



INSIGHT Teams Expo Presentation

CAL STATE LA

College of Engineering, Computer Science and Technology

INSIGHT - Mobile App Virtual Community

Advisor:

Dr. Won

Graduate Student

Advisor:

Kevin Delao

Members:

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Martinez

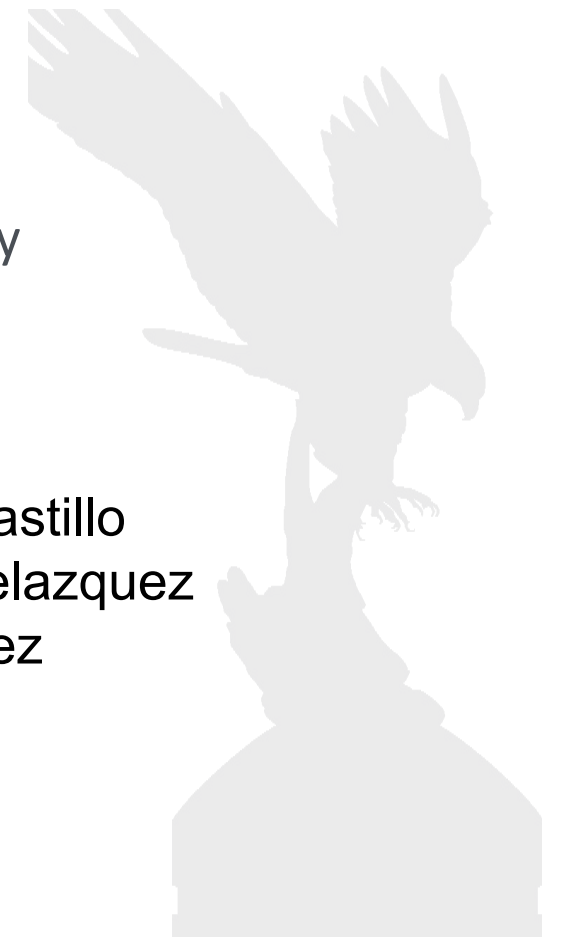
Natalie Diaz

Esau Martinez

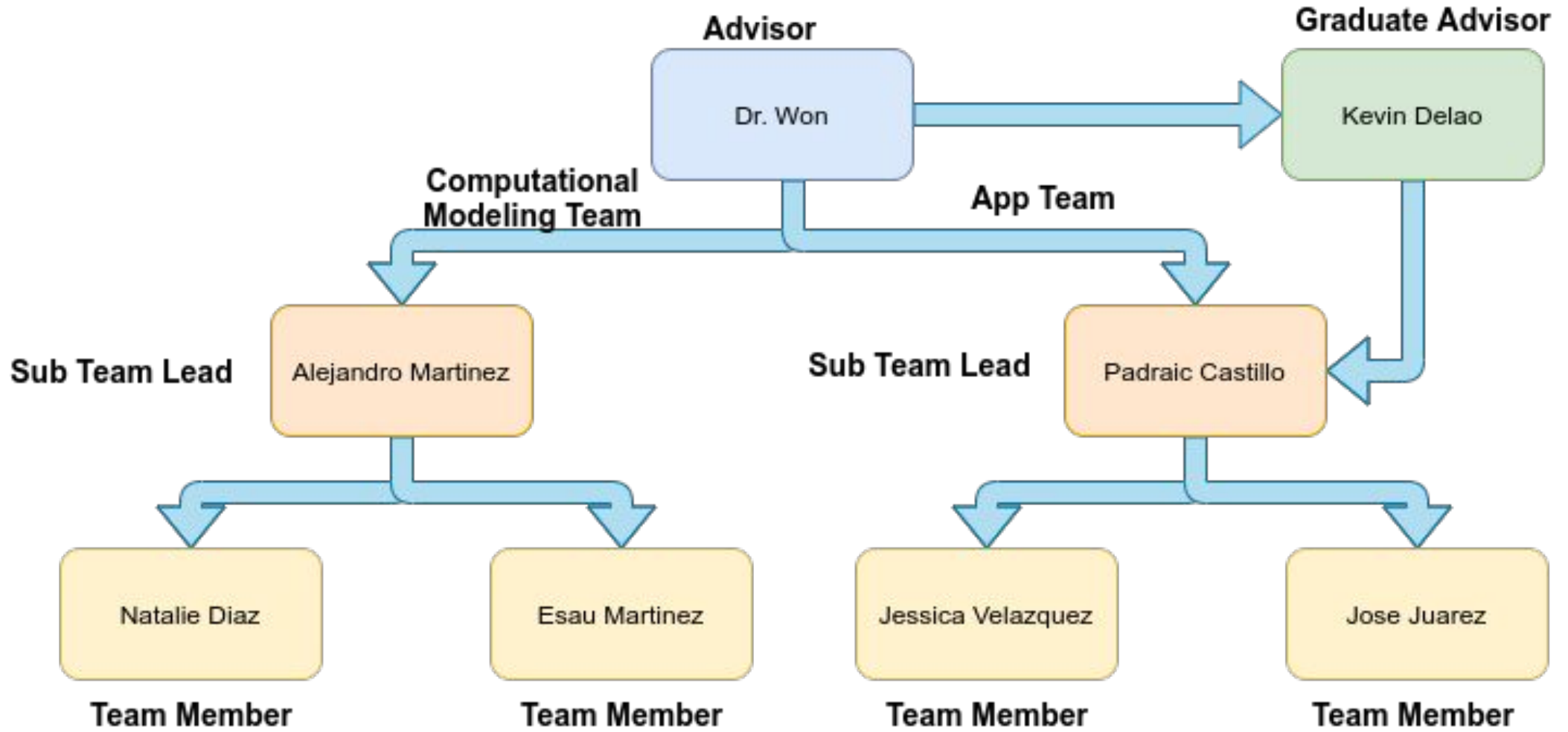
Padraic Castillo

Jessica Velazquez

Jose Juarez



Team Organization





INtelligent

System for

Inspiring

Glucose-related health management for

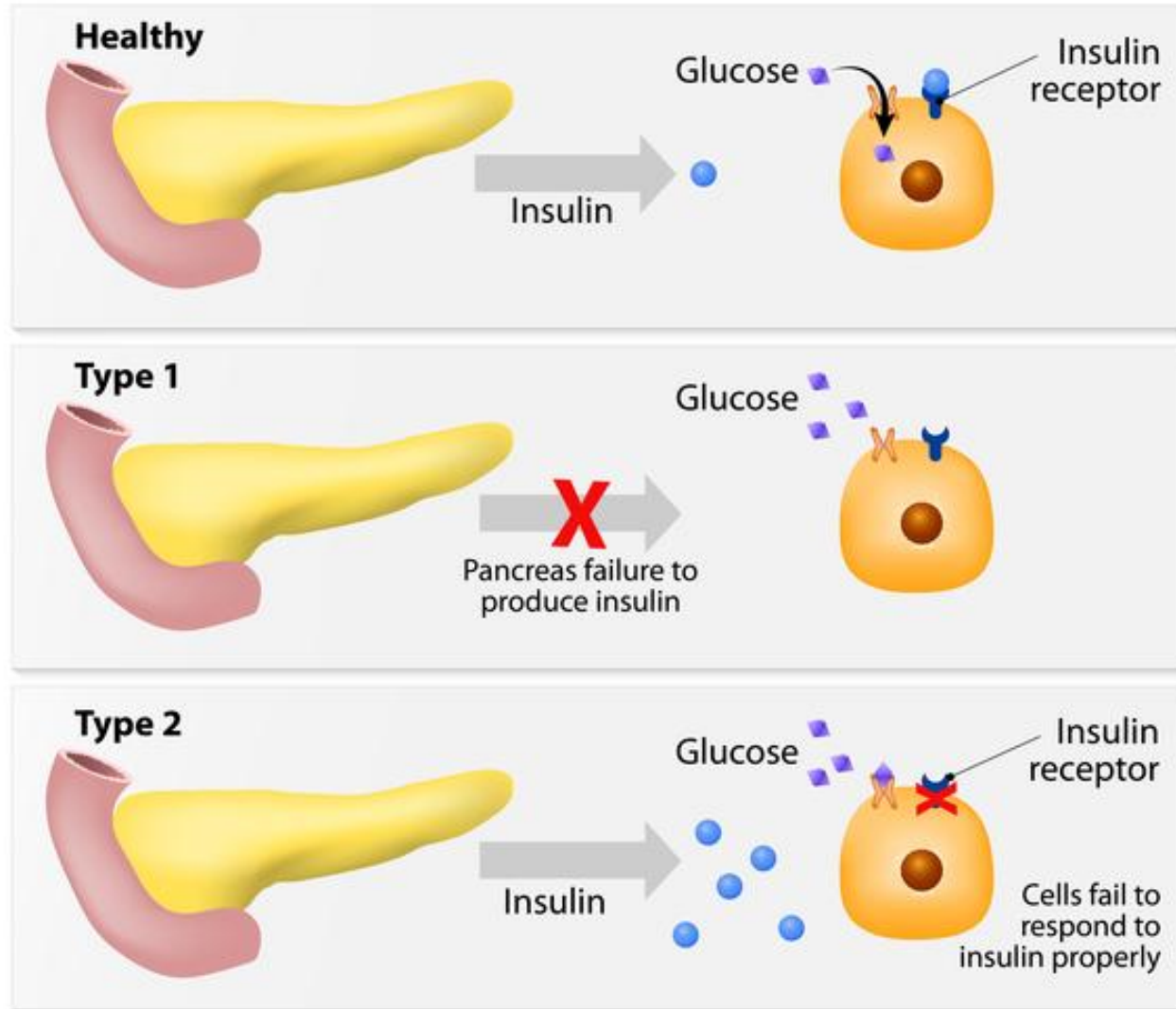
Hispanic individuals with

Type 2 diabetes



DIABETES MELLITUS

Background:



Problems and Scope

Problem:

- 12.5% Hispanic
- prescribed treatment
 - nutrition
 - physical exercise

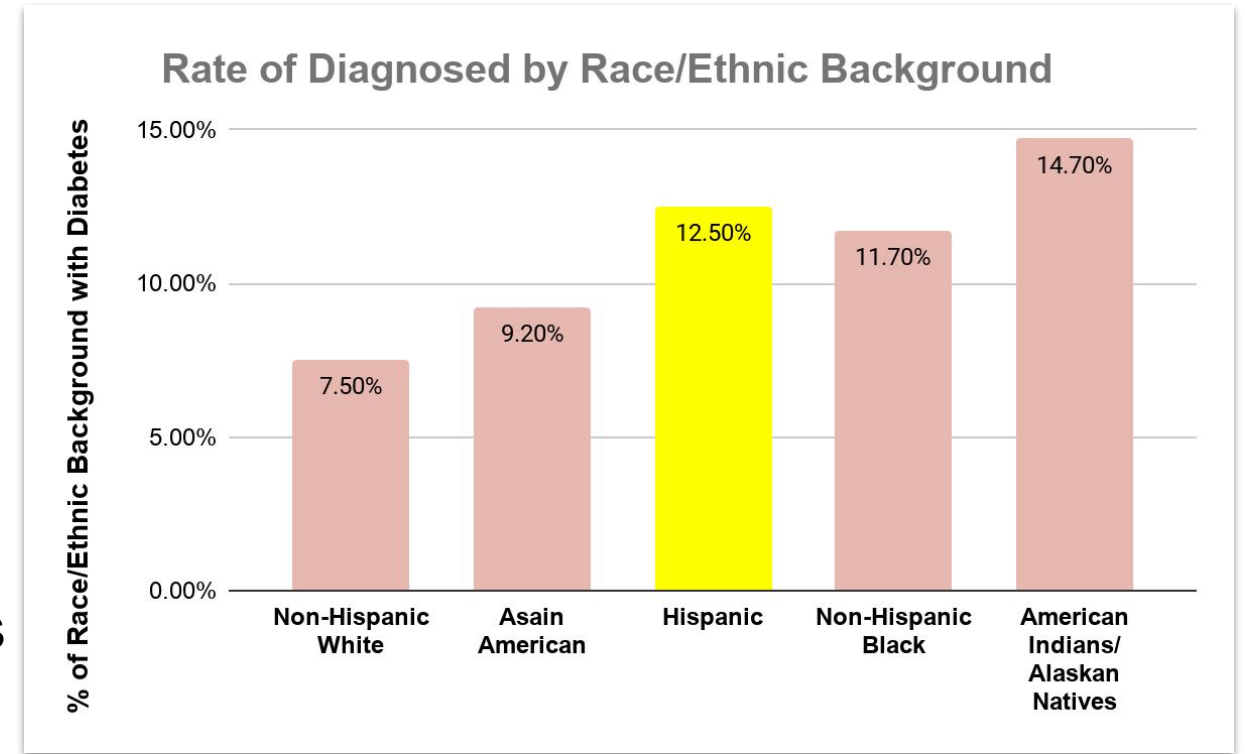
Objective: To design and implement a social media-based mobile app that helps individuals to manage their diabetes:

