INSIGHT Teams Expo Presentation

CAL STATE LA

College of Engineering, Computer Science and Technology

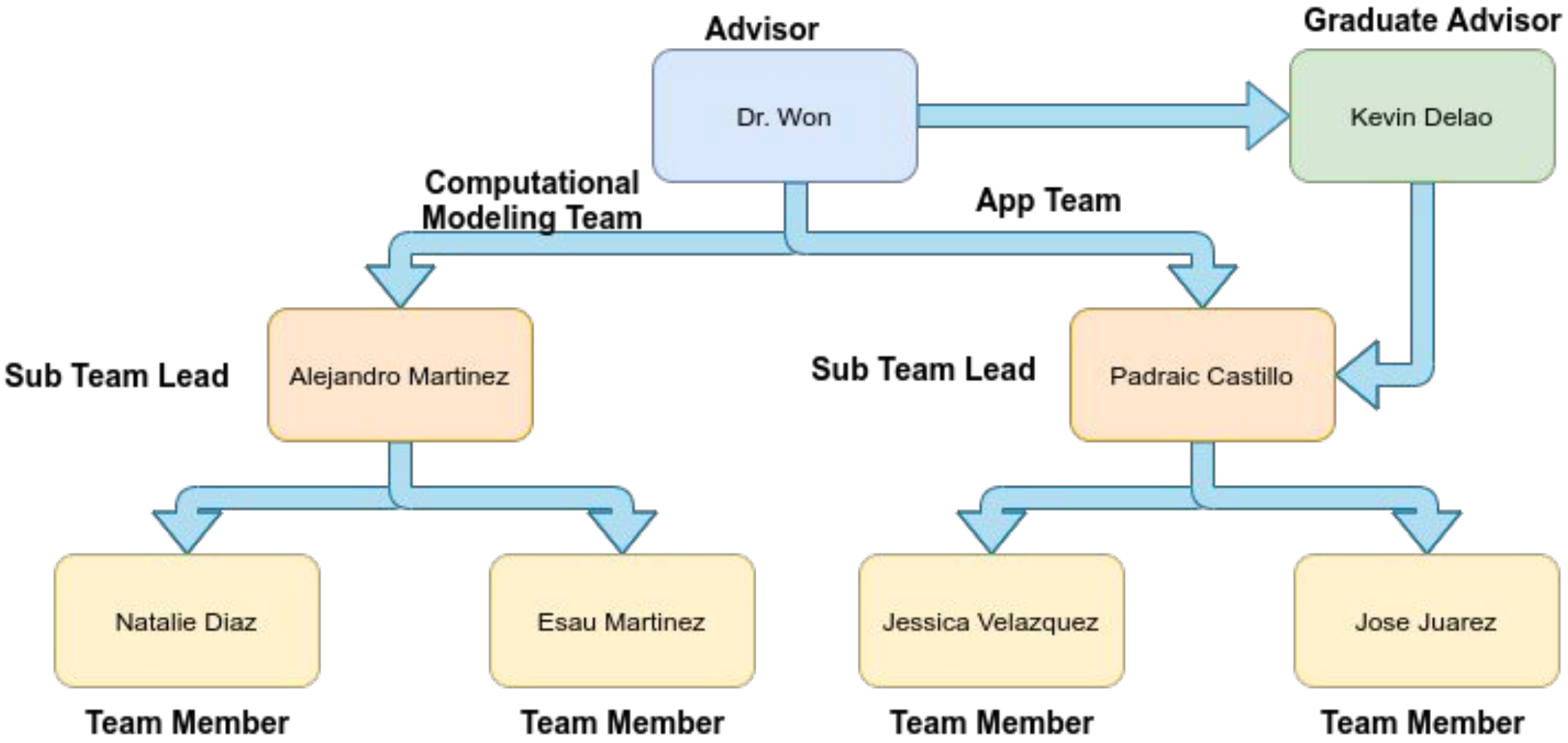
INSIGHT - Mobile App Virtual Community

Advisor:
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Kevin Delao

Members:
Alejandro Martinez
Natalie Diaz
Esau Martinez
Padraic Castillo
Jessica Velazquez
Jose Juarez

Team Organization



INtelligent

System for

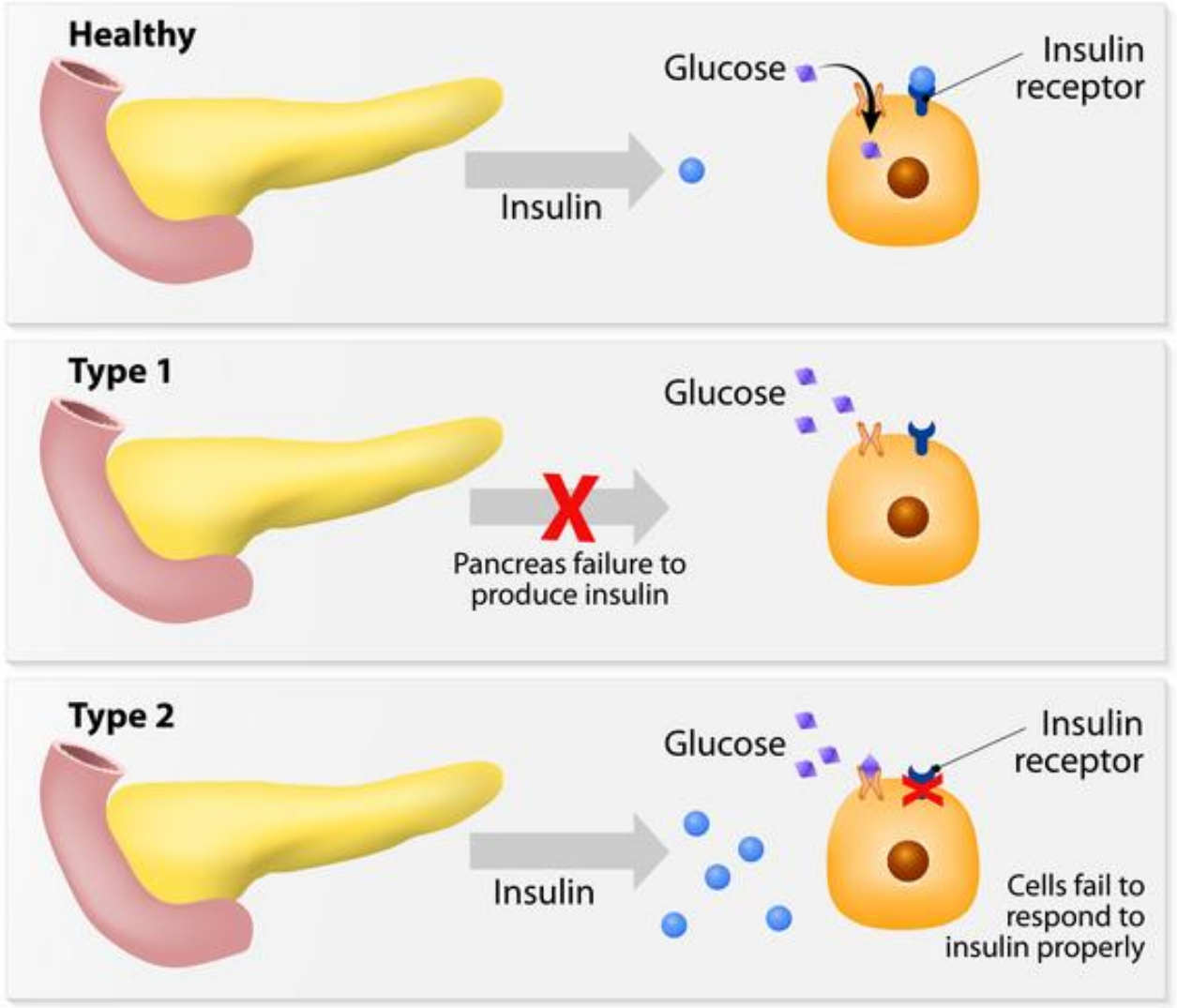
Inspiring

Glucose-related health management for

Hispanic individuals with

Type 2 diabetes

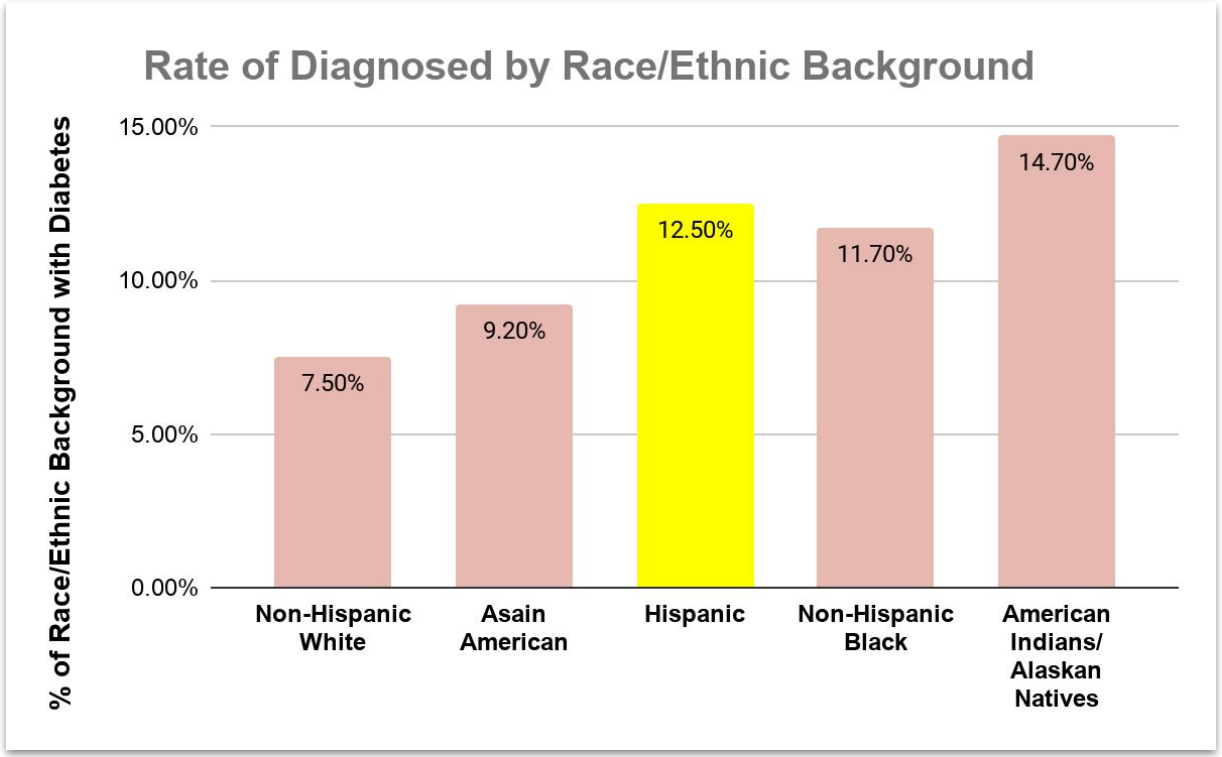
Background:


DIABETES MELLITUS
Healthy
Glucose
Insulin receptor
Insulin
Type 1
Glucose
Pancreas failure to produce insulin
Type 2
Glucose
Insulin receptor
Insulin
Cells fail to respond to insulin properly

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

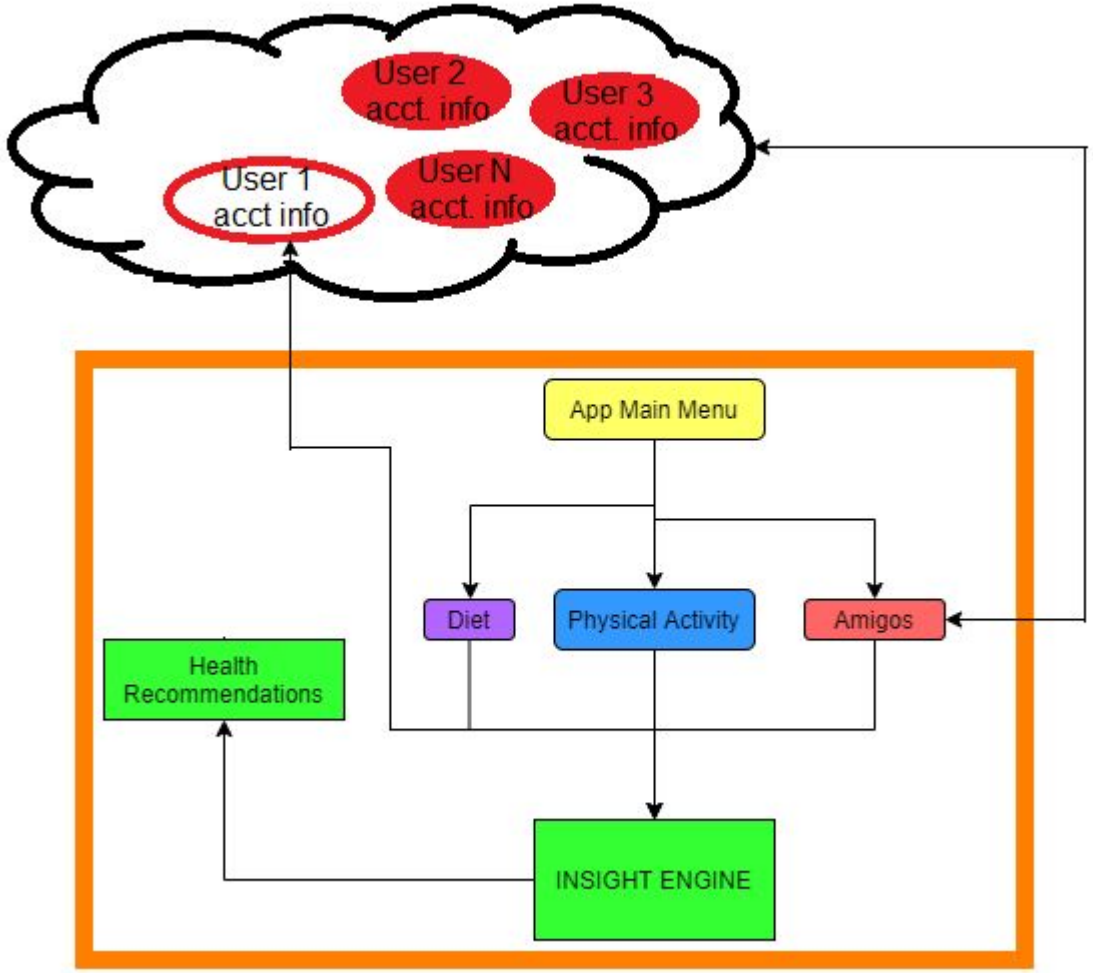
-a culturally relevant app and provide a virtual support community

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.

