency communication between the smartphone application and the dedicated server is paramount to be able to process data in a reasonably small amount of time. The implementation of the database/processing server combination as described in the model allows for near-instantaneous communication between these two modules. This eliminates a substantial amount of latency that can potentially offset the latency introduced in the smartphone to server link.

The final implementation challenge is the battery life and safety of the wearable device. For the smartwatch solution, the relevant battery safety measures are taken care of by the device manufacturer[3] and no further investigation is required. The battery life of different smartwatch models and operating systems will need to be carefully analysed for an optimal energy flow scenario that allows for extended logging. For the potential ring wearable that is developed in-house, testing the safety and reliability of the batteries in different conditions and modes of use would be necessary for the implementation of the product.

6 Findings Analysis

Upon looking at the top-level one block form of GlycoTrem's system, and then breaking it down into all of its functions and components, a better understanding of this system was reached. Thanks to this, the proper approach to implementing the design may now be taken by studying these functions and sub-functions and prioritizing certain tasks. For instance, it became evident that the data collection layer should be the number one priority at this point of the project, considering that it is the only input to the overall system. The algorithms that handle the computational aspect of the system, however, prove to be just as important as the data collection, as little can be deduced from raw accelerometer data.

Moreover, the study of the energy consumption of the system showed that the battery life of the smartwatch/smartphone pair plays a big role in GlycoTrem's functionality. The smartwatch application is expected to collect *and* send to the smartphone application the accelerometer data continuously. This may result in draining the smartwatch's battery faster than anticipated, meaning further testing and optimization of the smartwatch application will be needed.

7 Conclusion

The components of GlycoTrem can be summarized into two functional blocks with a singular primary input (accelerometer data) and two primary outputs (hypoglycemic events and visualized data). The design breakdown highlights the challenges and considerations that need to be taken into account such as energy flows, battery life, physical constraints, technological considerations, and safety.

8 References

[1] M. Kerrisk, *Unix socket manual*, Aug. 2019. [Online]. Available: http://man7.org/linux/man-pages/man7/unix.7.html.

[2] H. Jeong, H. Kim, R. Kim, U. Lee, and Y. Jeong, "Smartwatch wearing behavior analysis: A longitudinal study", *Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies*, vol. 1, no. 3, p. 60, 2017.

[3] *What's iec 62133-2:2017 certification of lithium-ion battery?* [Online]. Available: https://www.lipolbattery.com/What's-IEC62133-2-2017-Certification-of-Lithium-ion-Battery.html.