App Sub-Team

-a culturally relevant app and provide a virtual support community

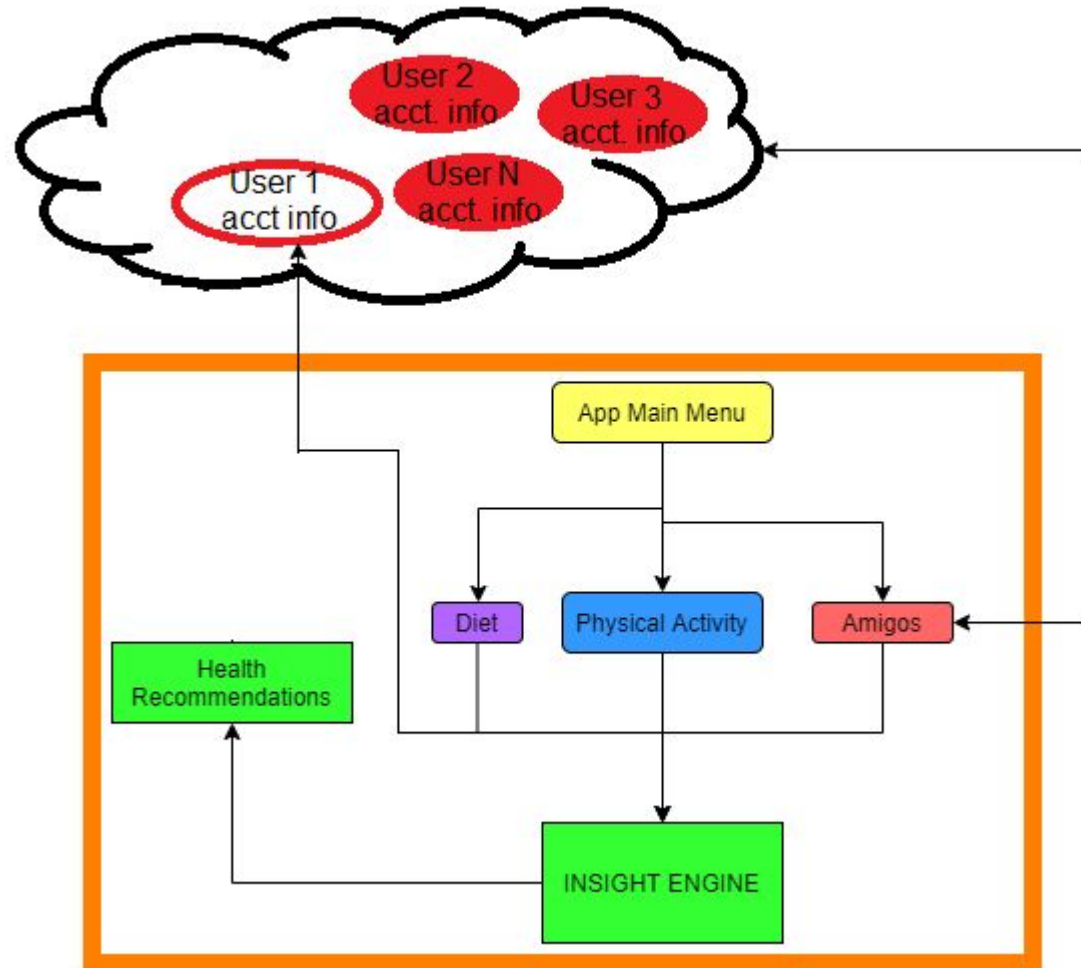
Computational Sub-Team

-physiological model to predict glucose to help guide lifestyle choices



INSIGHT Mobile App Virtual Community

- Create a community (Amigos) around diabetes management
- Give the user an INSIGHT into their diabetes



App Trade Analysis

Applications Trade Analysis

Diabetic Applications	Price			Tracks/Records							Sync		Notifications/Reminders	
	Free	Pay	Premium	Meals	Physical Activity	Blood Glucose	Medication	Carb Intake	HbA1c	Insulin	Devices	Apps	High/Low	To Check
Glucose Buddy	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Diabetes & Diet tracker		✓		✓	✓	✓	✓	✓	✓	✓	✓		✓	✓
Diabetes:M			✓	✓	✓	✓	✓	✓	✓	✓	✓			✓
Noom	✓		✓	✓	✓	✓		✓					✓	✓
Beat Diabetes	✓													
mySugr	✓		✓	✓	✓	✓	✓		✓	✓	✓			✓
Health2sync	✓		✓	✓		✓	✓							
Diabetes Connect	✓			✓	✓	✓		✓						✓
OneTouch Reveal	✓			✓	✓	✓		✓		✓	✓		✓	✓
Social Diabetes	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓		
Diabetes	✓					✓					✓			✓
Bant	✓			✓	✓	✓	✓	✓		✓	✓	✓		✓
One Drop	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓			✓
INSIGHT	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Premium

Pay to get more features

Price

App is free or not

Tracks/records

Tracks and keeps a record of the information

Sync

Able to sync to devices and/or apps

Notifications/Reminders

Notifications when blood glucose levels are too high and/or too low, reminders to check blood glucose level.

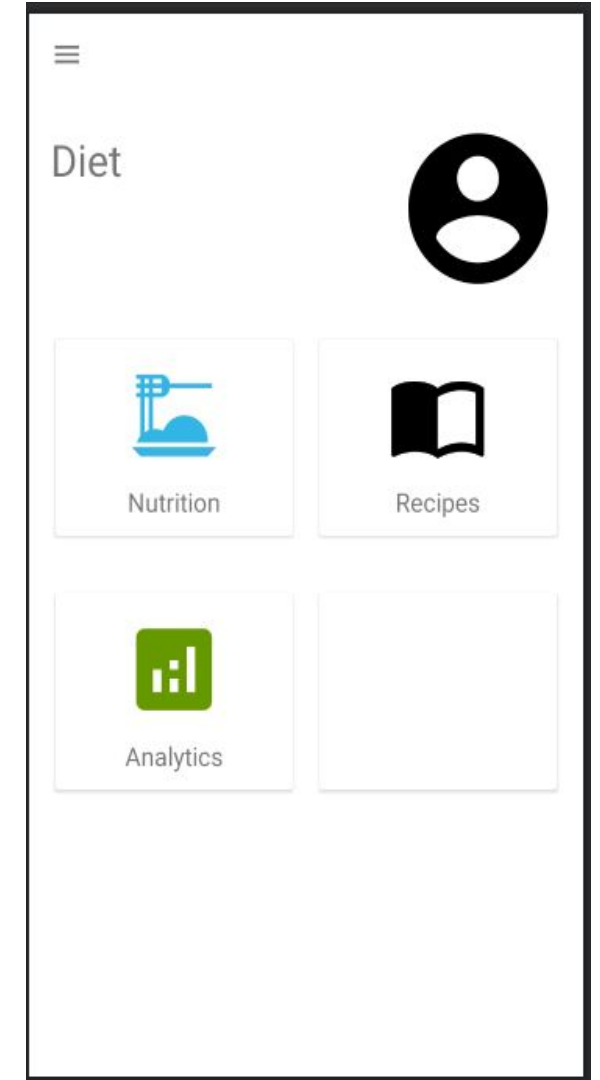
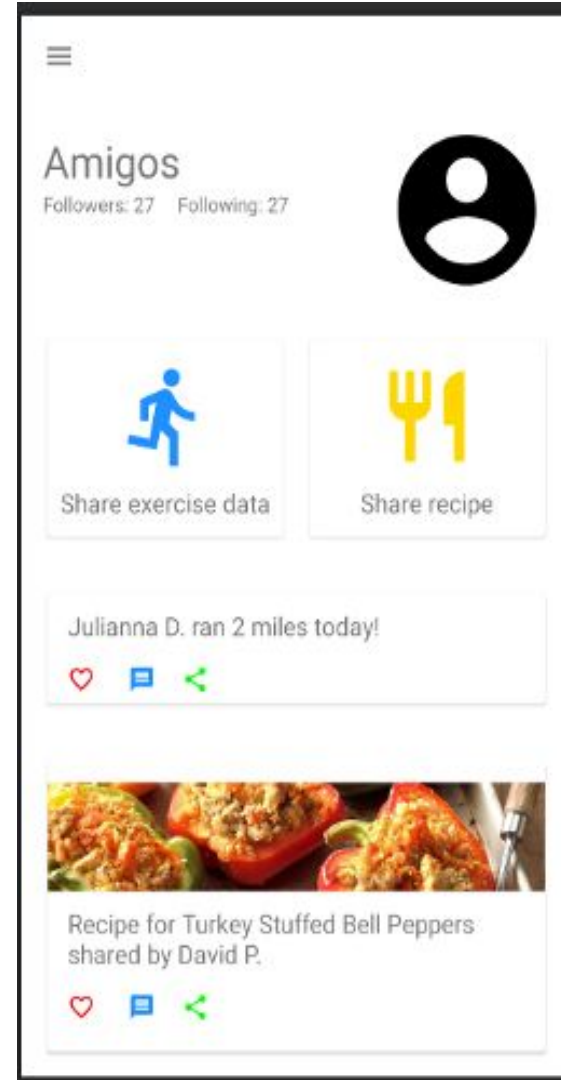
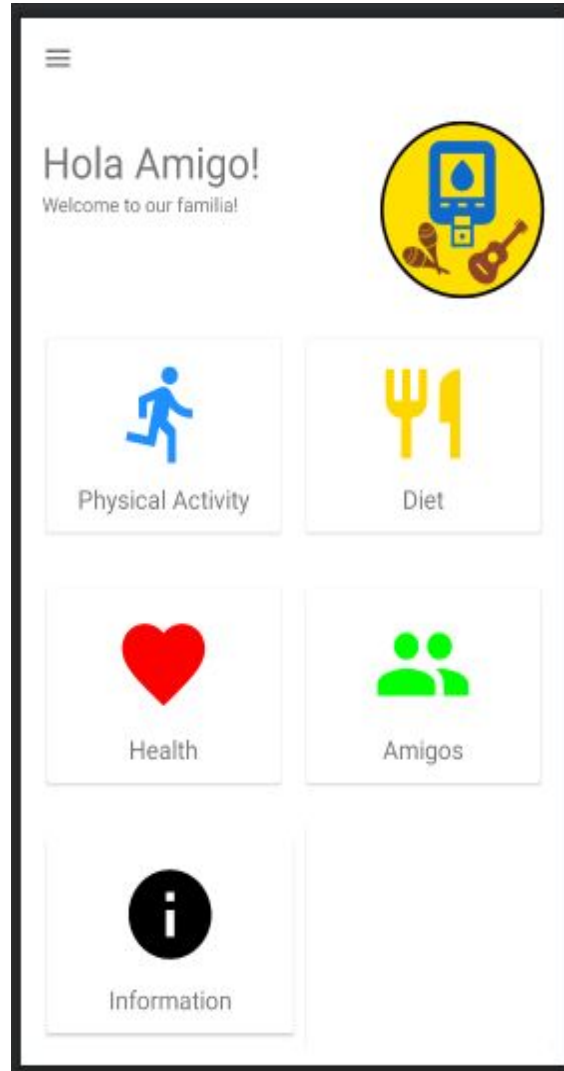
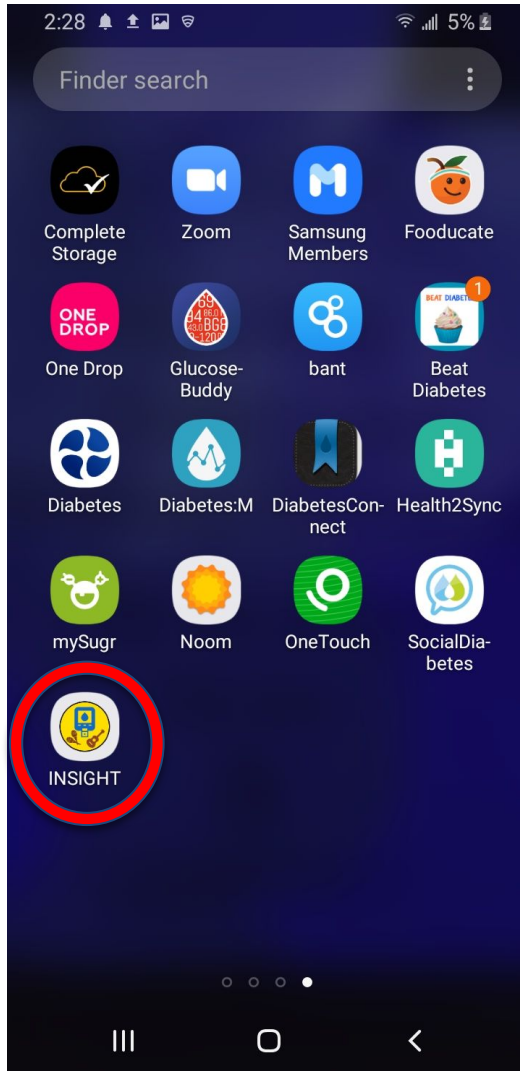
App Trade Analysis

Applications Trade Analysis

Diabetic Applications	How to Track Food			Reports					Info		Community			Language	
	Database	Scanner	Photo	PDF	Graphs	Import	Export	Printable	Advice	Lessons	Personal Assistant	Friends	Social	English	Spanish
Glucose Buddy	✓	✓	✓		✓			✓						✓	
Diabetes & Diet tracker	✓	✓			✓				✓	✓	✓			✓	
Diabetes:M	✓	✓		✓	✓	✓	✓							✓	✓
Noom	✓	✓			✓				✓	✓	✓			✓	
Beat Diabetes									✓	✓				✓	
mySugr	✓		✓	✓	✓	✓	✓	✓	✓		✓			✓	✓
Health2sync			✓	✓	✓		✓		✓	✓		✓		✓	
Diabetes Connect					✓		✓							✓	
OneTouch Reveal				✓	✓		✓		✓	✓				✓	✓
Social Diabetes				✓	✓		✓							✓	✓
Diabetes				✓	✓	✓	✓							✓	✓
Bant			✓		✓									✓	✓
One Drop	✓	✓	✓		✓		✓		✓		✓	✓	✓	✓	✓
INSIGHT	✓			✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓

How to Track	Nutrition info is gathered through food database, a scanner and/or through in-app camera to keep record of food consumption
Reports	The reports are available in PDF, could be printable, progress are displayed by graphs, are able to be imported/exported
Info	Educational Information is provided either snipits of advice or lessons provided
Community	User has a personal assistant that helps or has friends(other user or personal)
Language	Available in english and/or spanish
	Friends is only 1 person and social media aspect is being able to comment on other people's entries but can't communicate with other users