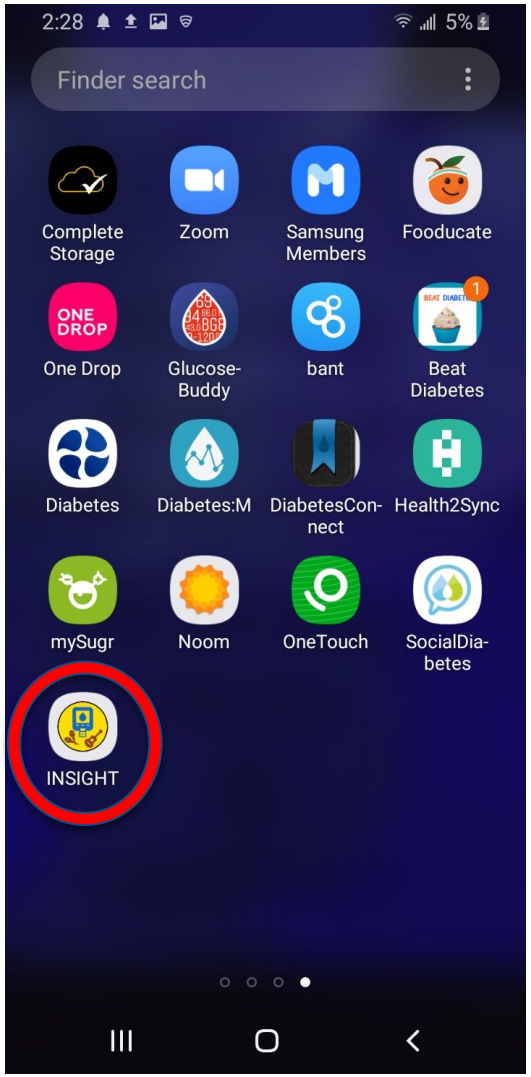
App Trade Analysis

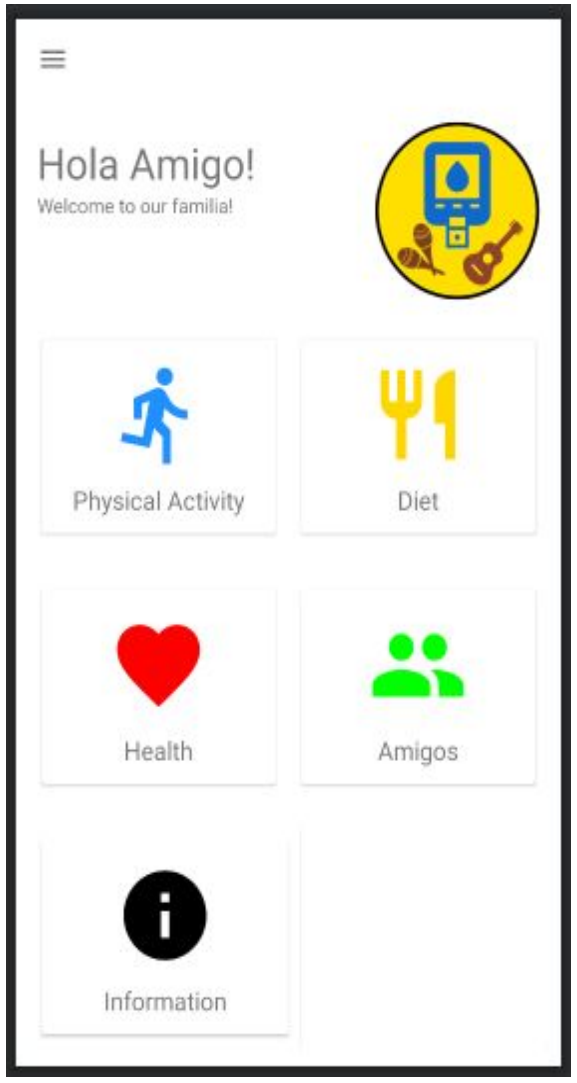
Applications Trade Analysis

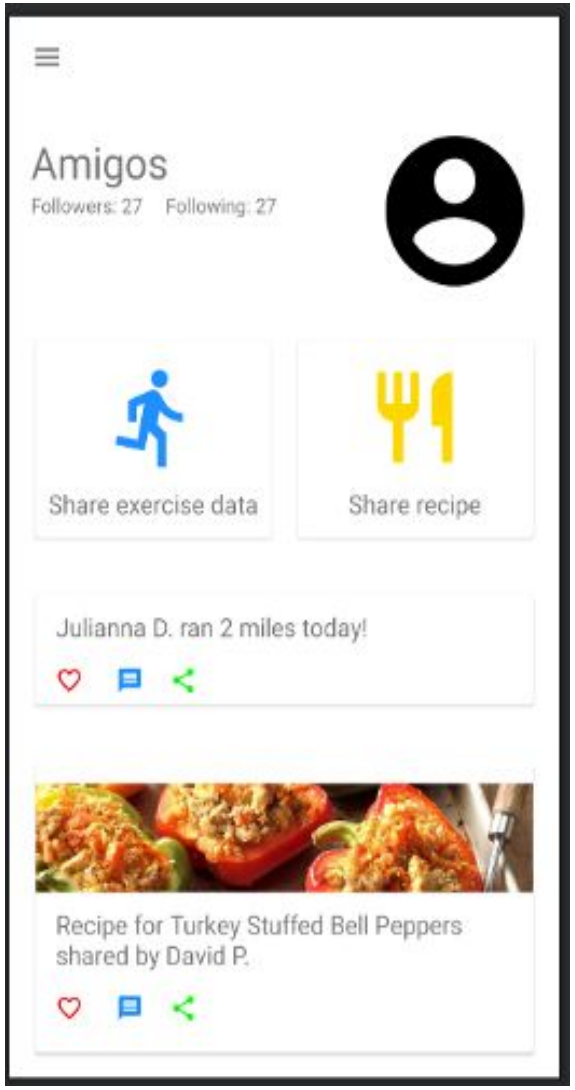
Diabetic Applications	How to Track Food			Reports					Info		Community			Language	
	Database	Scanner	Photo	PDF	Graphs	Import	Export	Printable	Advice	Lessons	Personal Assistant	Friends	Social	English	Spanish
Glucose Buddy	✓	✓	✓		✓			✓						✓	
Diabetes & Diet tracker	✓	✓			✓				✓	✓	✓			✓	
Diabetes:M	✓	✓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

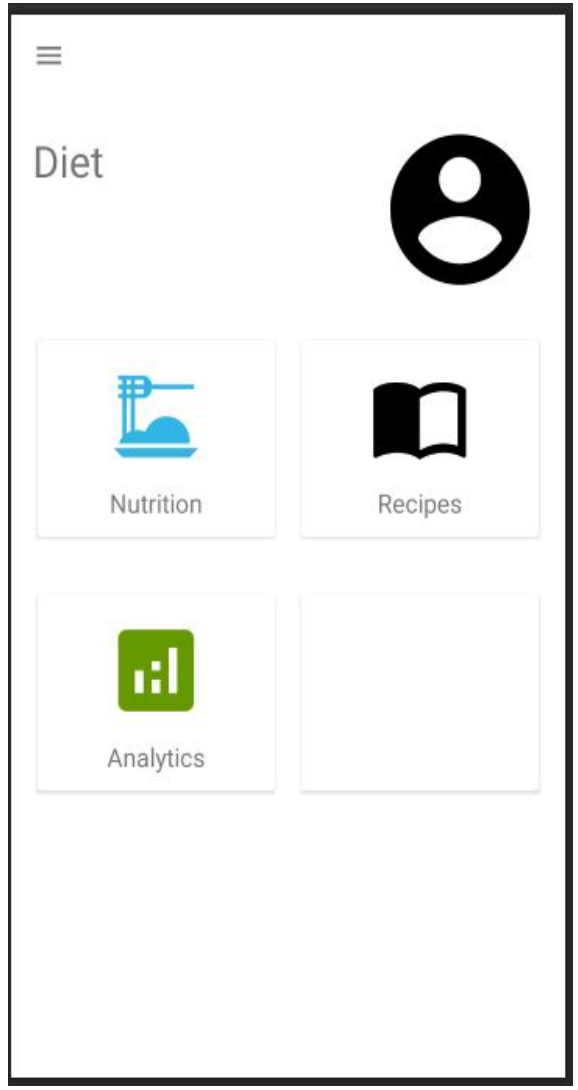
How to Track	Nutrition info is gathered through food database, a scanner and/or through in-app camera to keep record of food consumption
Reports	The reports are available in PDF, could be printable, progess are displayed by graphs, are able to be imported/exported
Info	Educational Information is provided 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