INSIGHT Functionality

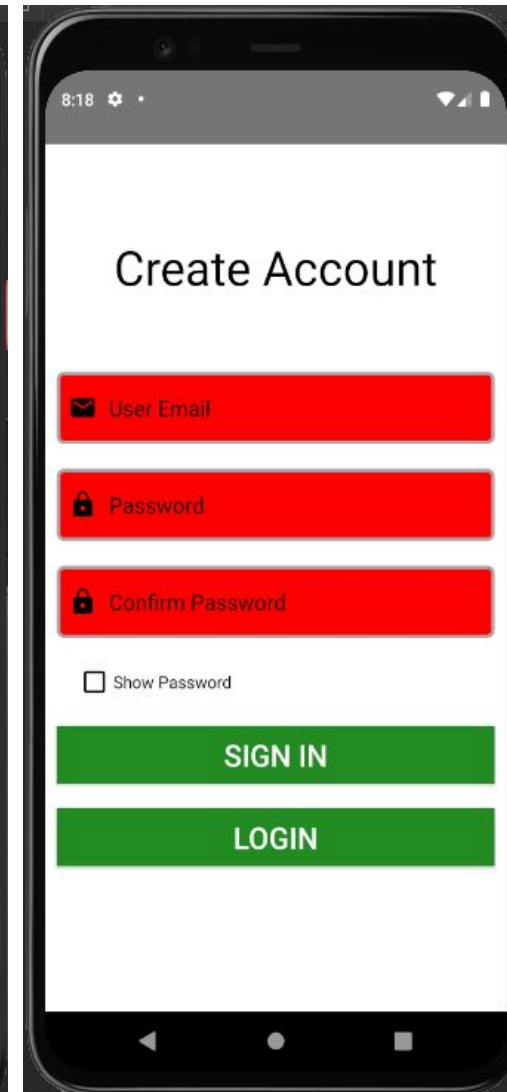
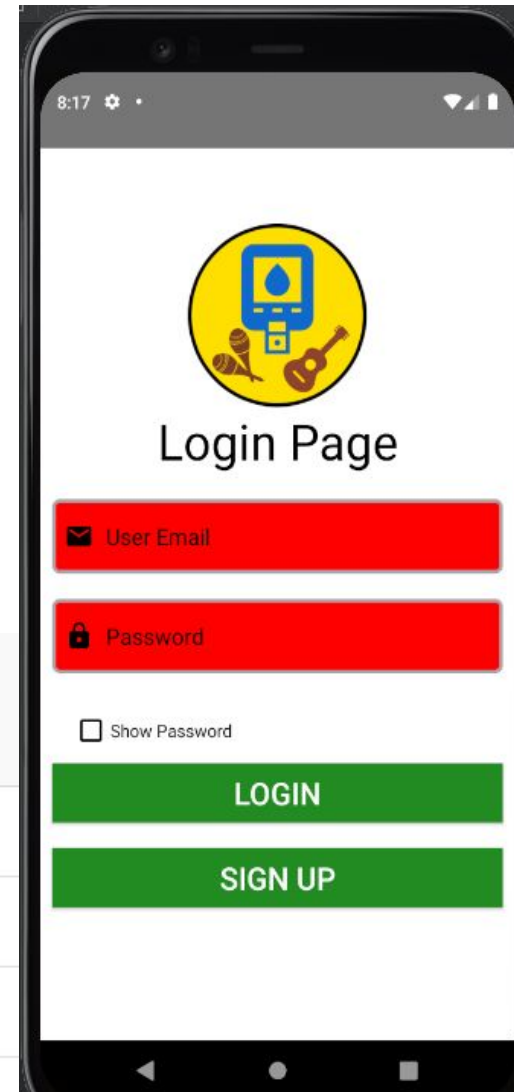


Amigos backbone – cloud services or mediators

- Google's Firebase is a platform that mediates user data storage and sharing.
- Users create secure accounts to store health status and recipe library.
- Users can share their status and data with each other => can send each other encouragement

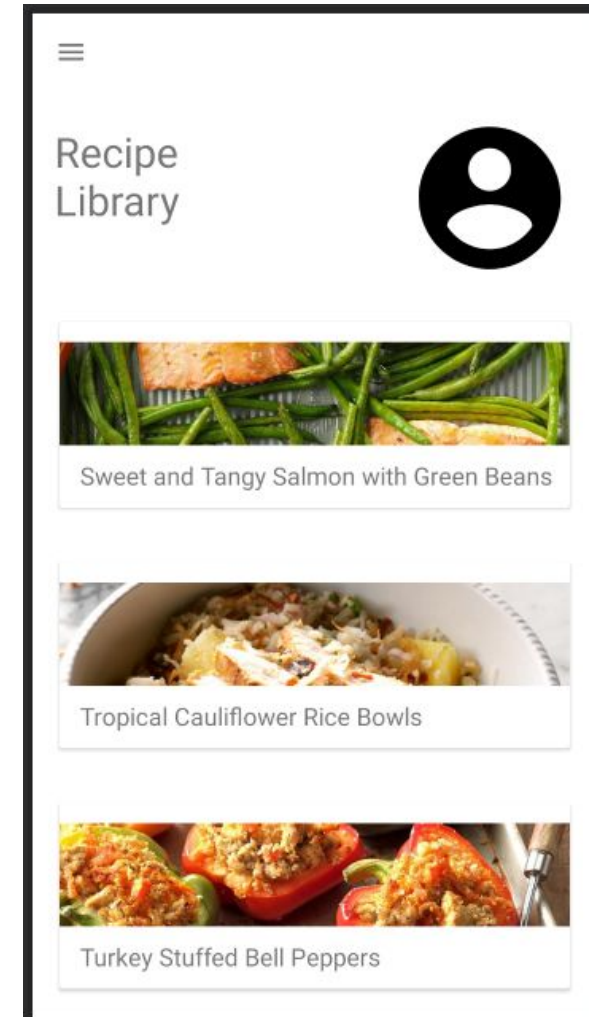
Search by email address, phone number, or user UID Add user

Identifier	Providers	Created	Signed In	User UID ↑
josemjuarezjr@rocketmail.c...	✉	Apr 21, 2021	Apr 21, 2021	G9zfcCaotjeVGnzFbWR3xr20CDM2
jjuares36@calstatela.edu	✉	Apr 8, 2021	Apr 20, 2021	HQdxtNygr4epPxsnej4zT11OWq52
josemjuarezjr@icloud.com	✉	Apr 20, 2021	Apr 21, 2021	cVYAbkCQL7dxGGklliu5RYXo00e2



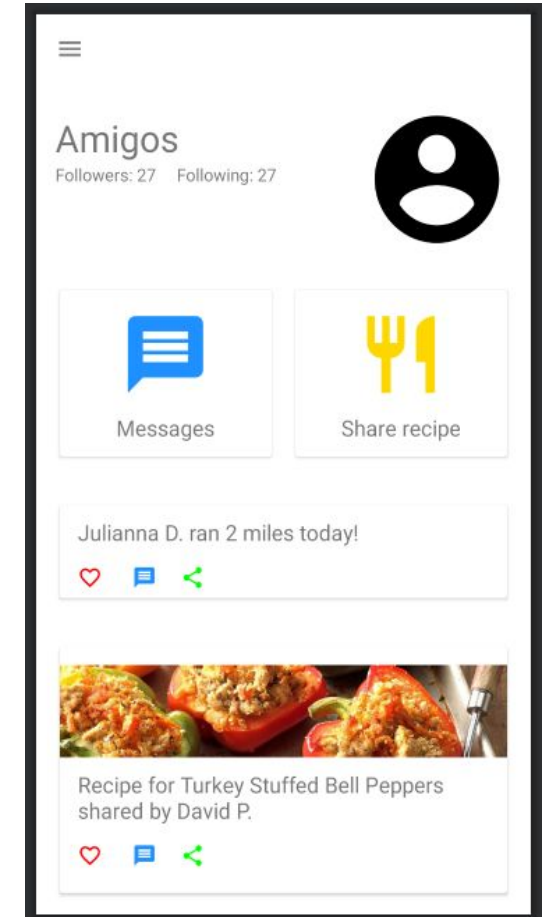
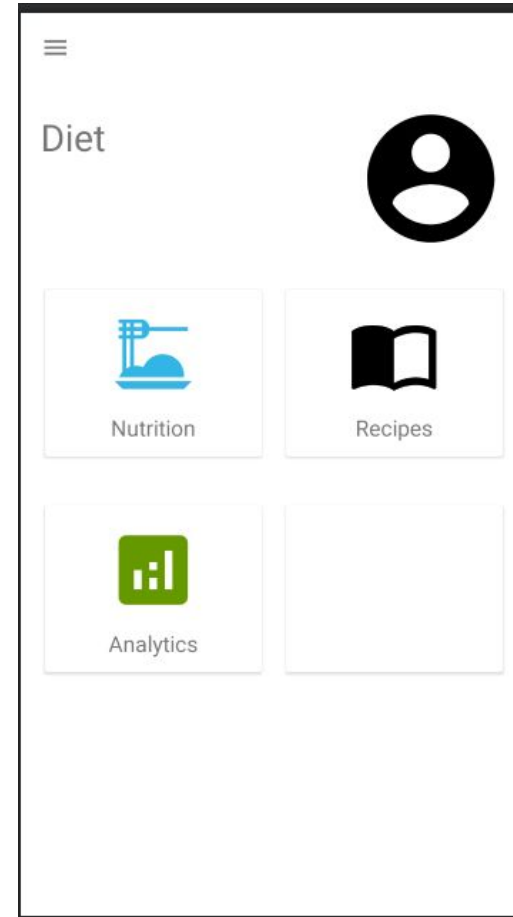
Recipe Feature in Diet Fragment

- Capture button
 - Will access phone camera to take picture of dish
- Input
 - Users will add an ingredients list and directions that will be accessible to other users after the recipe is shared
- Save button
 - Users will be able to save recipes they have posted and recipes their “Amigos” have posted for future reference

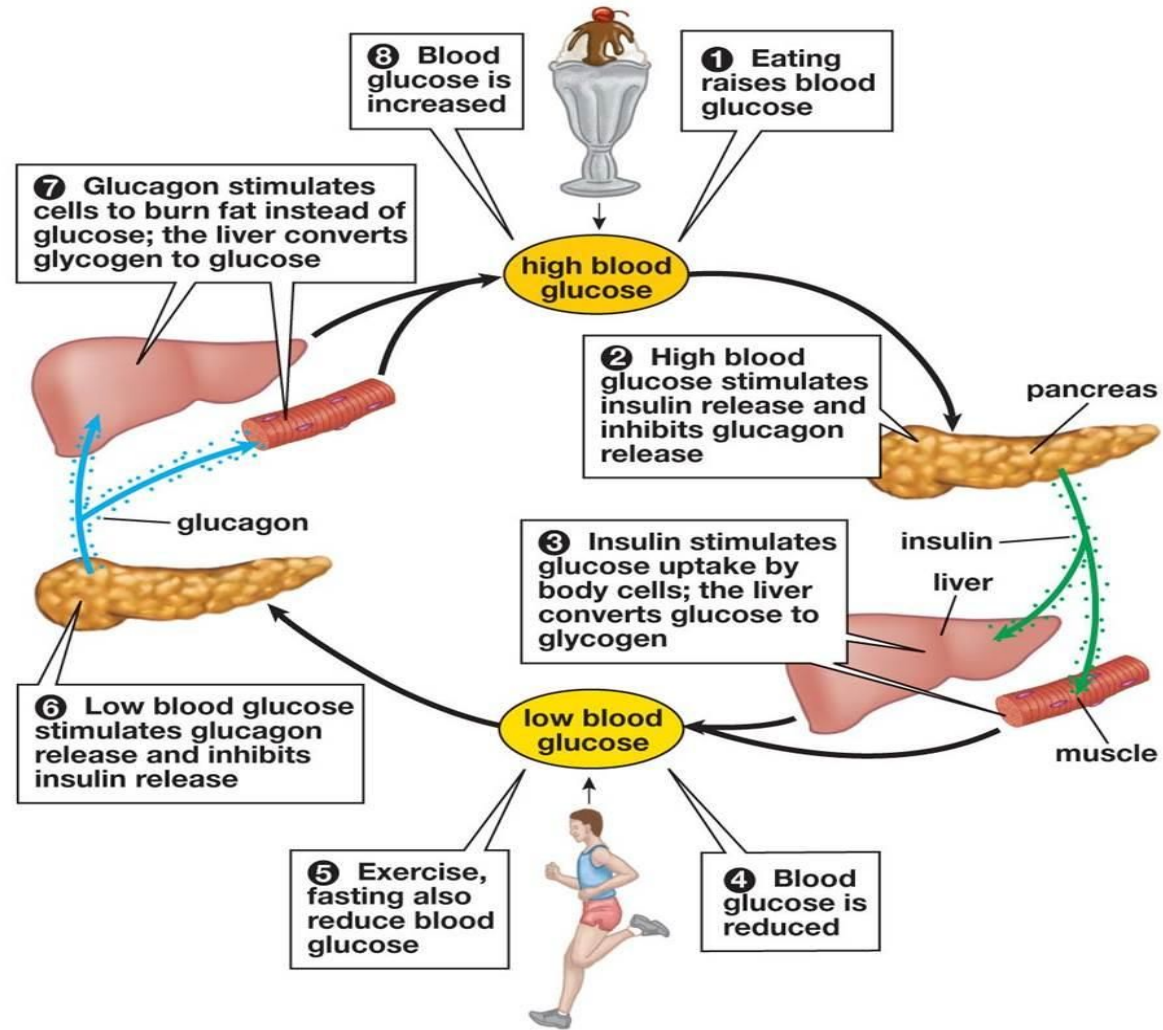


Future Implementations

- Diet
 - Completion of the Analytics and Nutrition features
 - Graphs and charts displaying information over a given time period (i.e total calories per day, average caloric intake)
 - Integration of food database API for nutrition information
- Amigos
 - Displays user's profile picture, followers and following
 - Tabs where user can message their friends and share their recipes
 - Displays friends' statuses
 - Like
 - Comment
 - Share



INSIGHT Engine - Computational Model

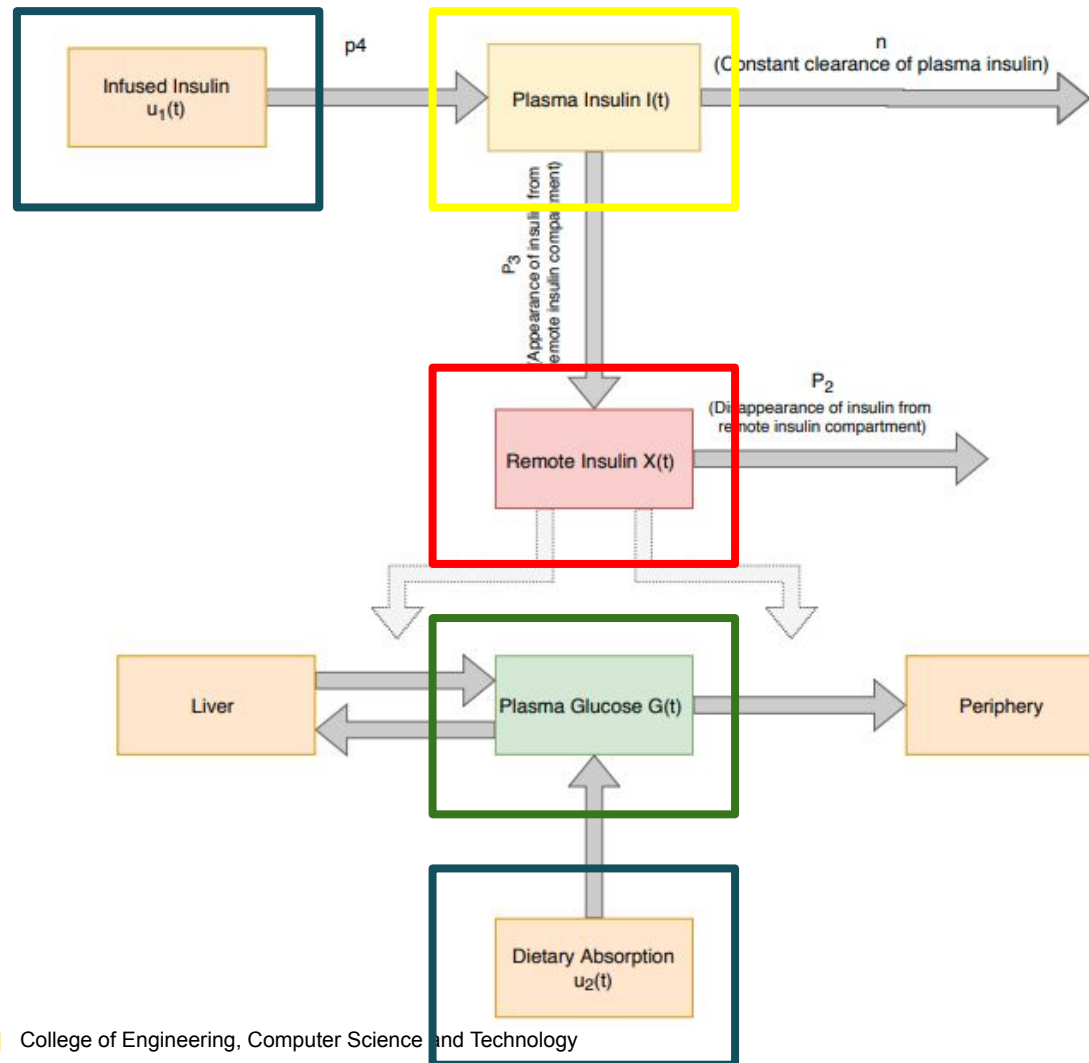


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Insight Engine - Trade Analysis

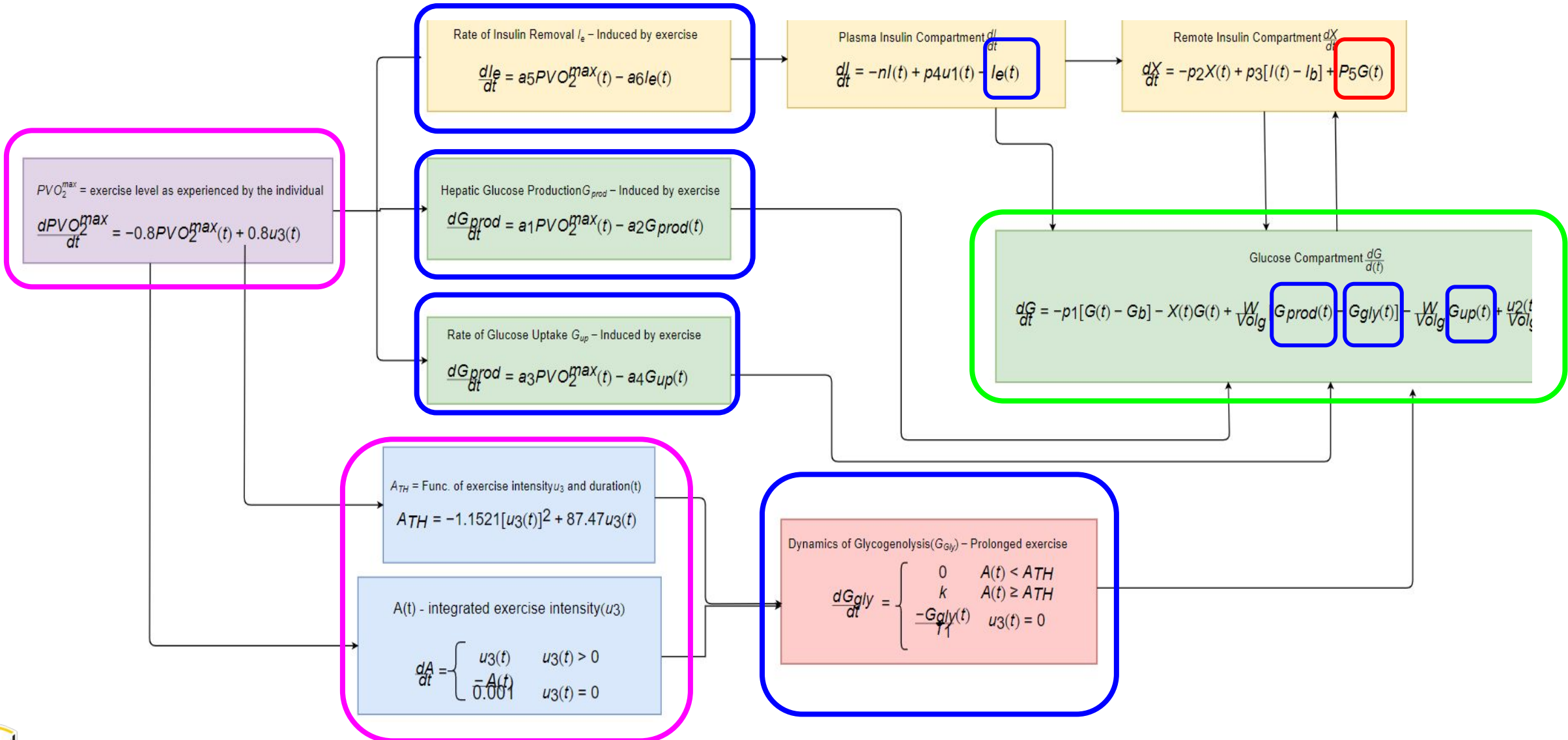
Models	HOMA	Bergman	Mari
Diabetes Type	Type 2	Type 1/2	Type 2
Accuracy	R= 0.88	R= 0.75-0.95	R=0.49
Predictions	Insulin Sensitivity & B-cell Function	Glucose & Insulin Concentration	Index of Insulin Sensitivity
Allowable Conditions	Insulin injection, Fasting and Eating	Insulin injection, Fasting, Eating, Exercise	Fasting and Eating
Equations	$\%S = \left(\frac{FBI * FPG}{22.5} \right)^{-1}$ $\%B = 20 * \frac{FPI}{(FPB - 3.5)}$	$\frac{dI}{dt} = -nI(t) + p_4u_1(t)$ $\frac{dX}{dt} = -p_2X(t) + p_3(I(t) - I_b)$ $\frac{dG}{dt} = -p_2G(t) - X(t)G(t) + p_1G_b + \frac{u_2(t)}{Vol_G}$	$Cl = Cl_b + S\Delta I$ $V \frac{dG(t)}{dt} = -Cl(t)G(t) + R_2(t)$

Bergman Glucose Model

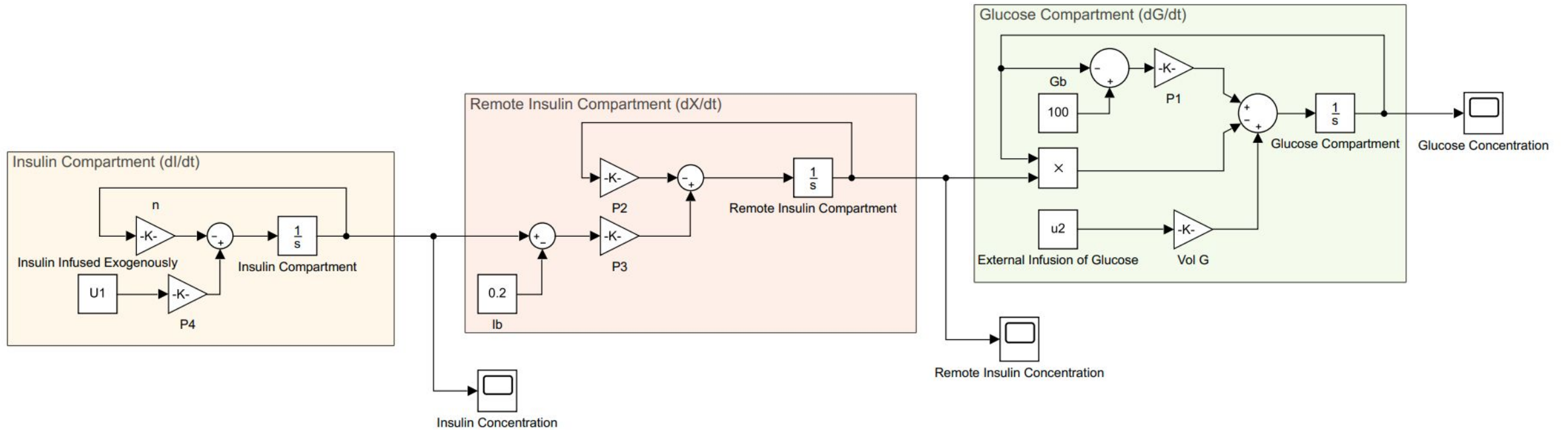


- Broken into three compartments and two Inputs
- Infused Insulin ($U_1(t)$)
- Dietary Glucose Absorption ($U_2(t)$)
- Plasma Insulin Compartment
 - $dI/dt = -n * I(t) + P_4 * u_1(t)$
- Remote Insulin Compartment
 - $dX/dt = -P_2 * X(t) + P_3 * [I(t) - I_b]$
- Plasma Glucose Compartment
 - $dG/dt = -P_1 * G(t) - X(t) * G(t) + P_1 * G_b + [u_2(t) / Vol_G]$