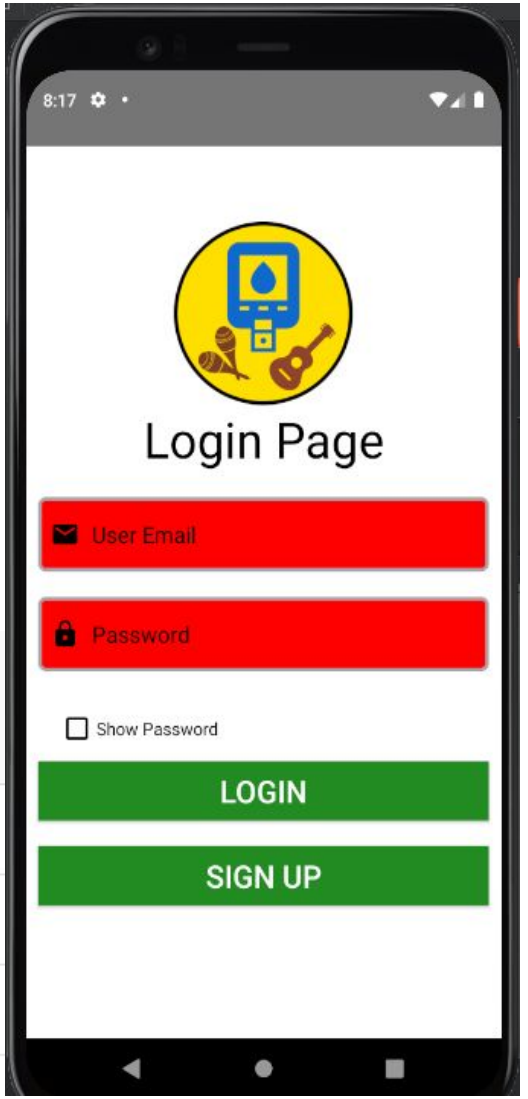


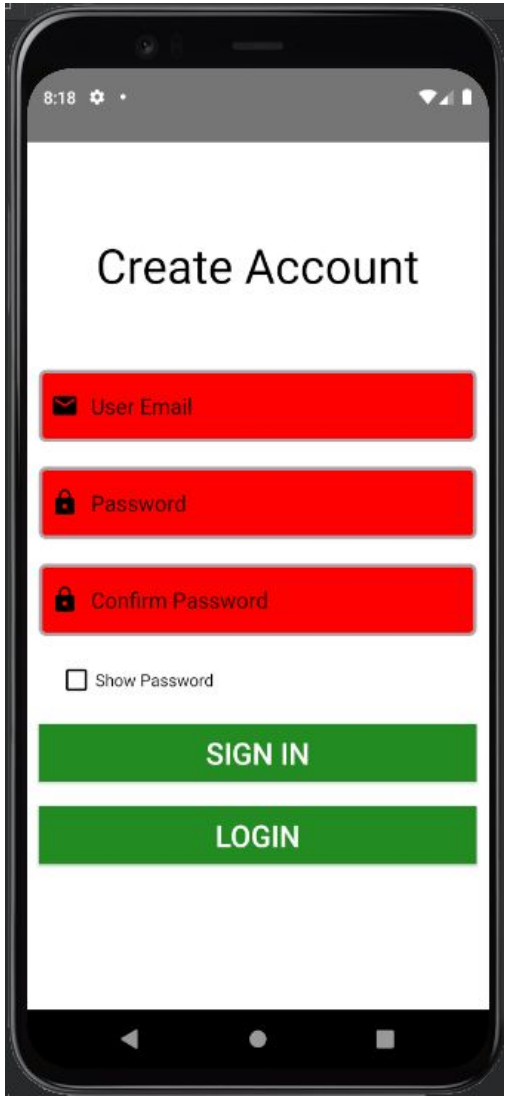


Amigos backbone – cloud services or mediators

- 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



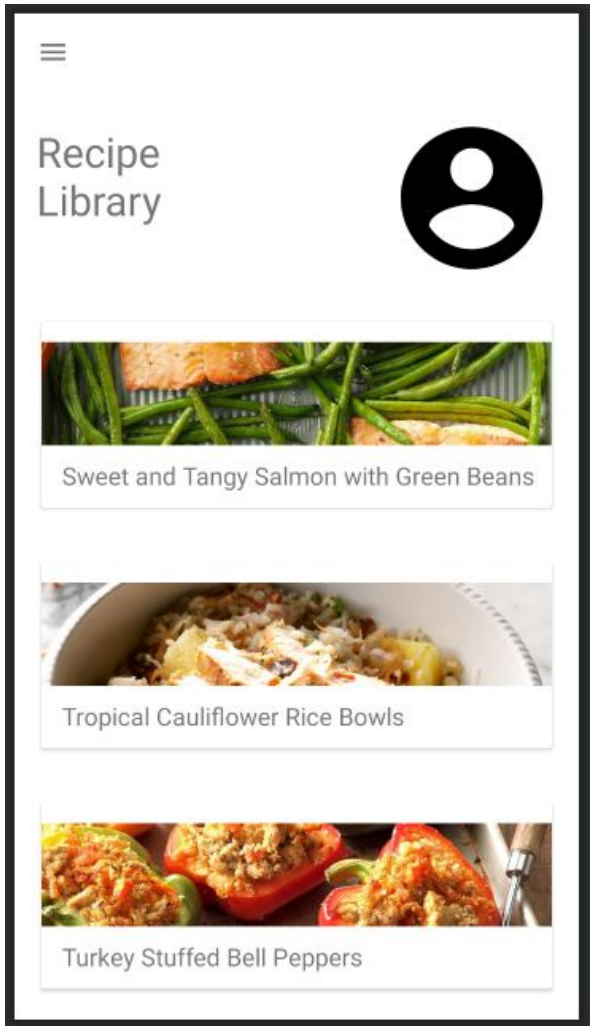




Recipe Feature in Diet Fragment

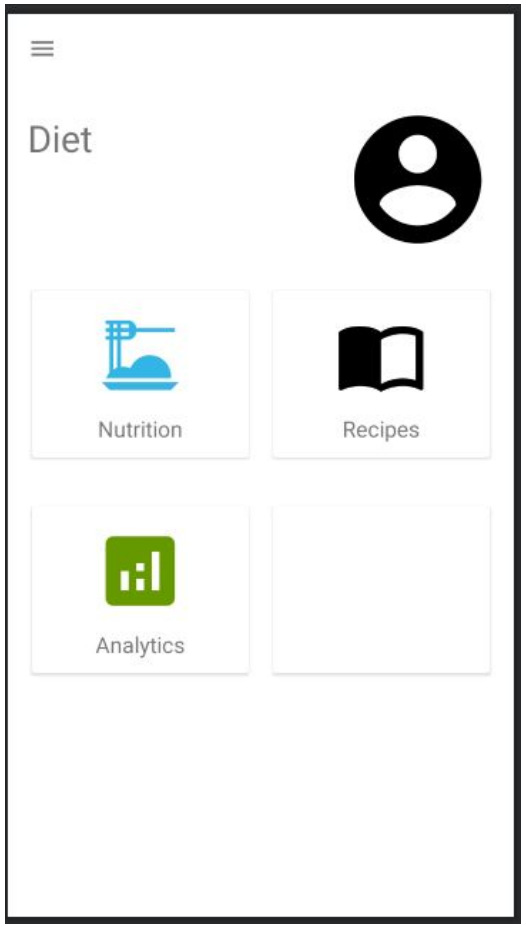
- Capture button
  - Will access phone camera to take picture of dish
- Input
  - Users will add an ingredients list and directions that will be accessible to other users after the recipe is shared
- Save button
  - Users will be able to save recipes they have posted and recipes their “Amigos” have posted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

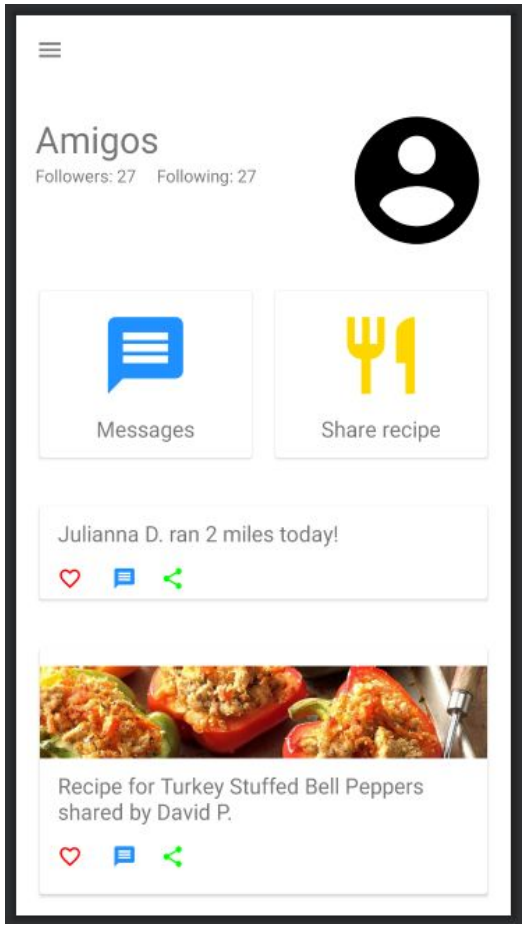




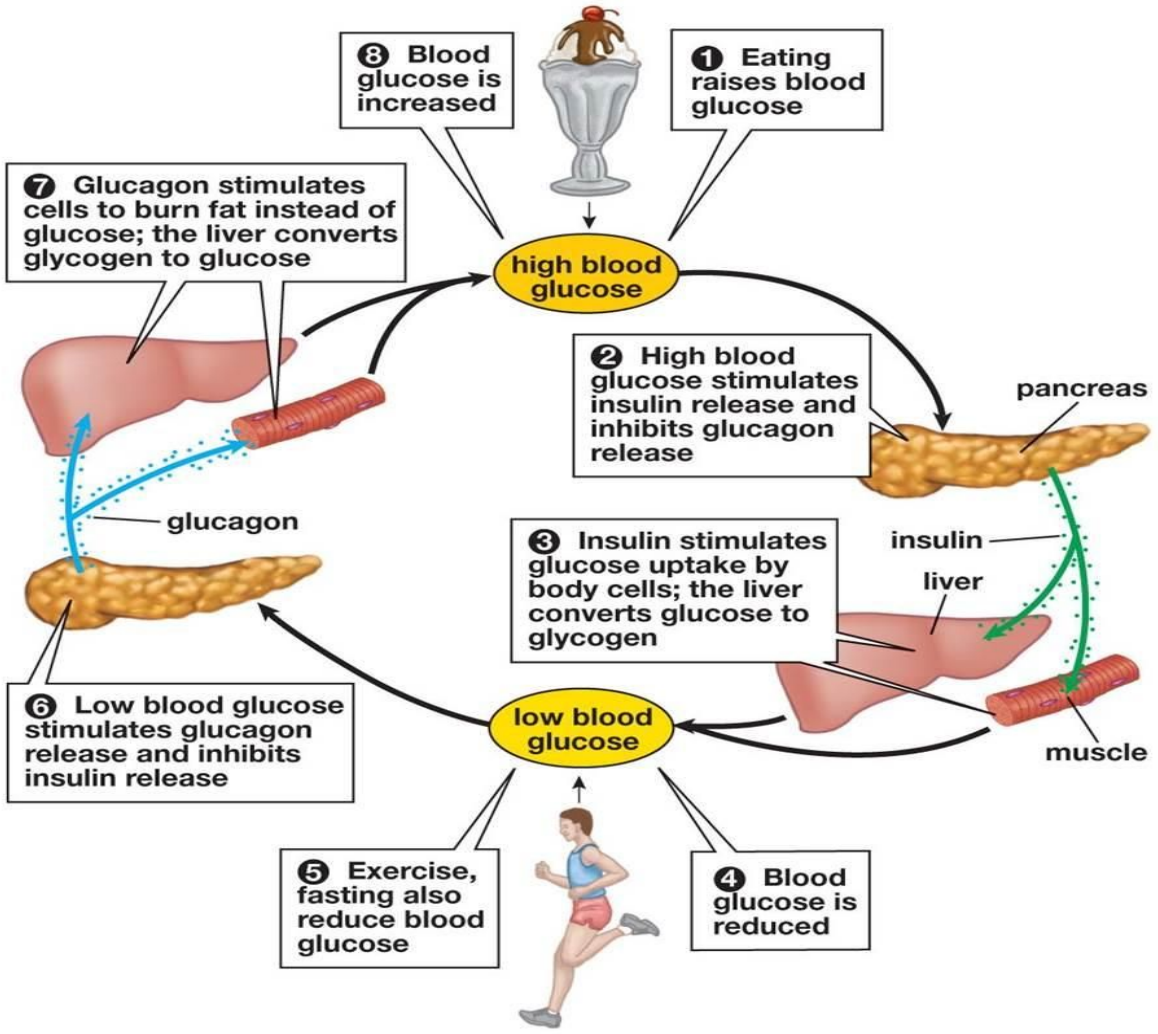
Future Implementations

- 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





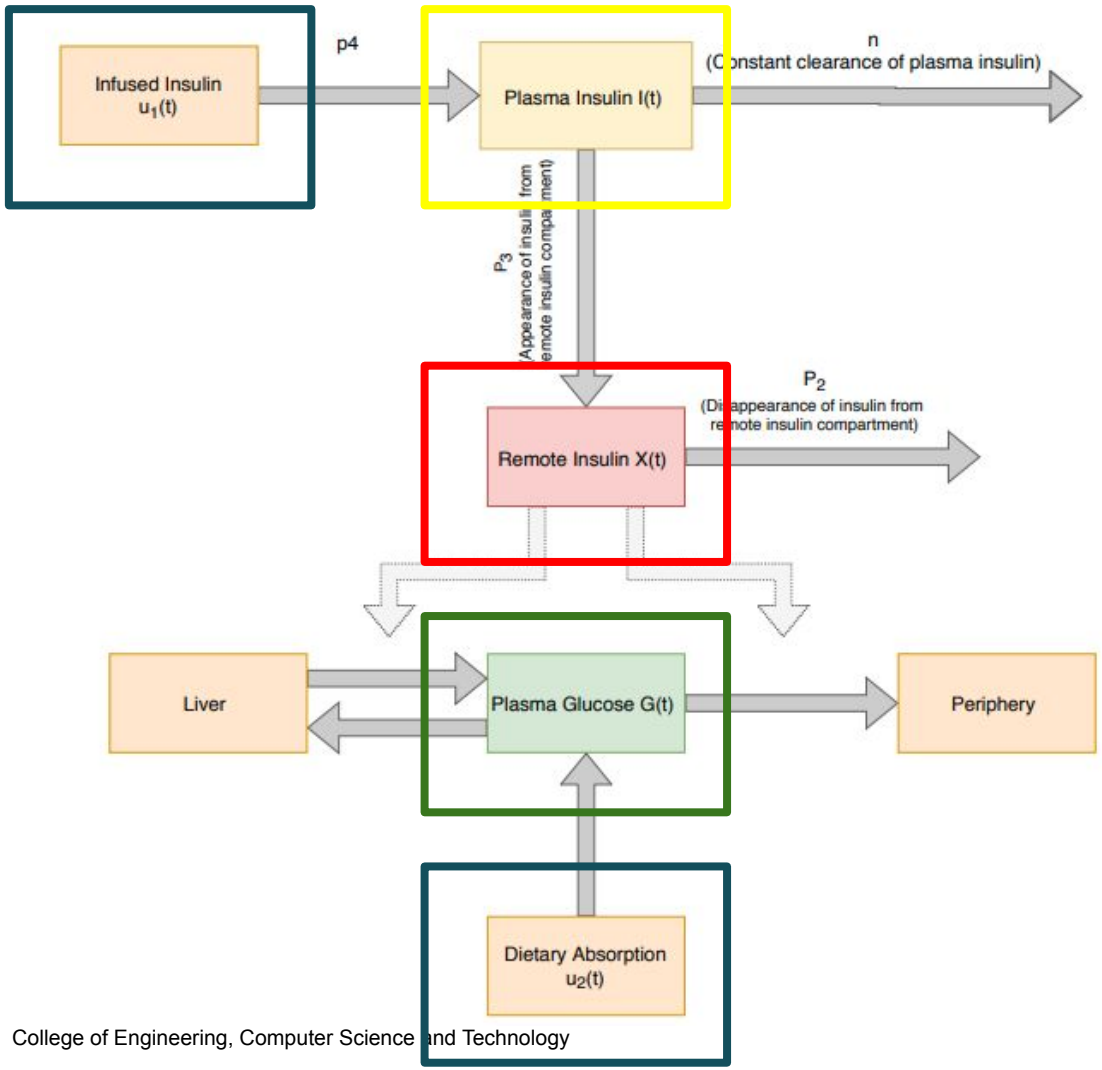
INSIGHT Engine - Computational Model



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 Condtions	Insulin injection, Fasting and Eating	Insulin injection, Fasting, Eating, Exercise	Fasting and Eating
Equations	$\%S = \left(\frac{FBI * FPG}{22.5}\right)^{-1}$ $\%B = 20 * \frac{FPI}{(FPB - 3.5)}$	$\frac{dI}{dt} = -nI(t) + p_4 u_1(t)$ $\frac{dX}{dt} = -p_2 X(t) + p_3(I(t) - I_b)$ $\frac{dG}{dt} = -p_2 G(t) - X(t)G(t) + p_1 G_b + \frac{u_2(t)}{Vol_G}$	$Cl = Cl_b + S\Delta I$ $V\frac{dG(t)}{dt} = -Cl(t)G(t) + R_2(t)$

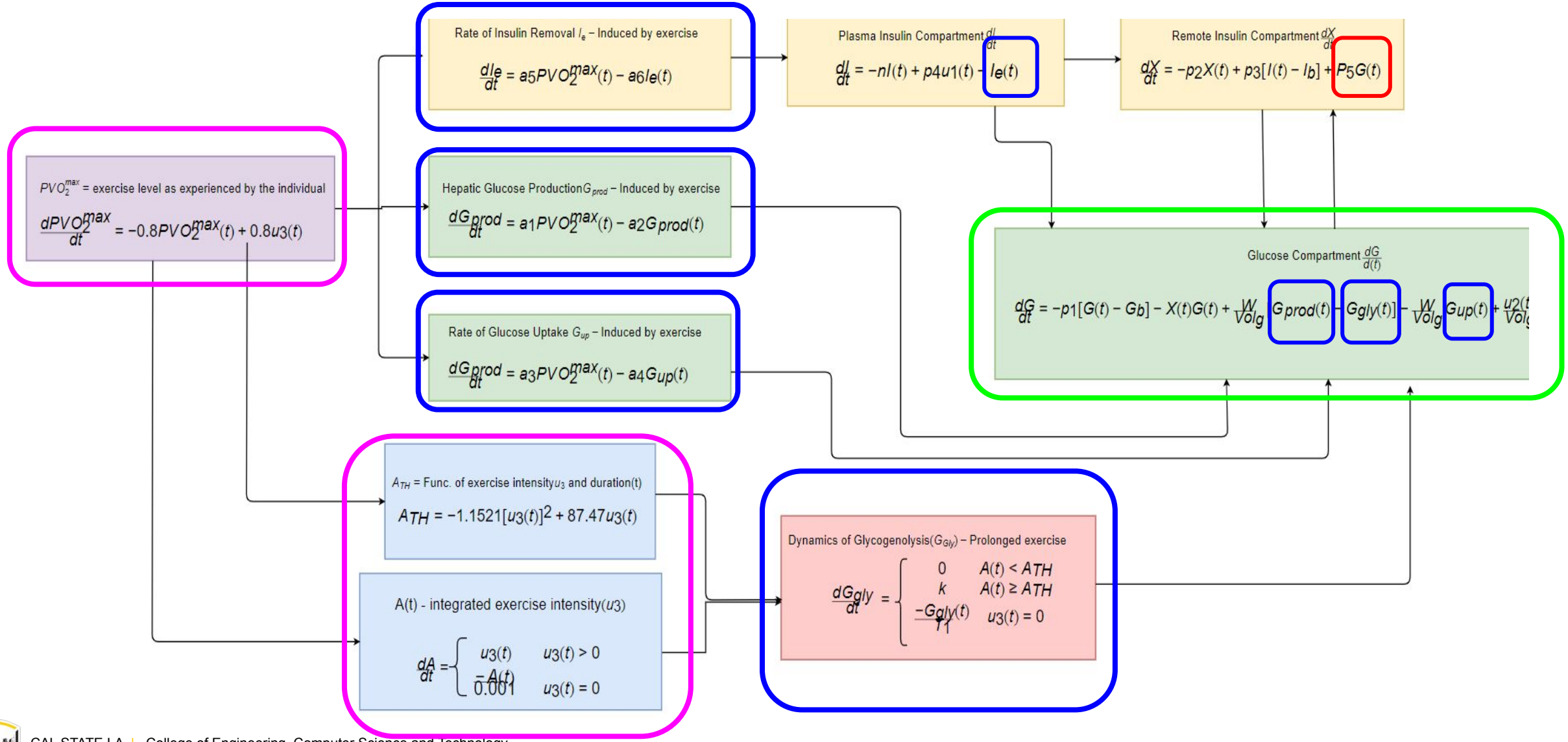
Bergman Glucose Model



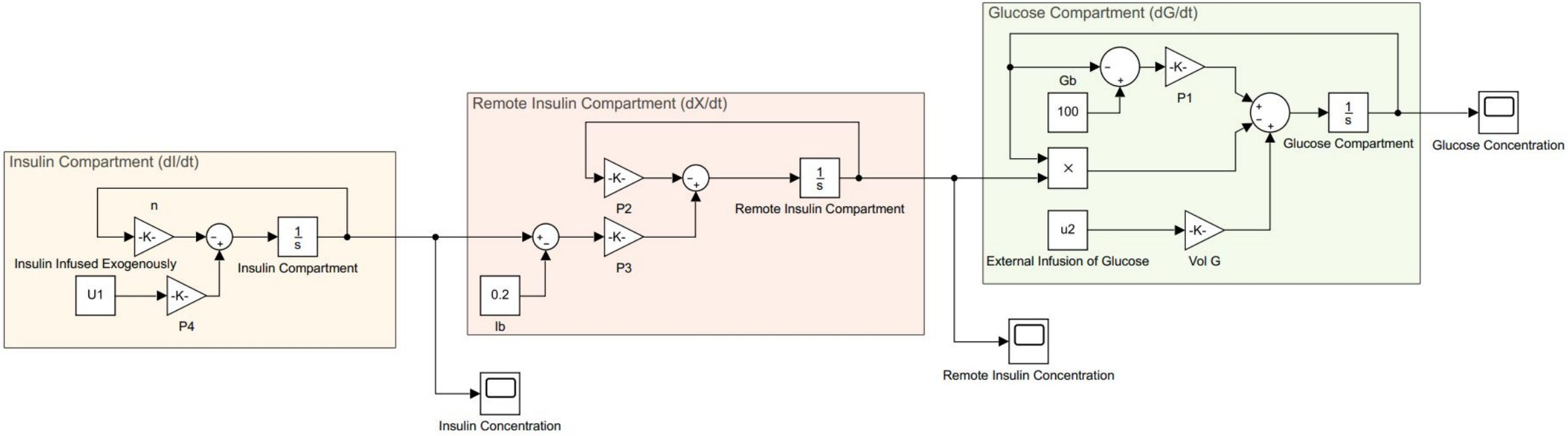
- Broken into three compartments and two Inputs
- Infused Insulin ($U_1(t)$)
- Dietary Glucose Absorption ($U_2(t)$)

- 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
  - $dG/dt = -P_1 * G(t) - X(t) * G(t) + P_1 * G_b + [u_2(t) / Vol_G]$

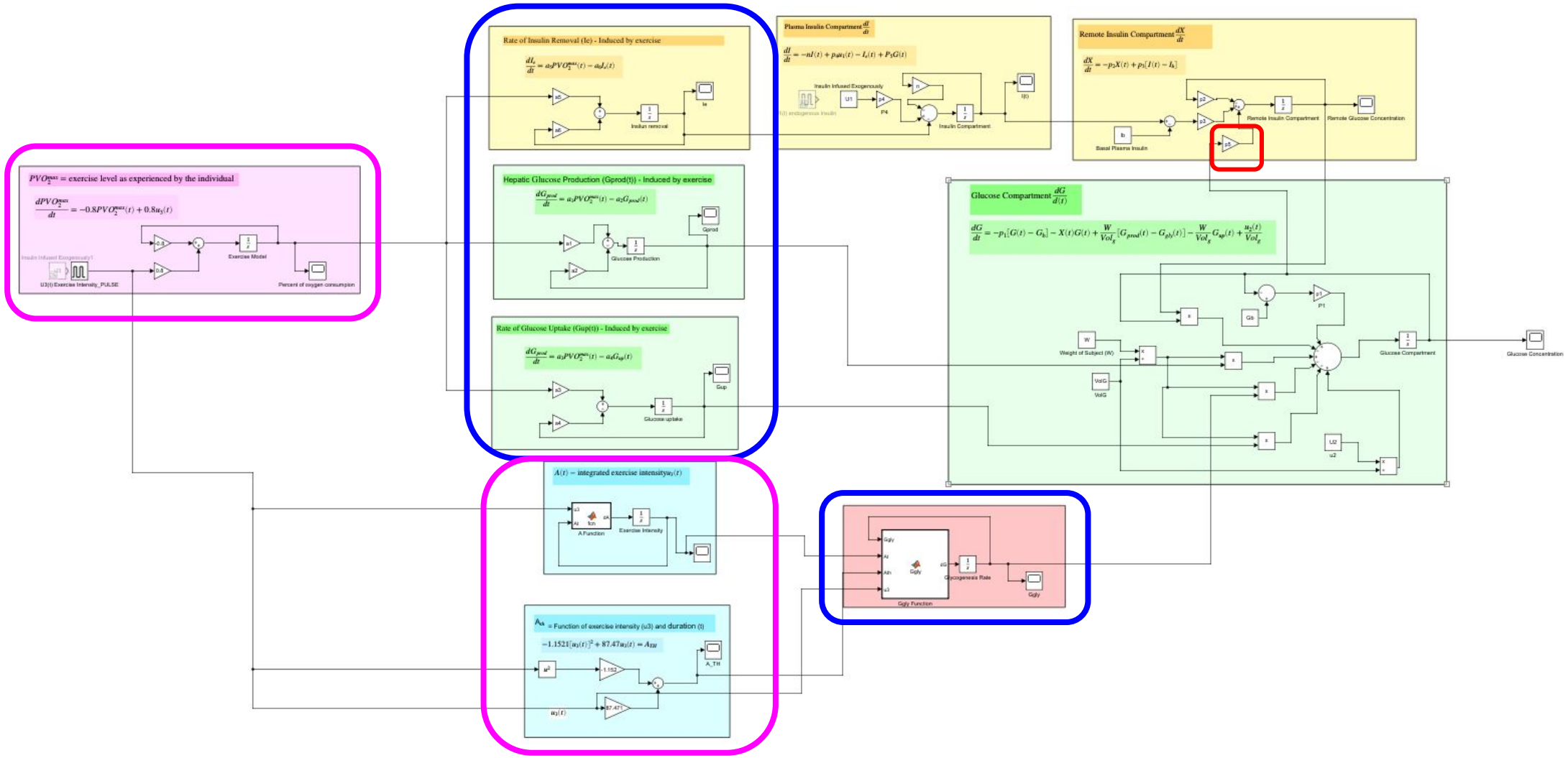
Extended Bergman Model



Simulink Model



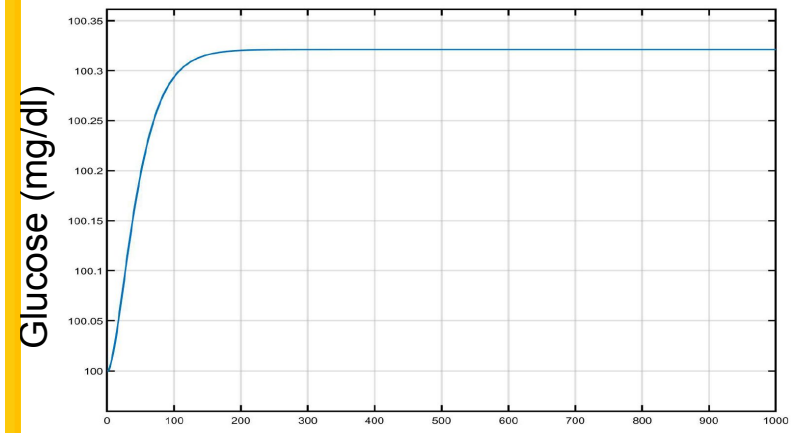
Extended Bergman Model Simulink



Simulink Simulation Test Runs

Validation – Bergman model

Zero Initial Conditions

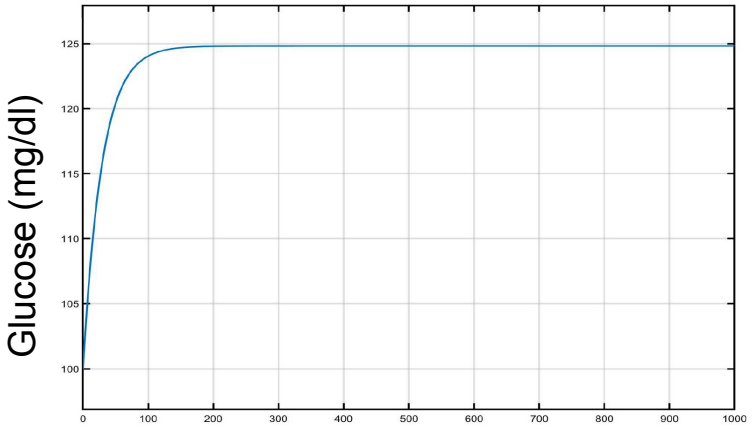


Initial Conditions
Glucose Intake: 0
Insulin Intake: 0
Ib:0.2
Plasma Insulin: 0
Plasma Glucose: 100