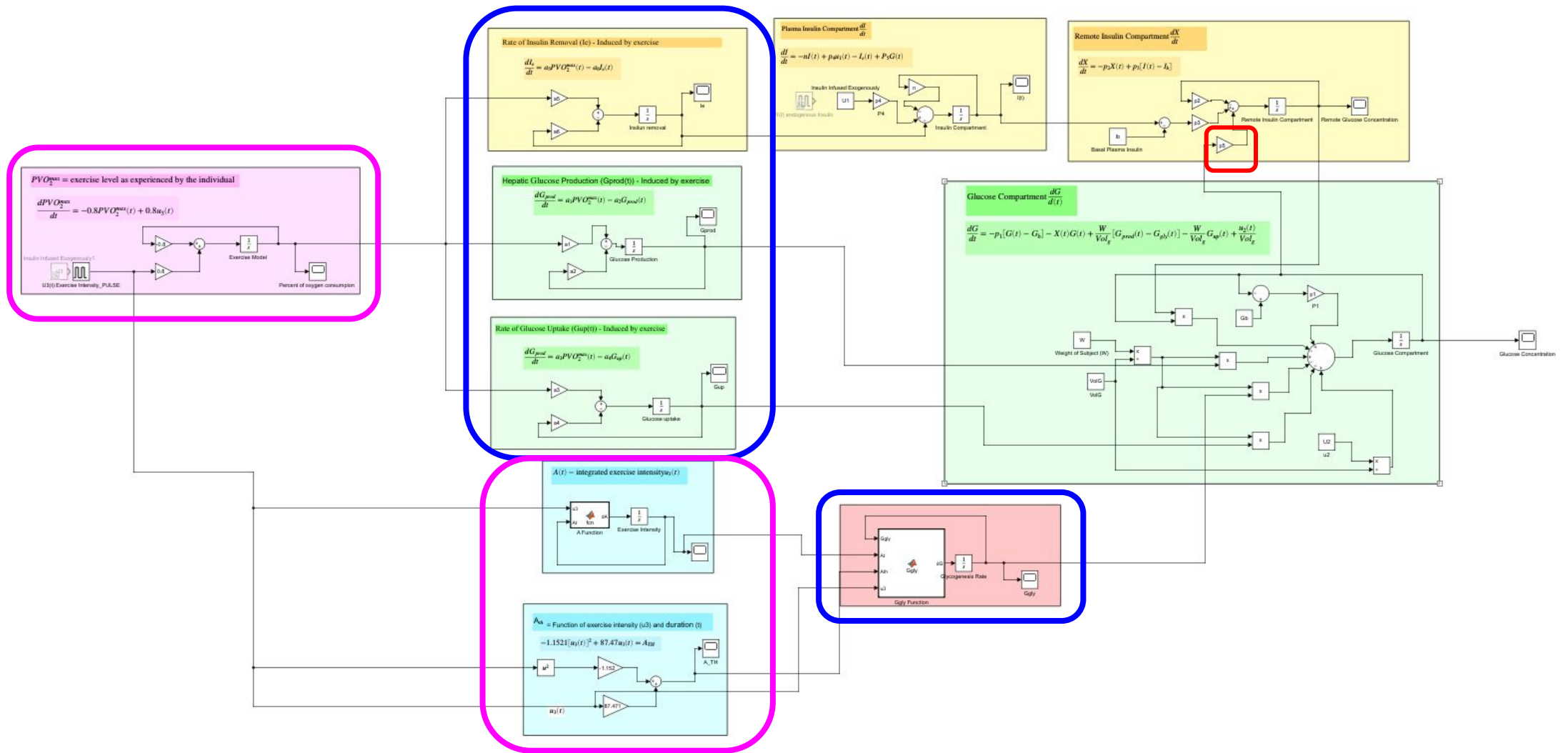
Extended Bergman Model



Simulink Model



Extended Bergman Model Simulink

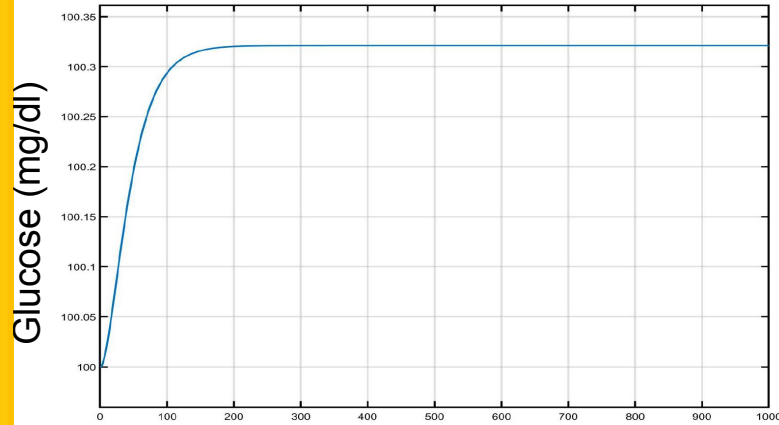


Simulink Simulation Test Runs



Validation – Bergman model

Zero Initial Conditions



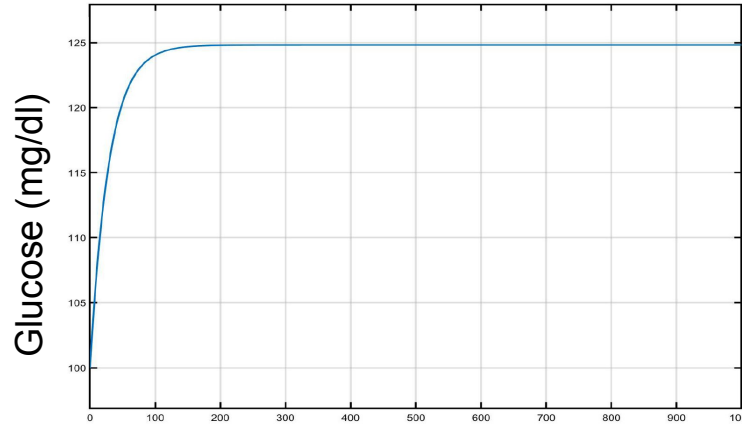
Initial Conditions
Glucose Intake: 0
Insulin Intake: 0
Ib:0.2
Plasma Insulin: 0
Plasma Glucose: 100

Prediction:
Very little change.

Results

Both inputs into the system are set to zero. The rise in glucose level of ~0.3 is due to the gain in the formula itself.

Extreme Glucose Input



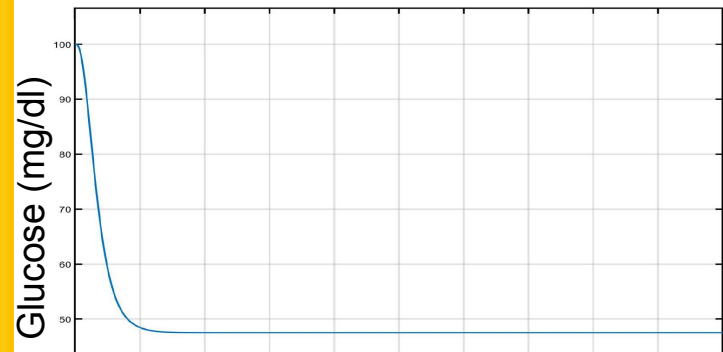
Initial Conditions
Glucose Intake: 100
Insulin Intake: 0
Ib:0.2
Plasma Insulin: 0
Plasma Glucose: 100

Predictions:
Blood glucose level will rise greatly due to the input of glucose and no exogenous insulin injection.

Results:

Blood glucose did rise but not to dangerous levels as we imagined.

Extreme Insulin Input



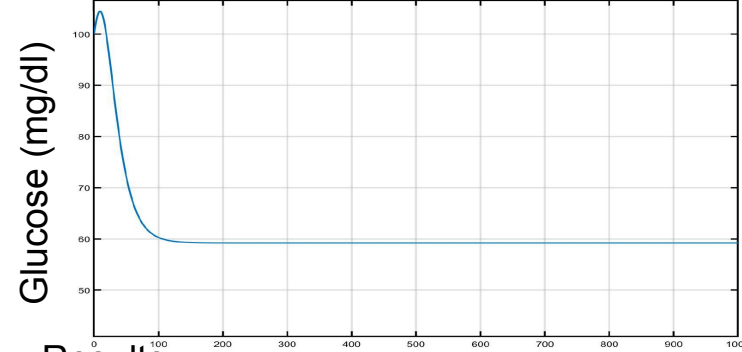
Initial Conditions
Glucose Intake: 0
Insulin Intake: 100
Ib:0.2
Plasma Insulin: 0
Plasma Glucose: 100

Prediction:
Blood glucose level will drop. This will be due to the lack of glucose input but high level of insulin input.

Results:

Blood glucose level plummeted as predicted but the drop was more than expected.

Extreme Glucose and Insulin



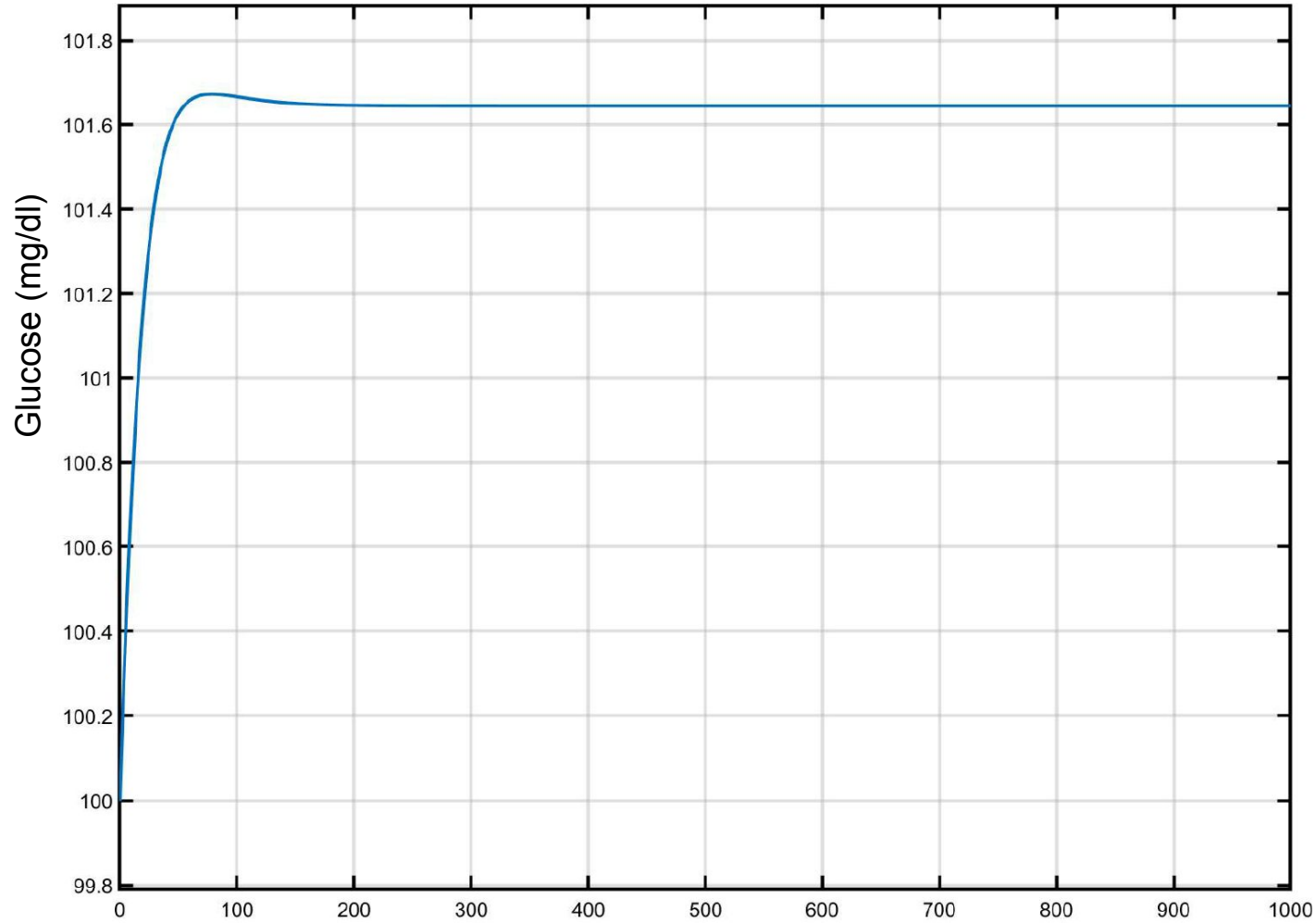
Initial Conditions
Glucose Intake: 100
Insulin Intake: 100
Ib:0.2
Plasma Insulin: 0
Plasma Glucose: 100

Prediction:
The high insulin input should override the high glucose input.

Results:

The glucose input was observed to prevent the blood glucose level from dropping as low as in case of insulin input only.

Normal Glucose and Insulin Inputs



Initial Conditions

Glucose Intake: 10

Insulin Intake: 1

Ib:0.2

Plasma Insulin: 0

Plasma Glucose: 100

Predictions:

We should get a minimal rise in the blood glucose levels. Due to the insulin input being low.

Results:

As we predicted the blood glucose level only rose by 1mg/dl

Inputs Table

Case Condition		Model Parameters / Inputs				
		u1	u2	u3	p1	p5
1	Starvation - healthy	0	0	0	0.5	3.00E-06
2	Starvation - diabetic-T1	10	0	0	0.035	0
3	Starvation - diabetic-T2	0	0	0	0.1	5.00E-06
4	Post-meal - healthy	0	100	0	0.5	3.00E-06
5	Post-meal - diabetic-T1	10	100	0	0.035	0
6	Post-meal - diabetic-T2	0	100	0	0.1	5.00E-06
7	Exercise - healthy	0	0	0.9	0.5	3.00E-06
8	Exercise - diabetic-T1	0	0	0.9	0.035	0
9	Insulin shot - healthy	10	0	0	0.5	3.00E-06
10	Insulin shot - diabetic-T1	10	0	0	0.035	0

Extended Model - Starvation Results

Initial Conditions

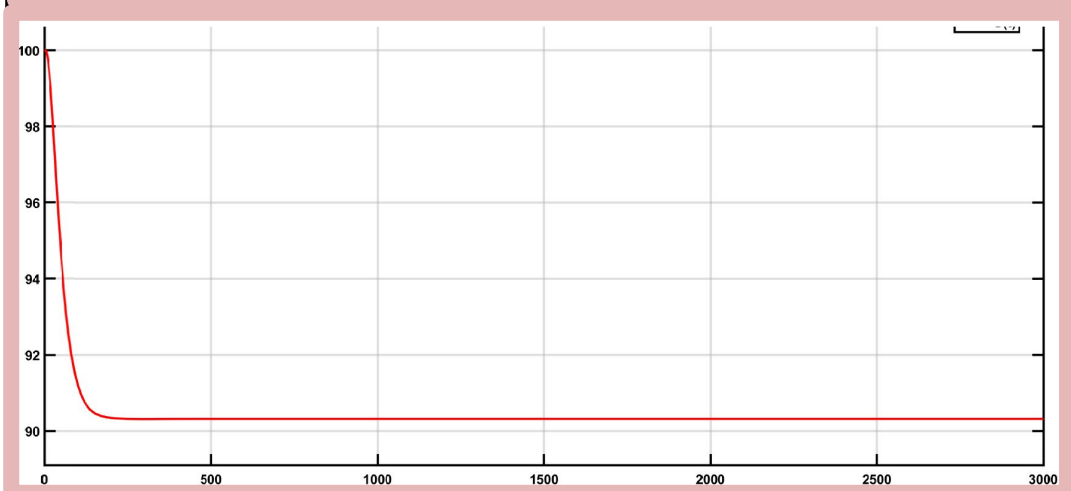
Glucose Intake: 0
Insulin Intake: 0
Exercise Intensity: 0
Plasma Insulin: 0.2
Plasma Glucose: 100

Prediction:

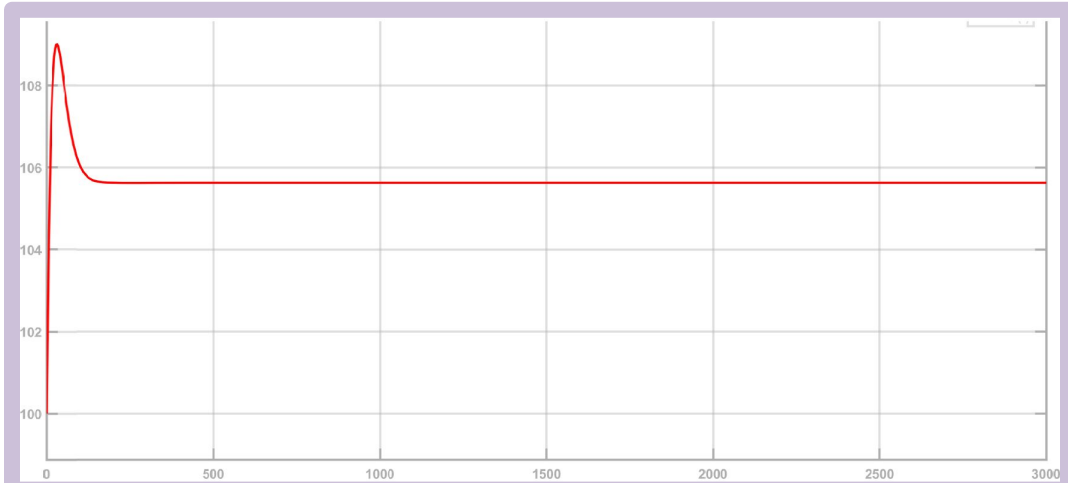
Drop in Glucose level due to no
Glucose intake. Insulin will stabilize
at below normal levels.

Results

Glucose levels dropped and it
did not drop as low as in the
healthy case because in type 2 the
system is more insulin tolerant.



Extended Model - Post Meal Healthy Results



Initial Conditions

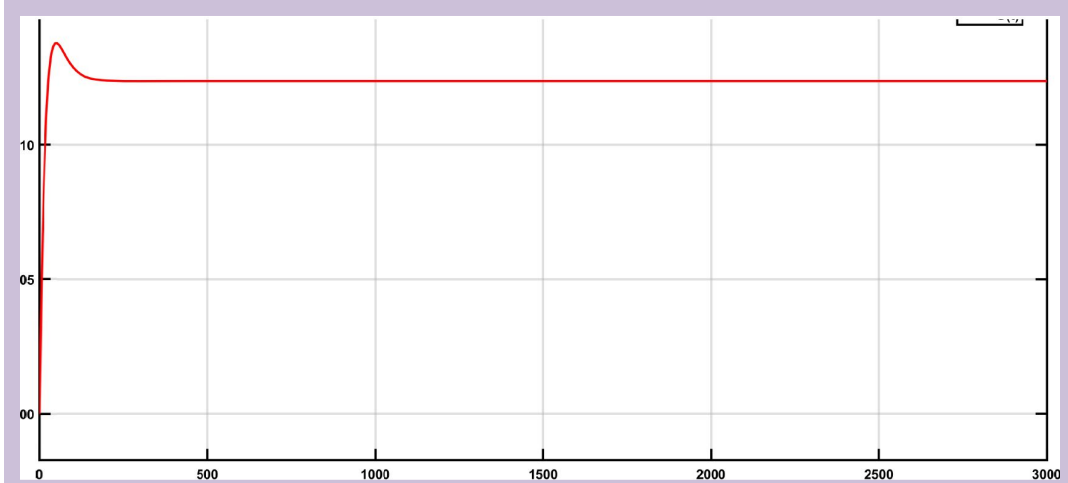
Glucose Intake: 100
Insulin Intake: 0
Exercise Intensity: 0
Plasma Insulin: 0.2
Plasma Glucose: 100

Results

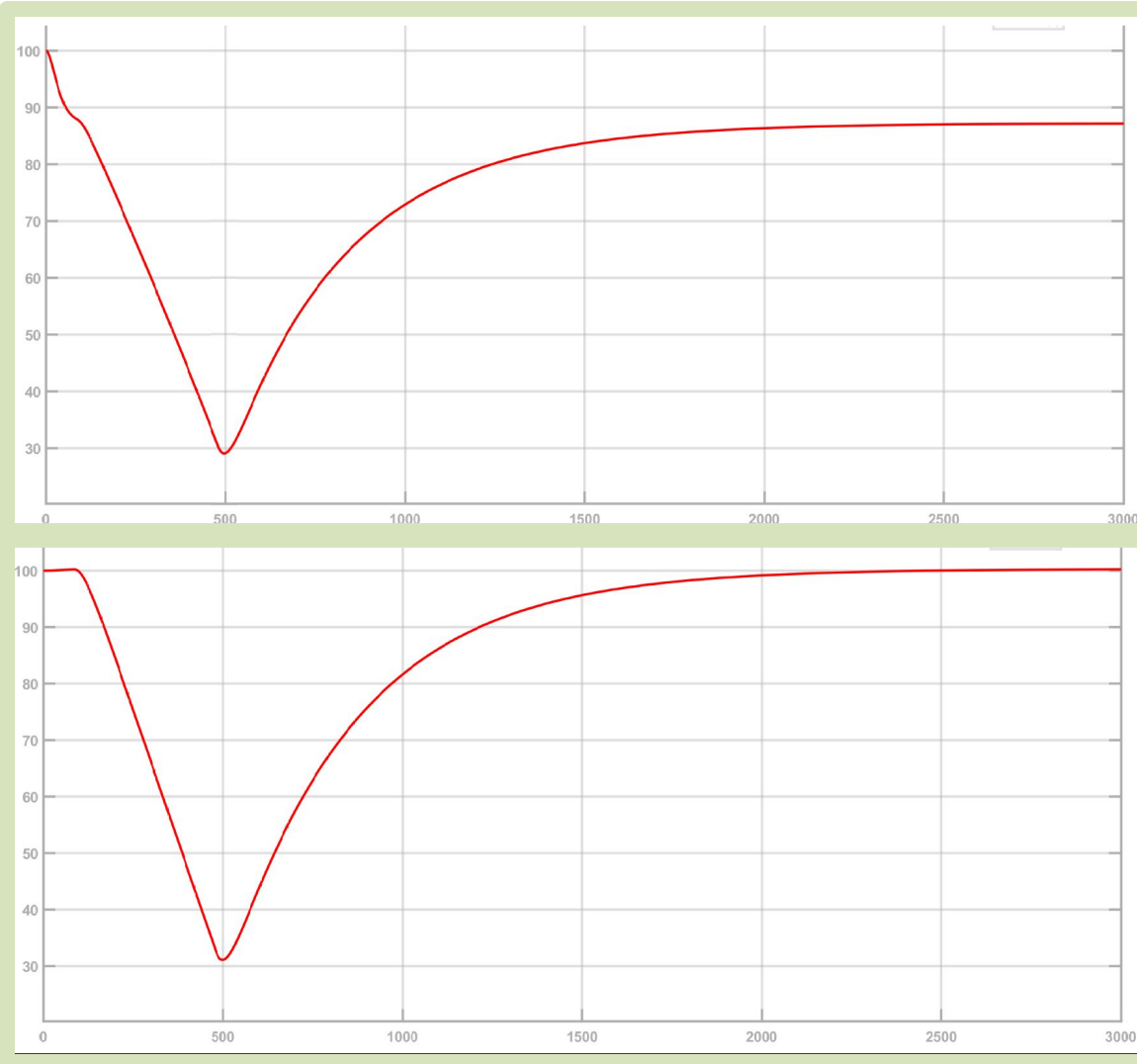
Glucose levels rose as predicted.

Prediction:

Rise in glucose levels due to the fact that low insulin levels.



Extended Model - Exercise Healthy Results



Initial Conditions

Glucose Intake: 0
Insulin Intake: 0
Exercise Intensity: 0.9
Plasma Insulin: 0.2
Plasma Glucose: 100

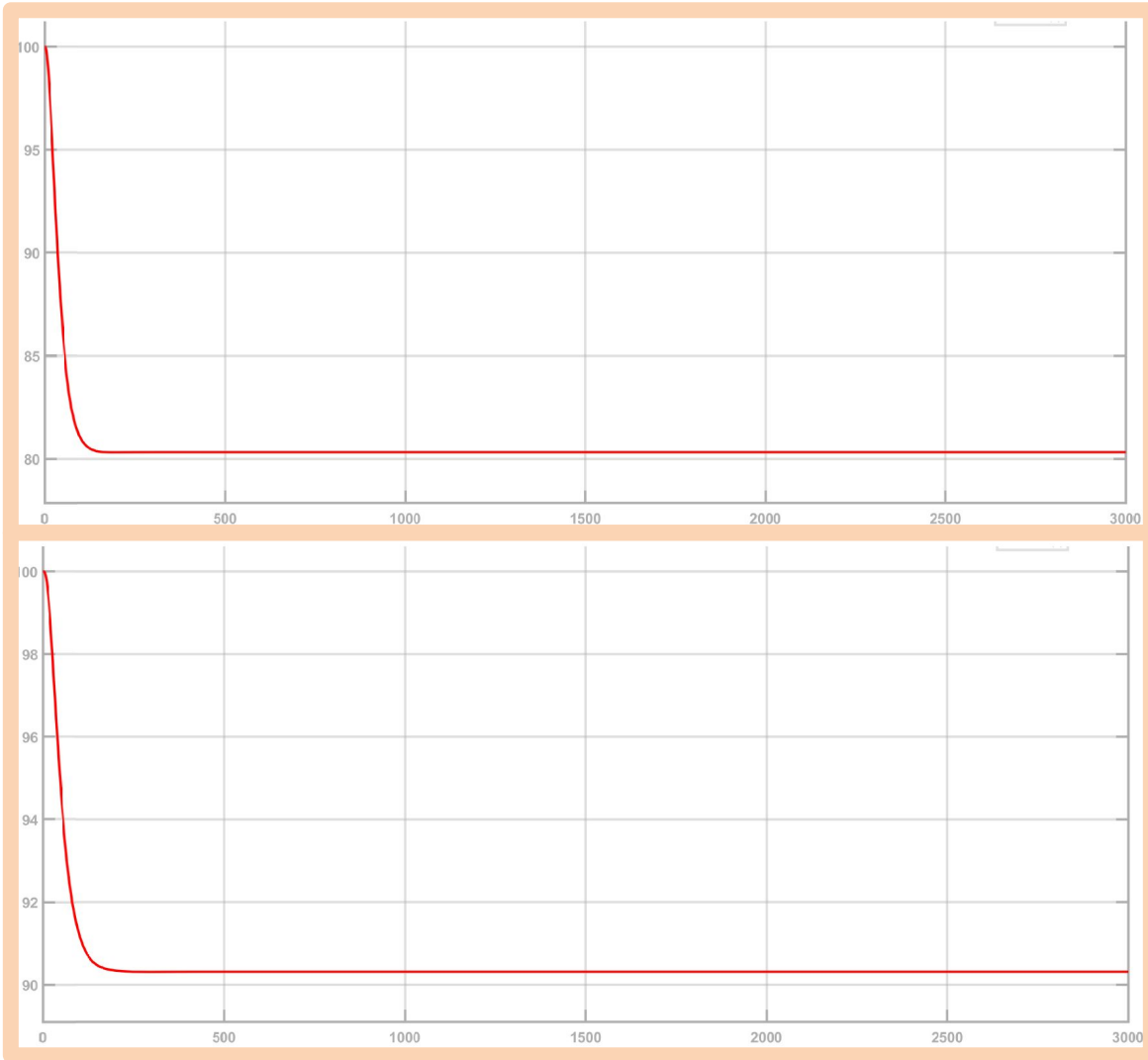
Results

Graph shape is similar to the shape of the healthy exercise graph. the difference is that there is a delay before the glucose level starts dropping.

Prediction:

Similar to the healthy case except the drop in glucose will not be as evident because of the lack of insulin

Extended Model - Insulin Shot Healthy Results



Initial Conditions

Glucose Intake: 0
Insulin Intake: 10
Exercise Intensity: 0
Plasma Insulin: 0.2
Plasma Glucose: 100

Results

Glucose level dropped to similar values to the healthy case meaning that the insulin injection helped get the model to normal levels.

Prediction:

The glucose level will drop.

Outputs Table

Case Name		Predicted outputs		Actual Outputs			
		Glucose (mg/dl)	Insulin	Glucose Initial	Glucose Final	Initial Insulin	Final Insulin
1	Starvation - healthy	~80-90	Normal	100	87.23	0.2	0
2	Starvation - diabetic-T1	~<59-79	High	100	90.32	0.2	6.9
3	Starvation - diabetic-T2	~95	Low	100	97.59	0.2	0
4	Post-meal - healthy	~120-140	High	100	105.6	0.2	0
5	Post-meal - diabetic-T1	~110	Normal	100	112.4	0.2	6.9
6	Post-meal - diabetic-T2	~140	High	100	120.6	0.2	0
7	Exercise - healthy	~70	Low	100	86.91(Low:29.08)	0.2	0
8	Exercise - diabetic-T1	~80	Low	100	99.89(Low:31.07)	0.2	0
9	Insulin shot - healthy	~80	High	100	80.3	0.2	6.9
10	Insulin shot - diabetic-T1	~90	Normal	100	90.32	0.2	6.9