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

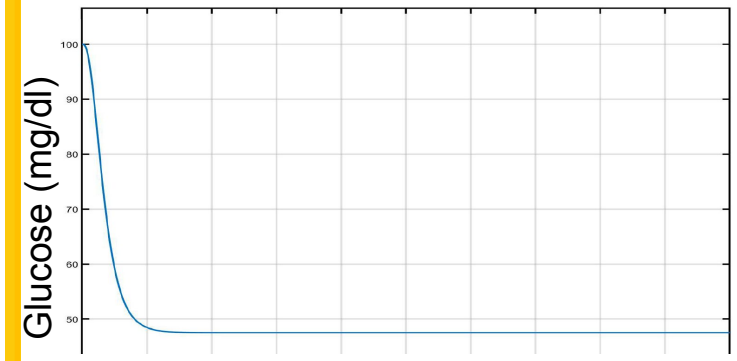


Initial Conditions
Glucose Intake: 100
Insulin Intake: 0
Ib:0.2
Plasma Insulin: 0
Plasma Glucose: 100

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

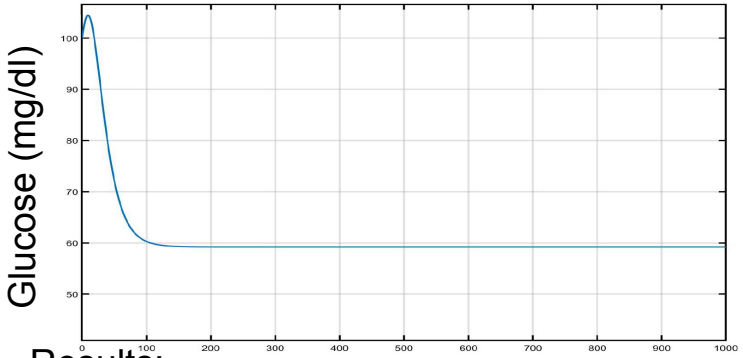


Initial Conditions
Glucose Intake: 0
Insulin Intake: 100
Ib:0.2
Plasma Insulin: 0
Plasma Glucose: 100

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

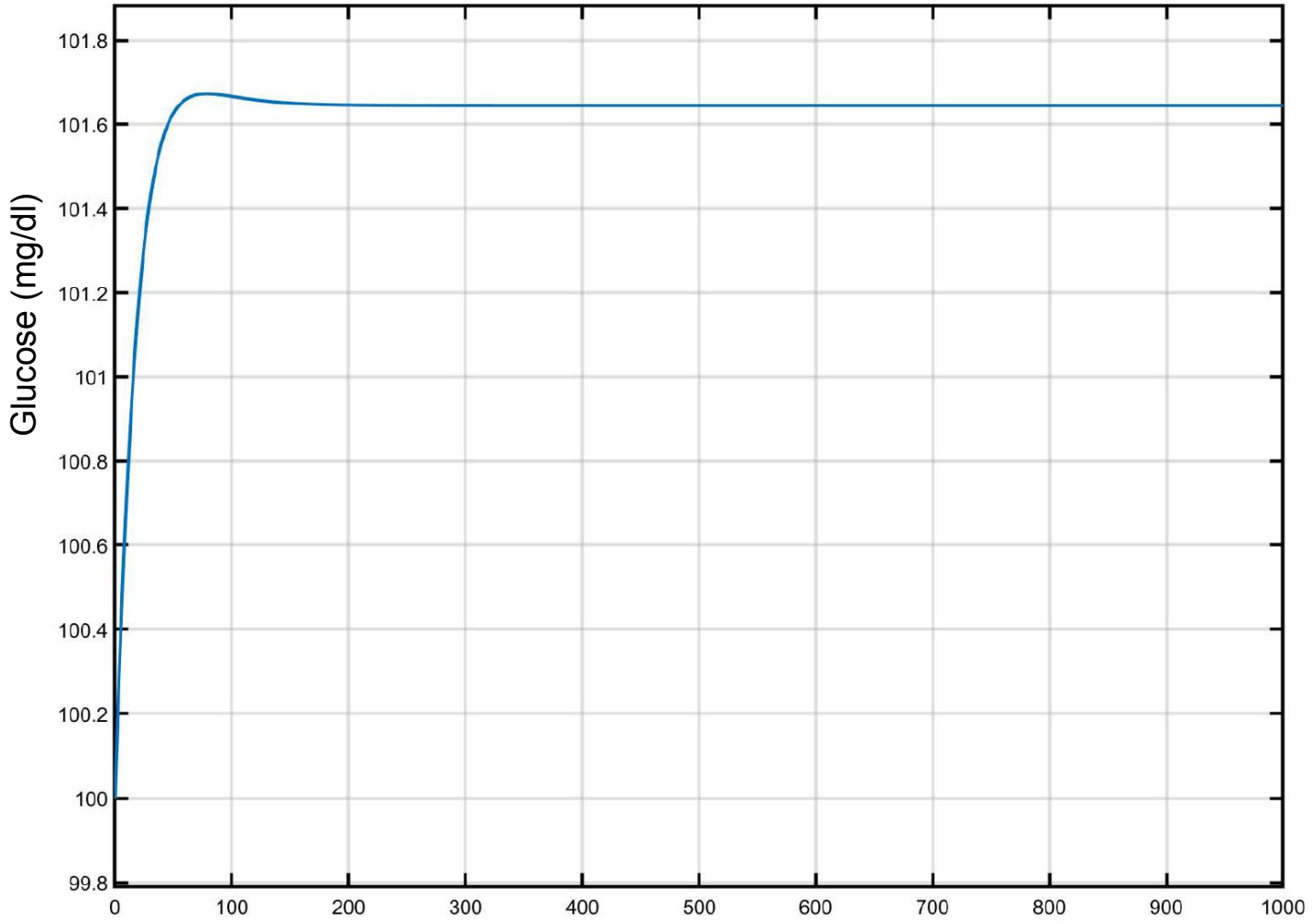


Initial Conditions
Glucose Intake: 100
Insulin Intake: 100
Ib:0.2
Plasma Insulin: 0
Plasma Glucose: 100

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

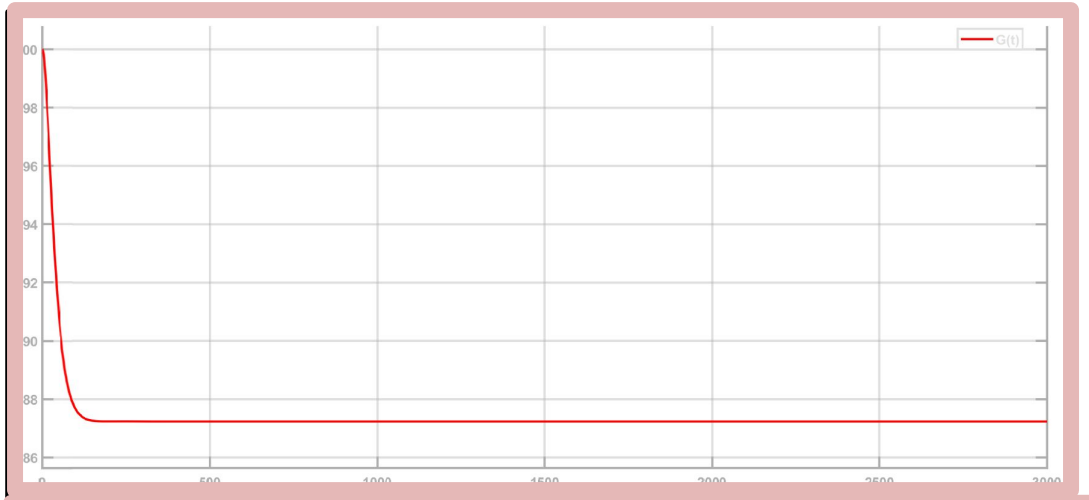
Predictions:
We should get a minimal rise in the blood glucose levels. Due to the insulin input being low.

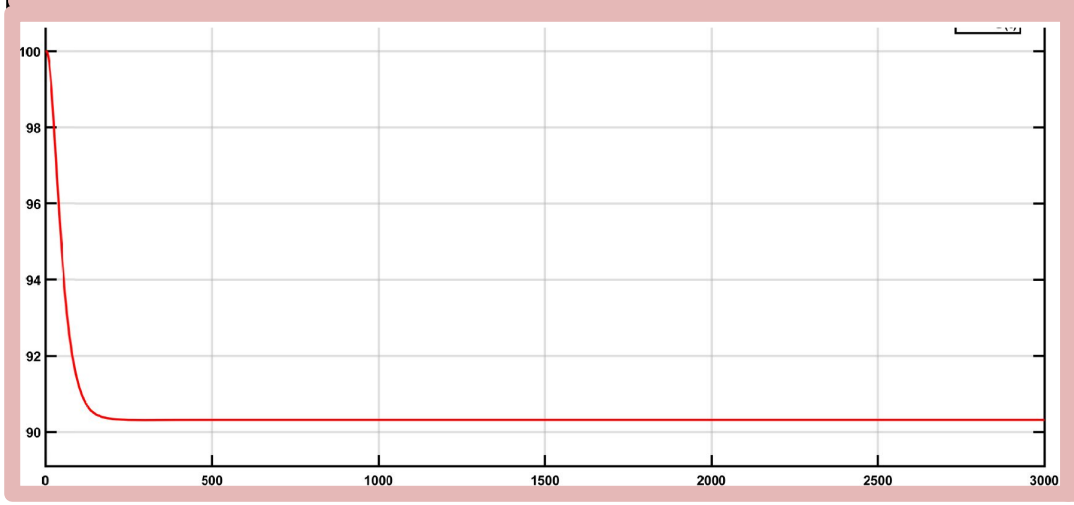
Results:
As we predicted the blood glucose level only rose by 1mg/dl

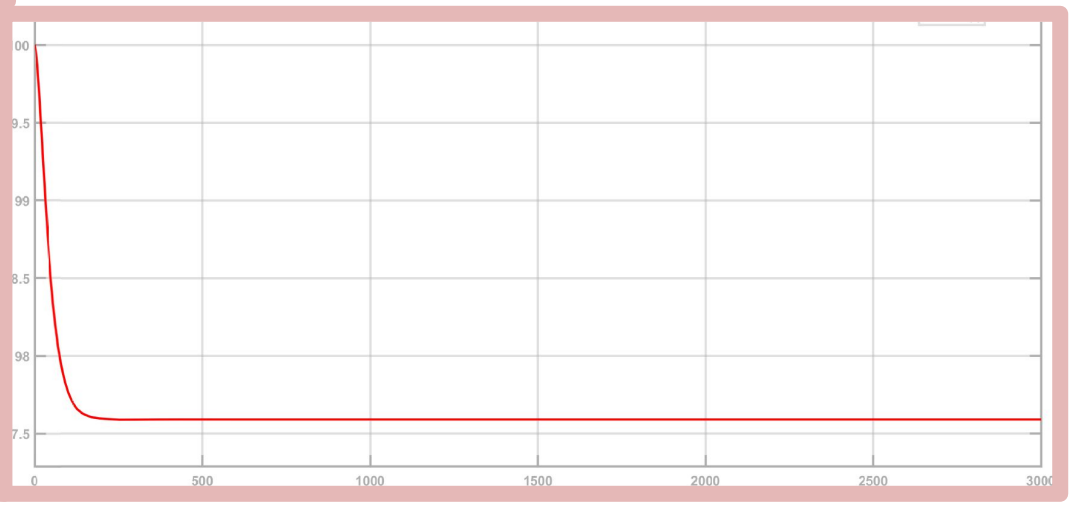
Inputs Table

Case Condition		Model Parameters / Inputs				
		u1	u2	u3	p1	p5
1	Starvation - healthy	0	0	0	0.5	3.00E-06
2	Starvation - diabetic-TI	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