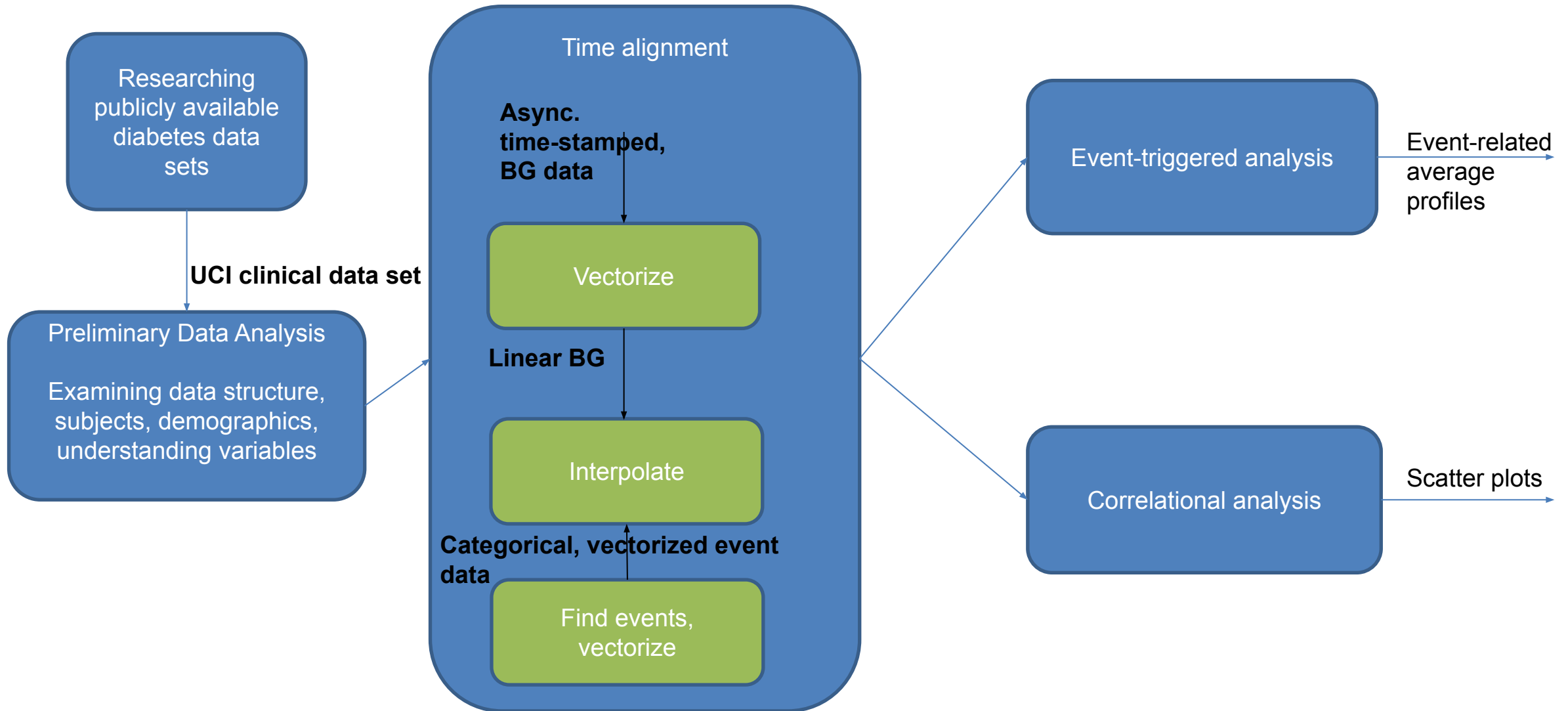
Experimental Data for Model Validation

Data Set Description:

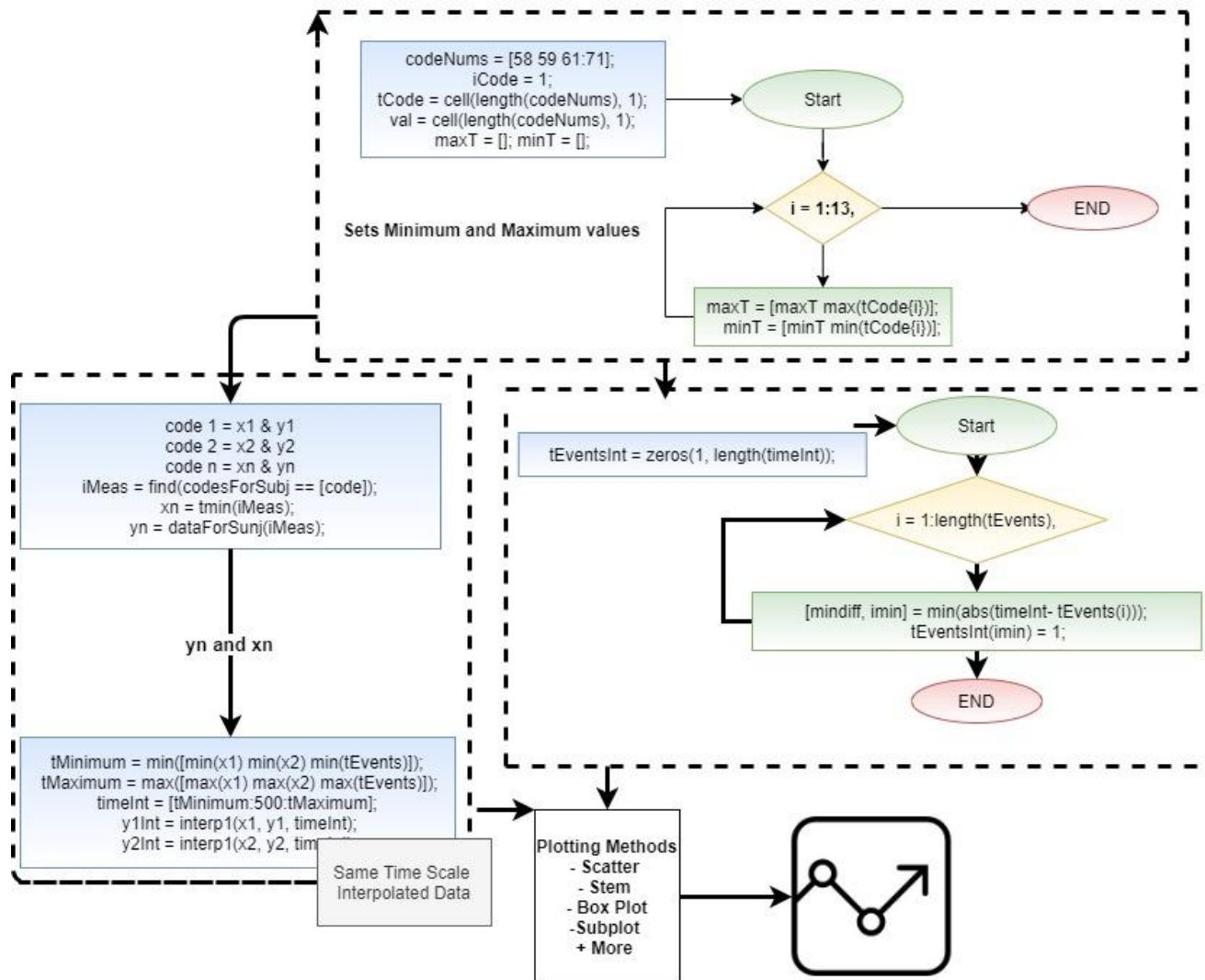
- UCI Machine Learning Department (University of California Irvine)
 - 70 Patients
 - 10,000 + Glucose Readings
 - Approximately (3 Months of Data Per Patient)
 - 20 Different Codes Categorizing Data

	<u>Glucose Measurement</u>		<u>Event data (categorical variables)</u>
58	Pre-breakfast	65	Hypoglycemic symptoms
59	Post-Breakfast	66	Typical meal ingestion
60	Pre-Lunch	67	More-than-usual meal ingestion
61	Post-Lunch	68	Less-than-usual meal ingestion
62	Pre-Supper	69	Typical exercise activity
63	Pos-Supper	70	More-than-usual exercise activity
64	Pre-Snack	71	Less-than-usual exercise activity
		72	Unspecified special event

Data Analysis Protocol



Correlation Analysis



Steps / Process

1. Interpolated Data
2. Different Codes 1-3 V.S Parameter Code
3. Look For Trends
4. Nearest Points

Graphing + Results

	58 = Pre-breakfast blood glucose measurement	59 = Post-breakfast blood glucose measurement	61 = Post-lunch blood glucose measurement	62 = Pre-supper blood glucose measurement	63 = Post-supper blood glucose measurement	64 = Pre-snack blood glucose measurement	65 = Hypoglycemic Symptoms	66 = Typical Meal Ingestion	67 = More-Than-Us- ual Meal Ingestion	68 = Less-than-usu- al meal ingestion	69 = Typical Exercise Activity	70 = More-than-usu- al exercise activity	71 = Less-Than-Us- ual Exercise Activity
Patient # : 1	135	0	0	102	0	0	51	0	0	0	0	0	0
3	40	0	5	30	21	16	3	0	10	0	0	0	0
4	35	0	2	32	10	32	1	0	6	0	0	0	0
5	37	0	1	33	7	36	0	0	2	0	0	0	0
6	21	0	0	17	0	0	0	0	0	0	0	0	0
7	34	0	0	29	0	0	0	0	0	0	0	0	0
8	41	2	5	32	5	16	15	0	7	1	3	0	0
9	24	0	6	19	4	24	0	1	1	1	1	1	1
10	34	0	0	34	0	0	0	0	0	0	0	0	0
11	28	1	1	13	0	15	16	6	19	0	4	2	2
12	40	1	1	18	0	18	23	1	22	0	2	4	2
13	32	0	0	24	0	23	24	0	20	1	8	1	11
14	34	1	0	11	0	12	8	24	14	0	13	3	2
15	53	2	0	15	0	22	16	1	18	0	0	3	1
16	53	2	0	24	0	14	6	0	20	0	0	2	1
17	24	0	0	25	0	22	7	0	0	0	2	13	3
18	32	0	0	28	0	32	4	0	0	0	0	16	1
19	31	0	1	27	0	32	3	0	1	0	1	18	1

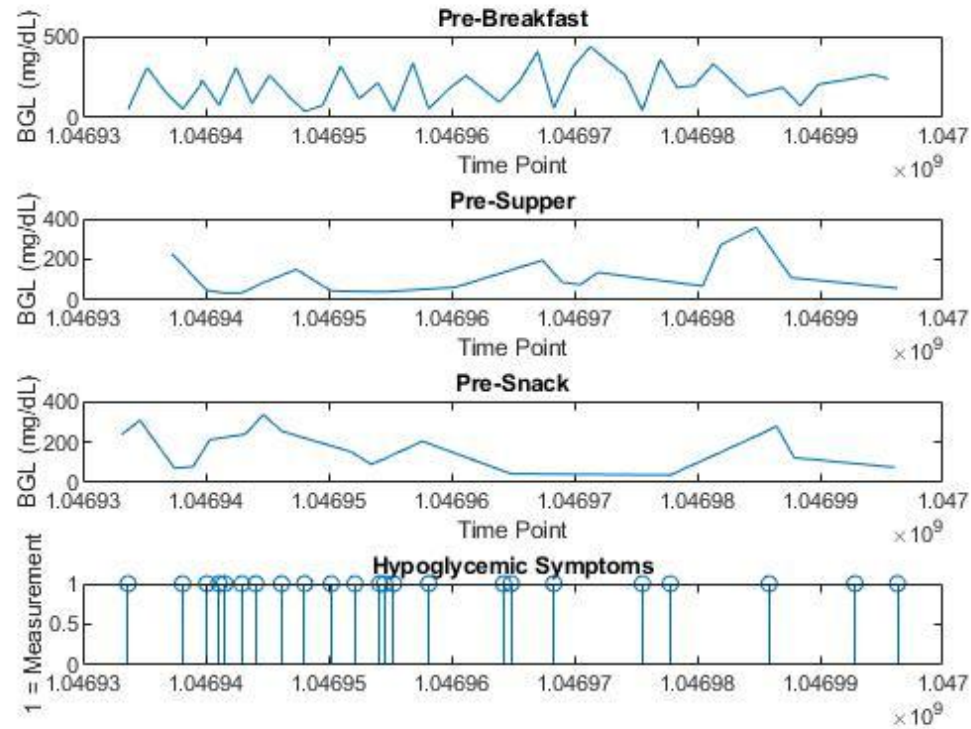
Data Points Per Code [58-71]

Patient 13 Will be used to be analyzed

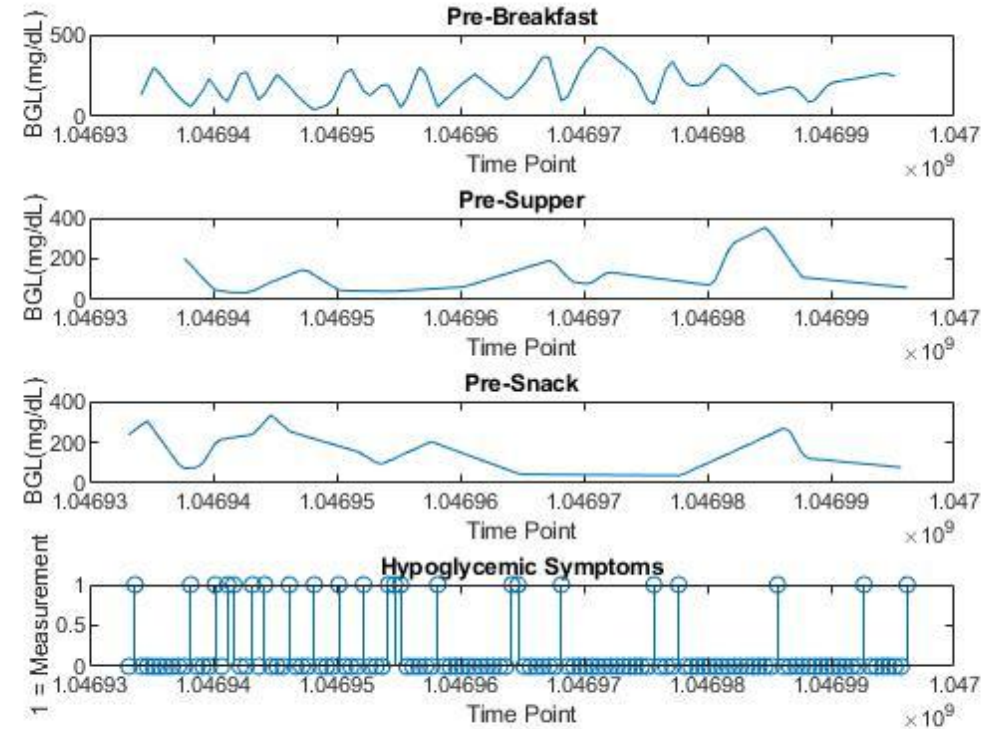
(65) Hypoglycemic Symptoms - Glucose Level is Lower than Normal
 (67) More than Normal Meal Ingestion



TIME ARRANGEMENT



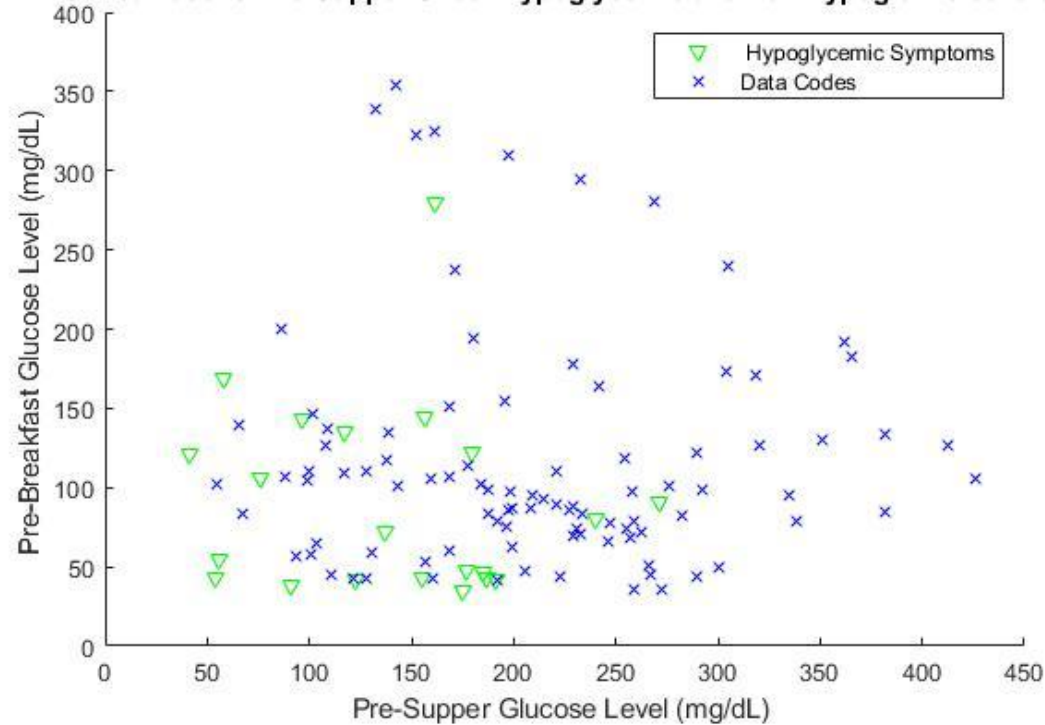
Data plotted on its own independent time recording



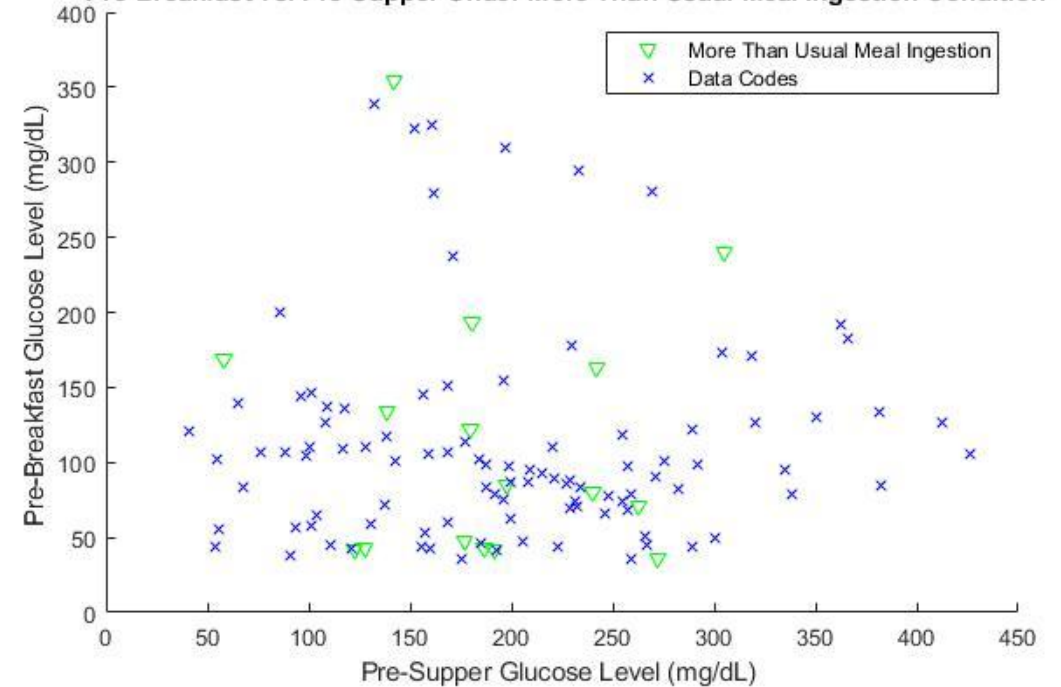
Interpolated Data Same Time Domain
Data plotted on the same time scale

Scatter Plots

Pre-Breakfast vs. Pre-Supper Under Hypoglycemic and non-Hypoglycemic conditions



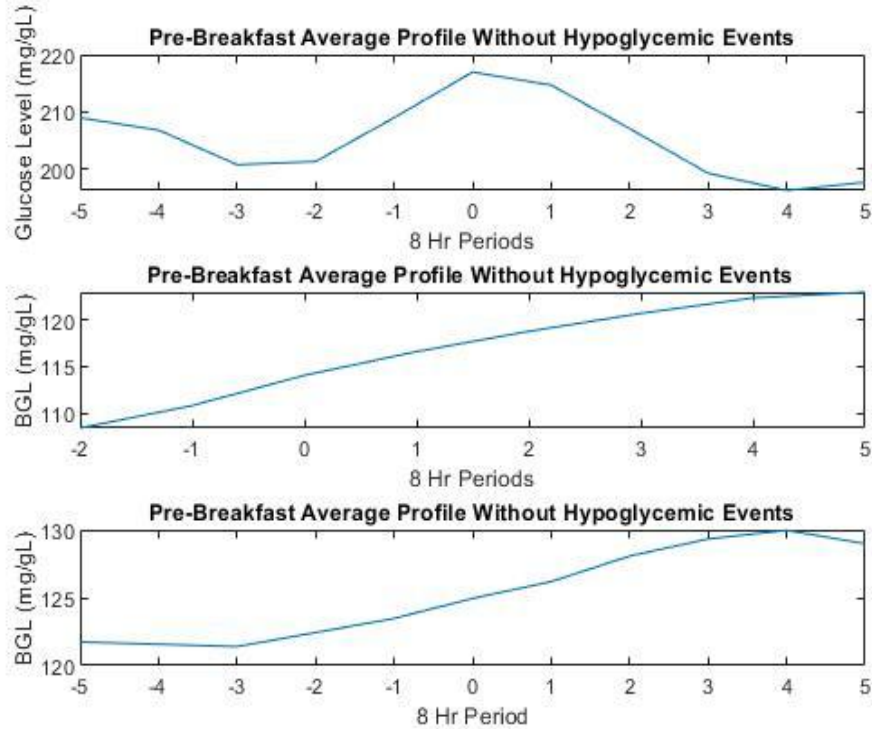
Pre-Breakfast vs. Pre-Supper Under More Than Usual Meal Ingestion Condition



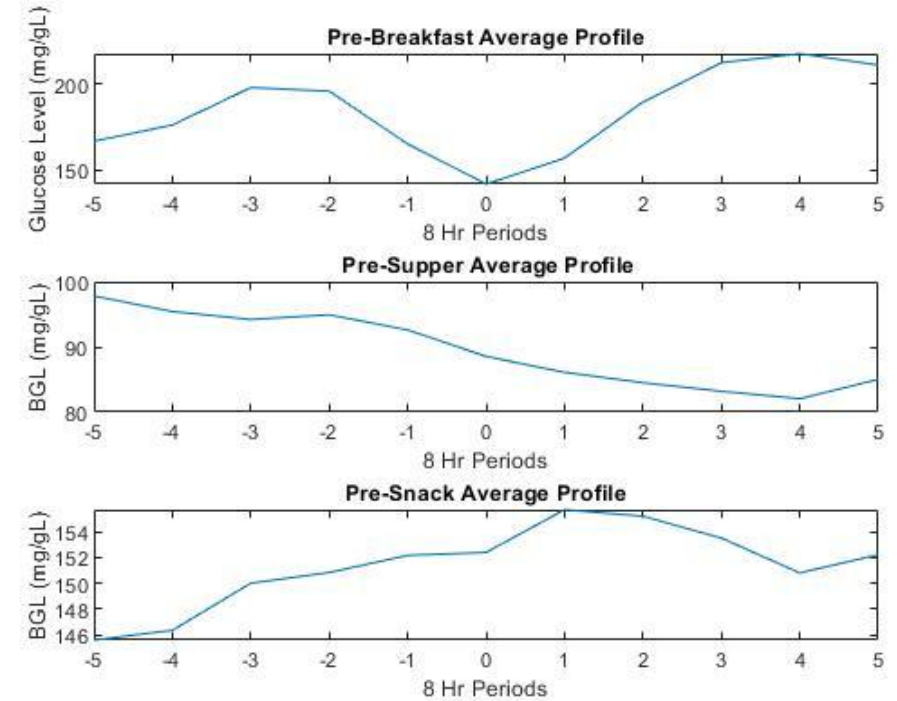
Understanding:

- Intended to look for clustered data points
- Relation between
- The greater the number of cluster points = congruent data.
- Location of Hypoglycemic Symptoms

Overall Average Profile Graphs

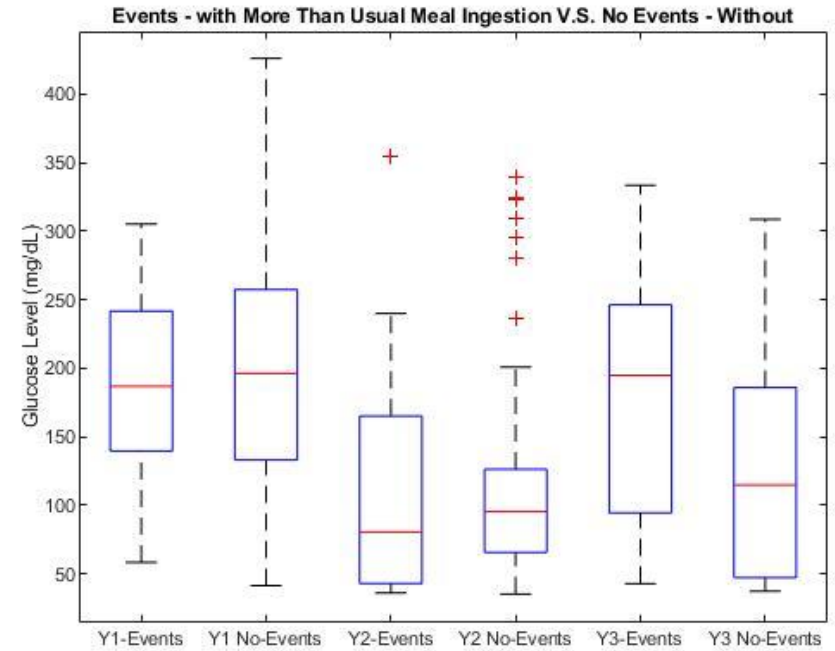
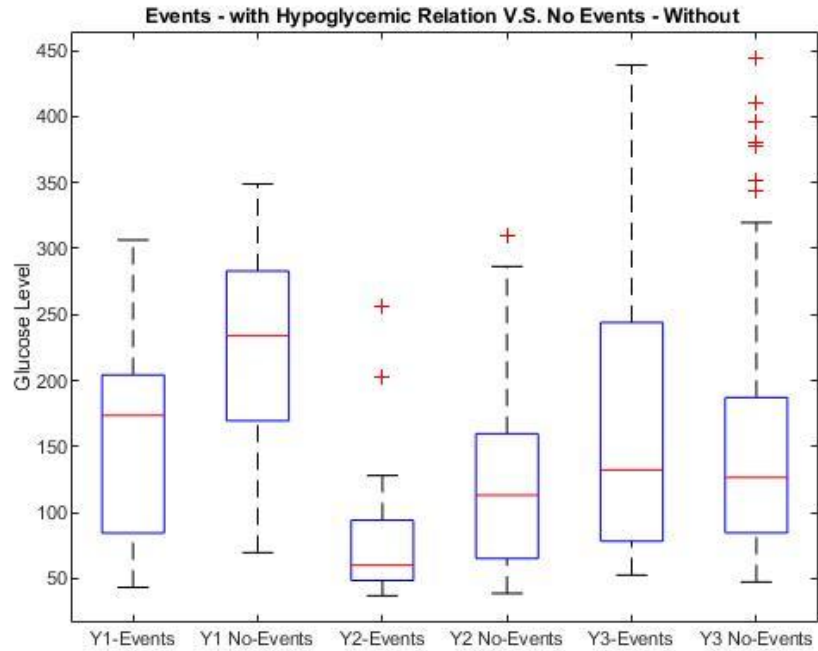


Hypoglycemic event-triggered glucose profiles



Comparing Hypoglycemic Events V.S. Non - Hypoglycemic Events

Box Plots



Box Graph - Glucose Levels
Red Line: Median
Minimum Value: Bottom Line Under Box
Maximum Value: Top Line Over the Box
Looking For Change Within Medians



Data Analysis Summary

Purpose

The initial purpose was to **Validate** the **Bergman Model** through the data set

Analysis

The data set is not consistent

There is no pattern between codes

Sparse Data - Missing values, each glucose recording has its own time constraint.

Time manipulation did not have the results we expected for the data set

Project Achievements

- Developed a UI design for app dashboard and two fragments
- Loaded app onto a mobile device and successfully implemented multiple functions (recipe upload, user account creation, dashboard navigation)
- Implemented cloud storage for user account information
- Implemented photo upload function for recipe sharing
- Created Extended Bergman
- Analyzed validation data set
- Tested Extended Bergman Model using extensive simulation scenarios

Future Endeavors

- Enable peer-to-peer sharing
- Implement health monitoring functions
- Integrate computational model into app
- Validate Extended Bergman Model using real world data
- Investigate richer experimental data sets
- Create a machine learning algorithm to predict HbA1c, Blood Glucose
- Merge Machine learning model with the app team



**Thank You For Your
Time and Attention**

**Please join us for Q&A on
Thursday May 6, 1:00-2:00pm**