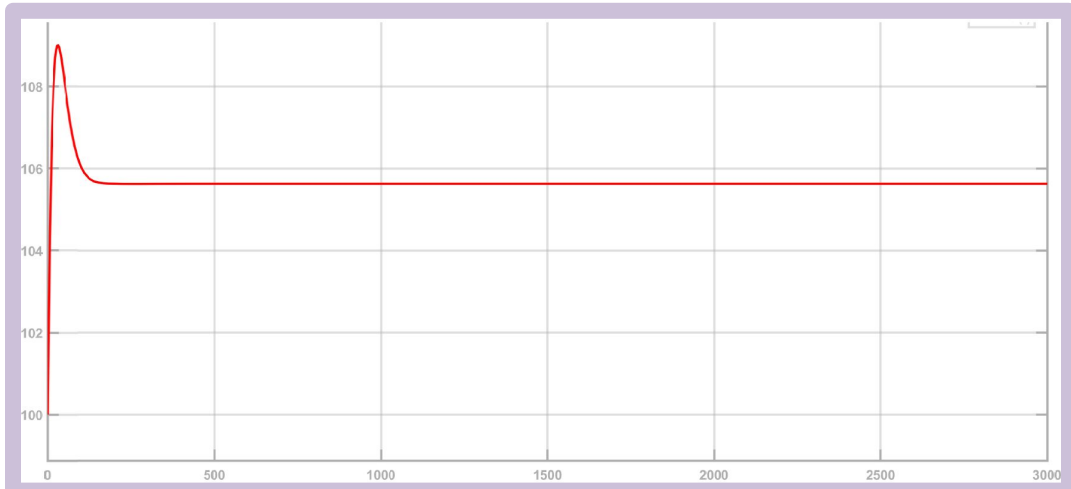
Glucose Intake: 0
Insulin Intake: 0
Exercise Intensity: 0
Plasma Insulin: 0.2
Plasma Glucose: 100

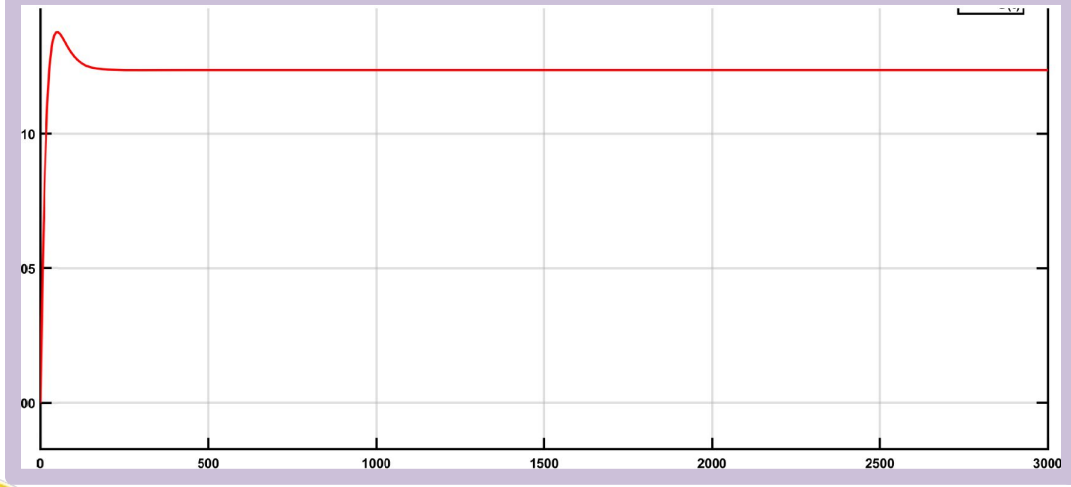
Prediction:
Drop in Glucose level due to no Glucose intake. Insulin will stabilize at below normal levels.

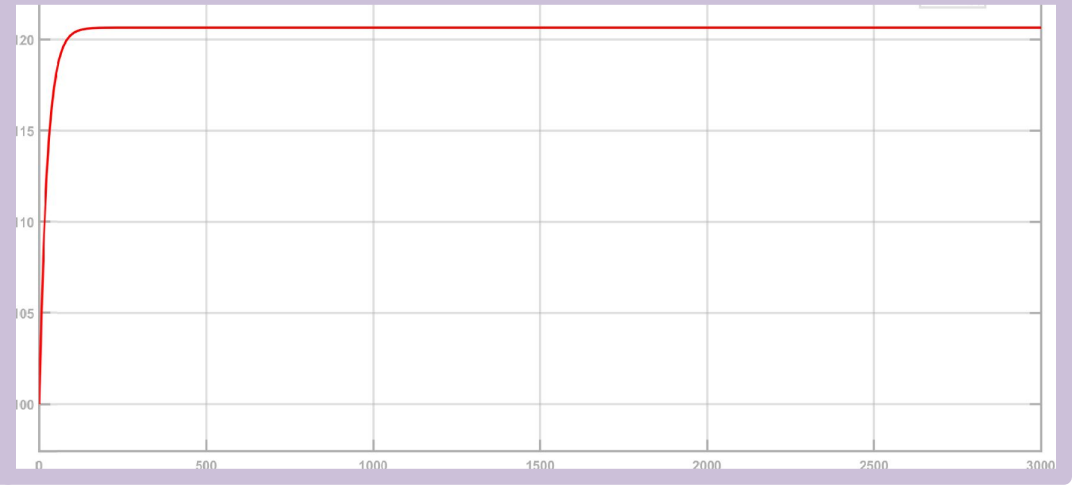
Results

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

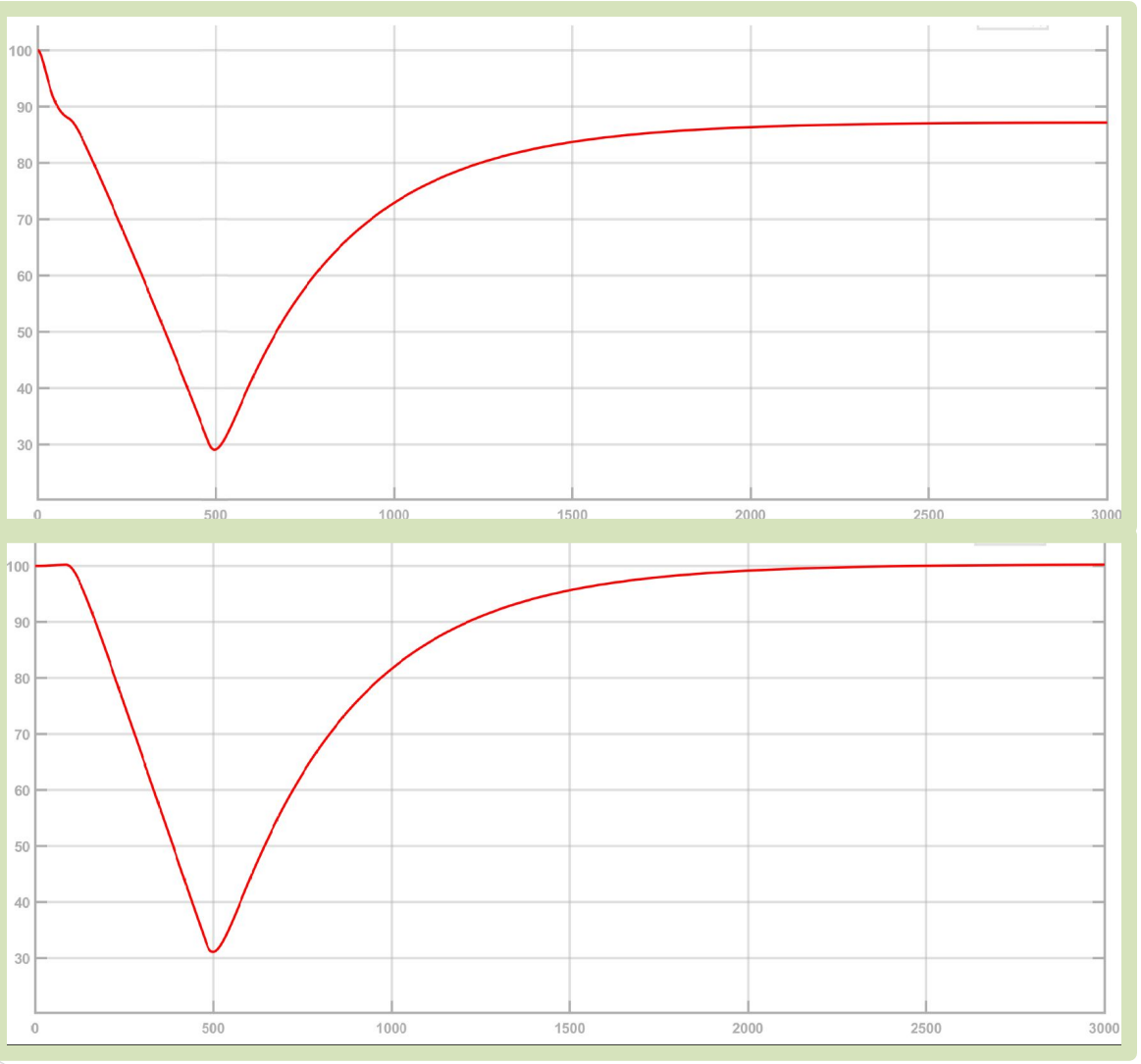






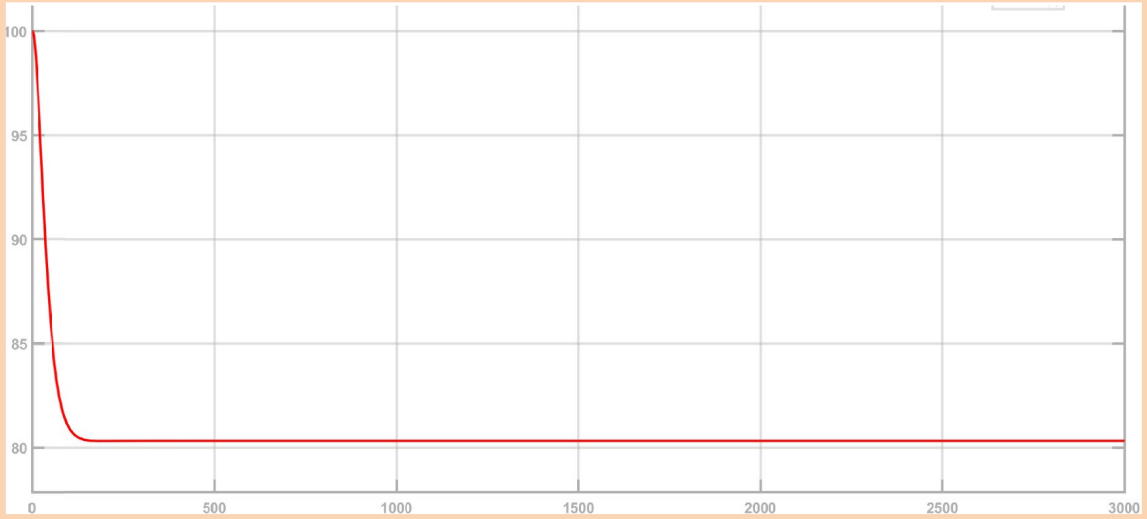
Initial Conditions	Results
Glucose Intake: 100 Insulin Intake: 0 Exercise Intensity: 0 Plasma Insulin: 0.2 Plasma Glucose: 100 Prediction: Rise in glucose levels due to the fact that low insulin levels.	Glucose levels rose as predicted.

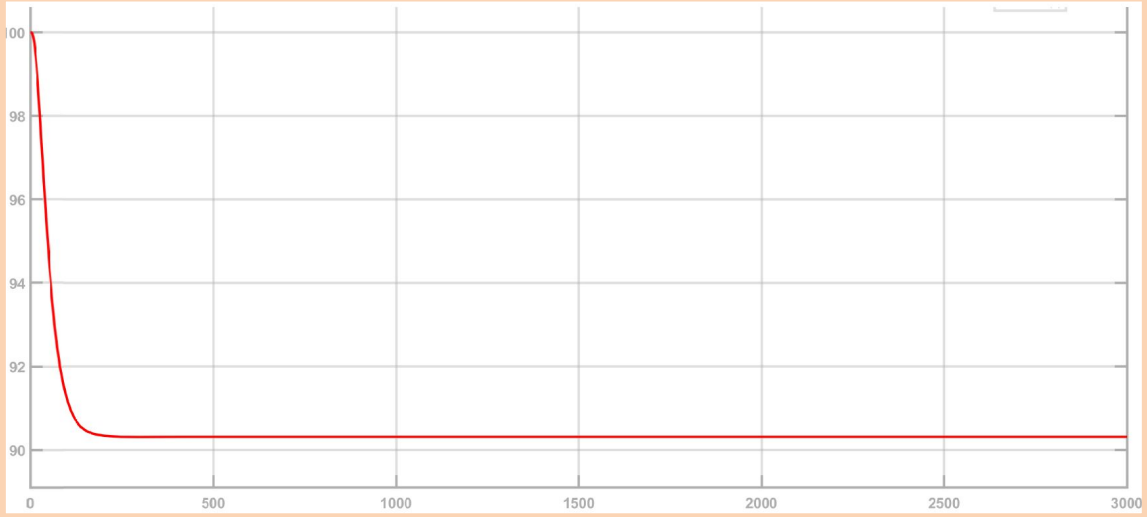
Extended Model - Exercise Healthy Results



Initial Conditions	Results
Glucose Intake: 0 Insulin Intake: 0 Exercise Intensity: 0.9 Plasma Insulin: 0.2 Plasma Glucose: 100 Prediction: Similar to the healthy case except the drop in glucose will not be as evident because of the lack of insulin	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.

Extended Model - Insulin Shot Healthy Results





Initial Conditions	Results
Glucose Intake: 0 Insulin Intake: 10 Exercise Intensity: 0 Plasma Insulin: 0.2 Plasma Glucose: 100 Prediction: The glucose level will drop.	Glucose level dropped to similar values to the healthy case meaning that the insulin injection helped get the model to normal levels.

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-TI	~<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

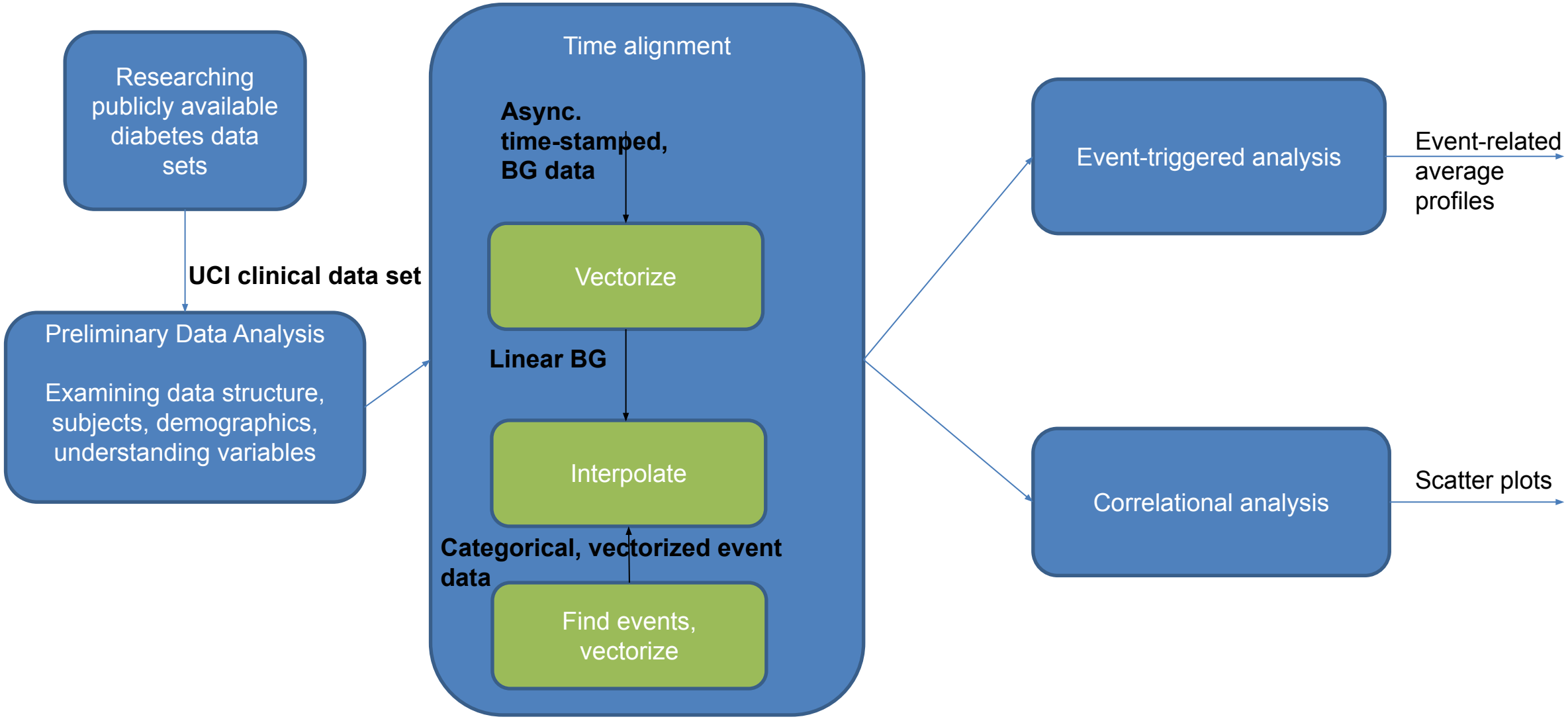
Experimental Data for Model Validation

Data Set Description:

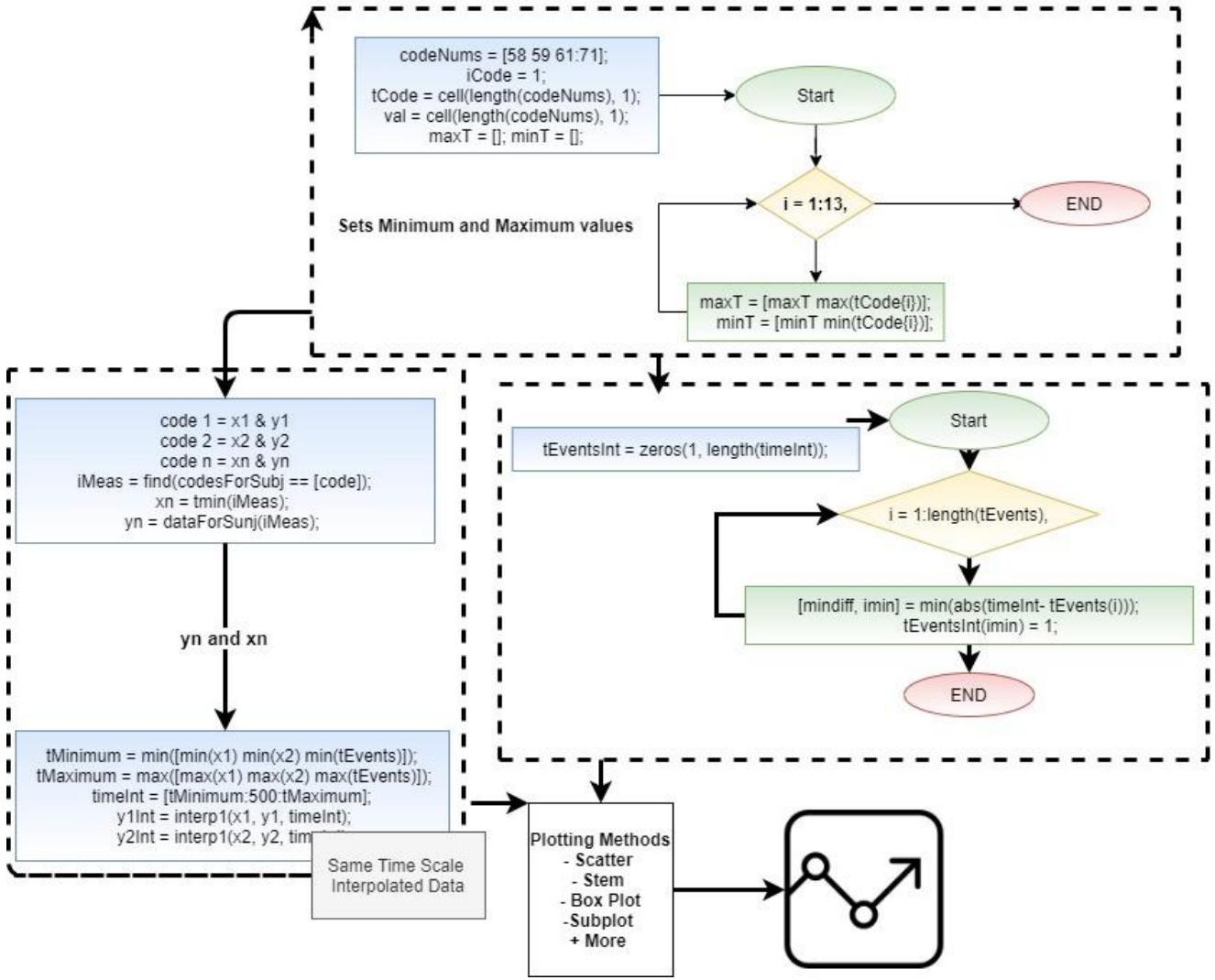
- UCI Machine Learning Department (University of California Irvine)
  - 70 Patients
  - 10,000 + Glucose Readings
  - Approximately (3 Months of Data Per Patient)
  - 20 Different Codes Categorizing Data

	Glucose Measurement		Event data (categorical variables)
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

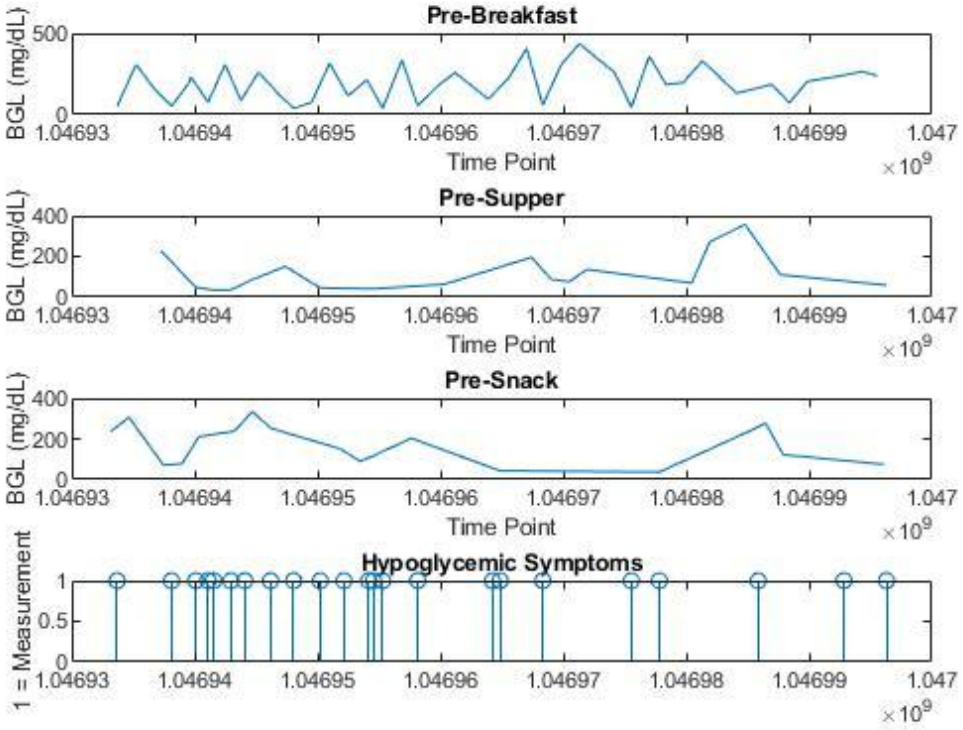
	58 = Pre-breakfast blood glucose measurement	59 = Post-breakfast blood glucose measurement	61 = Post-lunch blood glucose measurement	62 = Pre-supper blood glucose measurement	63 = Post-supper blood glucose measurement	64 = Pre-snack blood glucose measurement	65 = Hypoglycemic Symptoms	66 = Typical Meal Ingestion	67 = More-Than-Usual Meal Ingestion	68 = Less-than-usual meal ingestion	69 = Typical Exercise Activity	70 = More-than-usual exercise activity	71 = Less-Than-Usual 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]

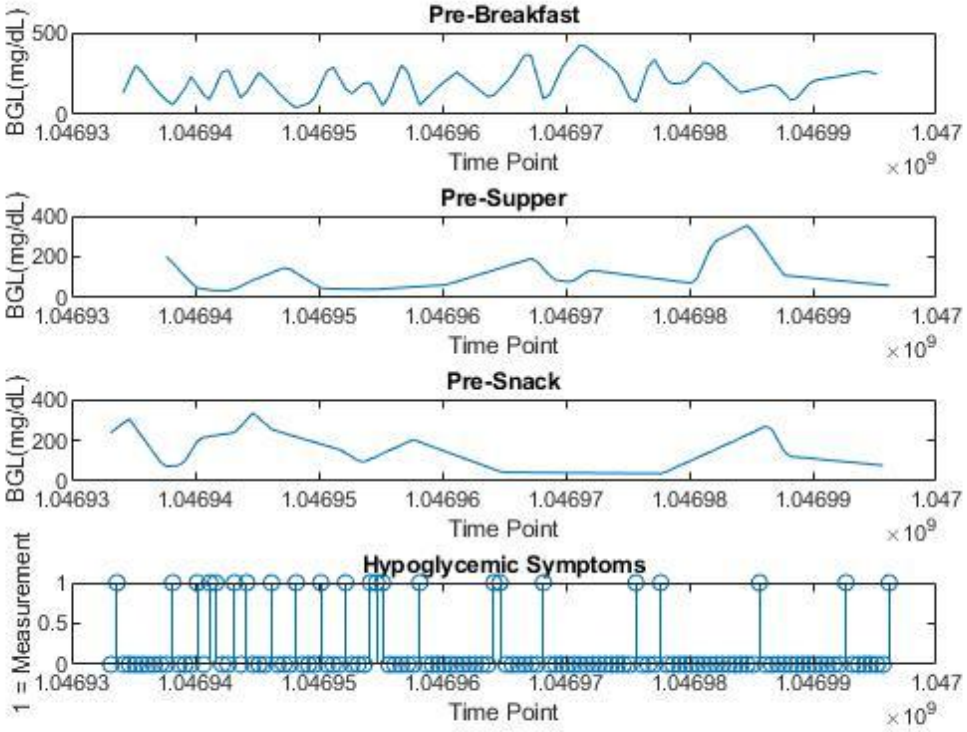
Patient 13 Will be used to be analyzed

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

TIME ARRANGEMENT

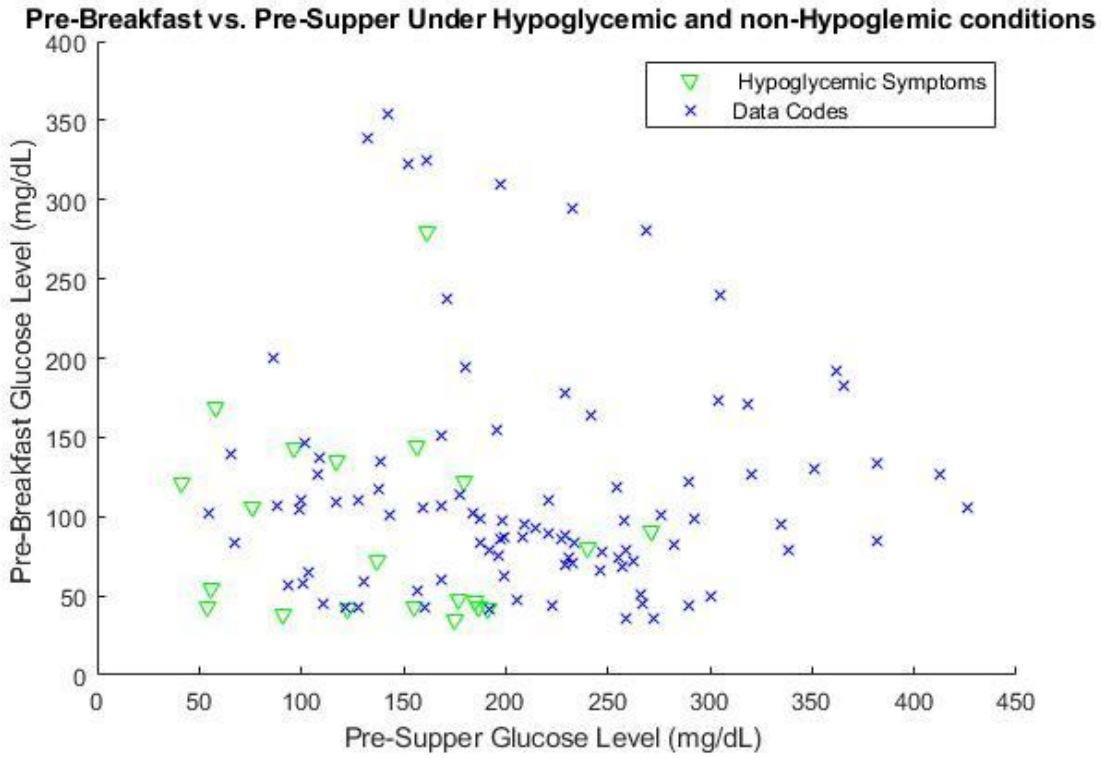


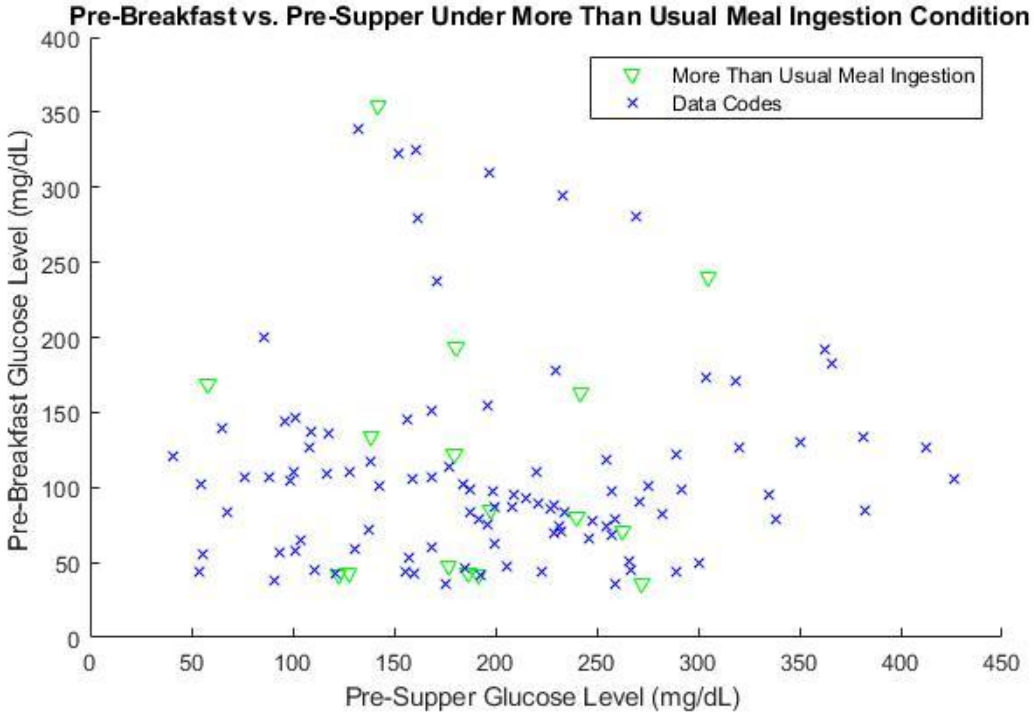
Data plotted on its own independent time recording



<u>Interpolated Data Same Time Domain</u>
Data plotted on the same time scale

Scatter Plots

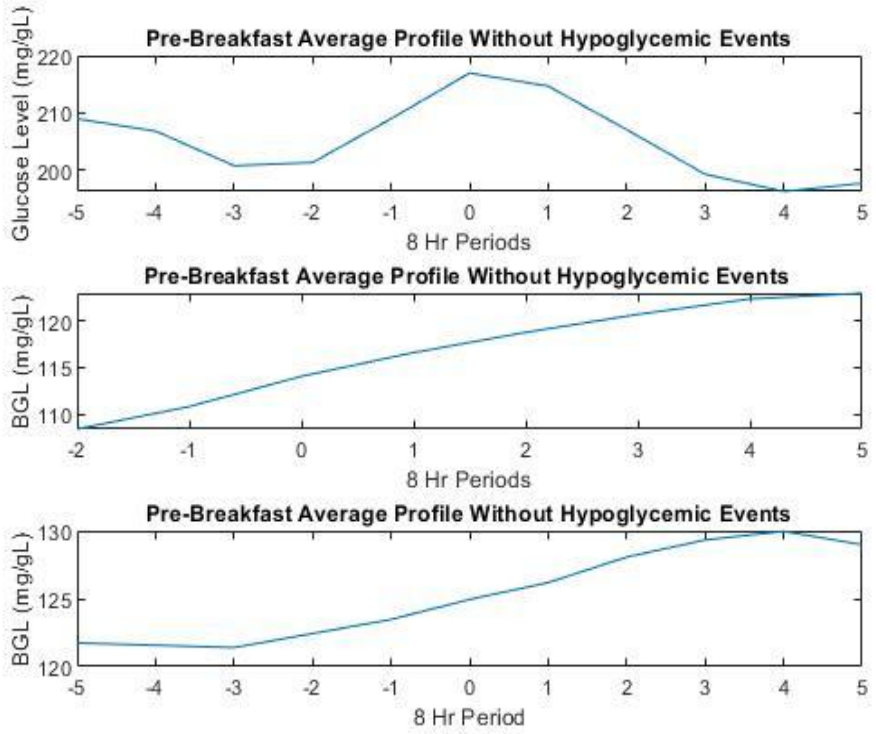




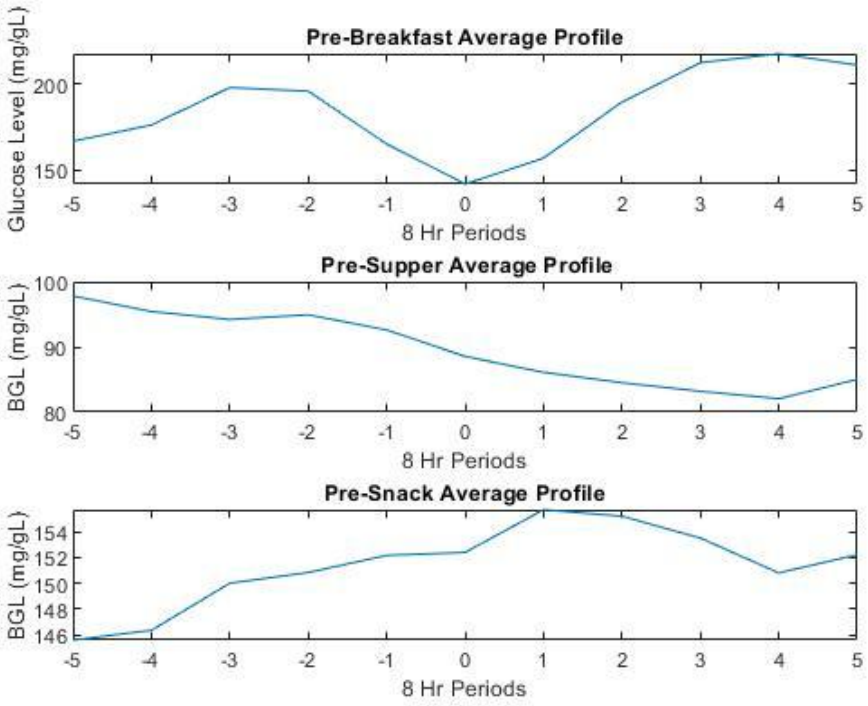
Understanding:

- **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

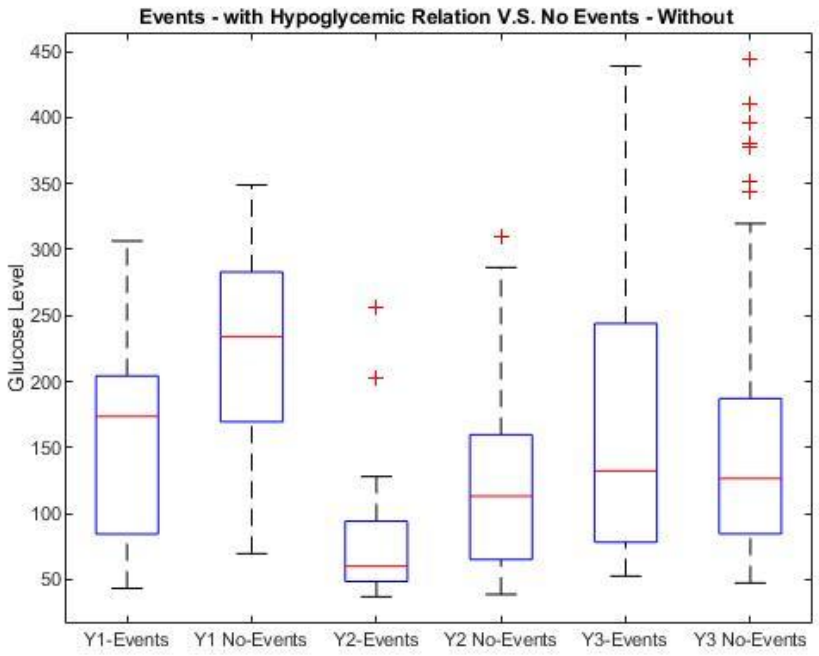


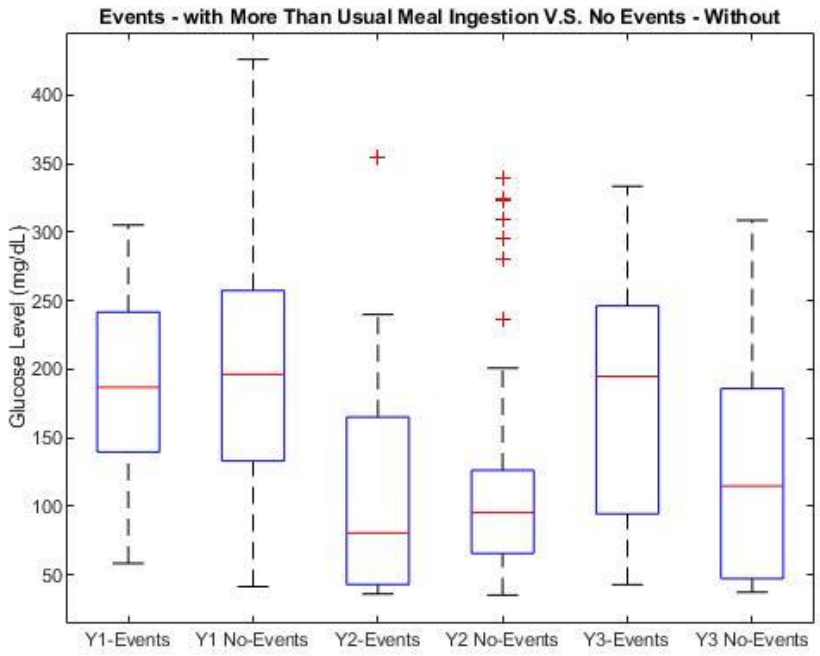
Hypoglycemic event-triggered glucose profiles



Comparing Hypoglycemic Events V.S. Non - Hypoglycemic Events

Box Plots





<u>Box Graph - Glucose Levels</u>
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