# Non-Invasive Blood Glucose Monitor


Group 8: Mya Cohen, Boon Le, Karishma Rohatgi

# Credits

*Which team members did what parts.  Who owned and solved which problems?*

| | |
|---|---|
| **Mya (Hardware/Software Assistance)** | ❏ Initial LED code<br>❏ PPG sensor code assistance<br>❏ Soldering assistance<br>❏ ML Literature Review Assistance<br>❏ Demo-video slide deck |
| **Boon (Hardware)** | ❏ Circuit assembly<br>❏ Hardware research/testing<br>❏ CAD case design/printing<br>❏ Sourcing/optimizing PPG sensor code<br>❏ Demo-video editing |
| **Karishma (Software)** | ❏ ML model training/experimentation and evaluation/testing<br>❏ Regression feature extraction and selection<br>❏ PPG dataset sourcing/cleaning<br>❏ Project scope literature review<br>❏ LED code troubleshooting |

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  Advisement on project directions and team deadlines.
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  Advisement on CAD case files and assistance with case design/assembly.
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  Advisement on BOM and PPG code troubleshooting.
- **Ray Peck**
  Soldering and case assembly assistance.
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  Crash course on SolidWorks.
- **Myilan Muruganujan**
  Soldering assistance.


# Introduction

*Unmet need scenario*

**Type 2 Diabetes Mellitus** affects 38.4 million working-age adults in the United States. Of that number, 8.7 million people are undiagnosed.

**SO:** *How do we encourage people, who are unaware of their condition, to actively take care of their health?*

**Unmet Need:** *Prime working age individuals (25-54) in the United States with T2DM need an easy, convenient, fast, and non-invasive method to monitor their blood glucose levels throughout the day.*

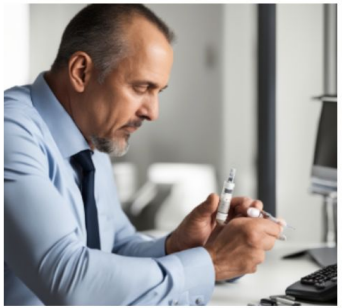
# *Use-Case Scenario*

John, a type 2 diabetic, just had his lunch. He returns to work but feels uneasy.

He decides to drink some water. Even now, he still feels incredibly thirsty.

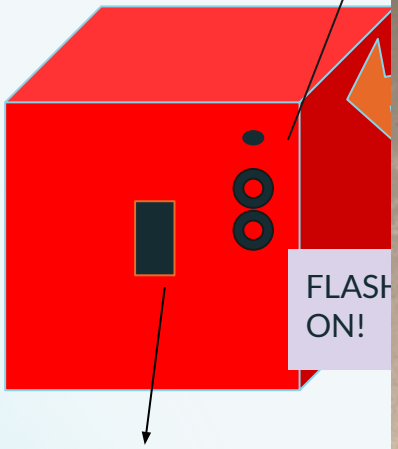
He then refers to his sensor because he feels like it has something to do with his glucose levels.

His monitor shines red. He is hyperglycemic!



Because he knows this, he will now take his medication to control his sugar levels, as recommended by his doctor.

Thanks to our sensor, John was able to take appropriate measures. He feels better!




PPG Sensor

1

1


Arduino Code for LED Bulbs

3

# MVP Parameters

| MVP Feature | Parameters | Parameter Threshold + Qualification |
|---|---|---|
| PPG Sensor (MAXREFDES117) | $SpO_2$ (%) | **NORMAL: 95-100%**<br>**ABNORMAL: $SpO_2$ < 95%**<br>Note: This output is not used for the rest of the MVP |
| | Heart Rate (beats/min) | **NORMAL: 60-100 bpm**<br>**ABNORMAL: HR<60 bpm OR HR>100 bpm** |
| ML Algorithm (Python) | *Predetermined Inputs (UNCHANGED, PATIENT-SPECIFIC)*<br>❏ PPG Signal, Patient ID (ID #), Systolic Peak, Diastolic Peak, Pulse Area, Index (Integer), Gender, Height (cm), Weight (kg), Age Range (1-5)<br><br>*Sensor Data Input:* Heart Rate (beats/min) | **In testing data (X_test):**<br>❏ PPG Signal: 507-515 nm<br>❏ Systolic Peak: 514-529 nm<br>❏ Diastolic Peak: 504-512 nm<br>❏ Pulse Area: 309.5-481.5 nm<br>❏ Patient ID: 1-23 (23 patients sampled in dataset)<br>❏ Index: 0-66 (patients were sampled >1 times)<br>❏ Gender: 0 for Male, 1 for Female<br>❏ Height: 157-187 cm<br>❏ Weight: 50-103 kg<br>❏ Age Range: 1-5 (1 = 0-20 years old, 2 = 21-30... 5 = 51-70) |
| LED Bulbs (Arduino) | *Input:* Blood Glucose (mg/dL)<br>*Output:* Red LED Flash, Red LED on, Green LED on | **Hypoglycemic (Low):** BG < 80 mg/dL → Red FLASH<br>**Euglycemic (Normal):** 80<BG<130 mg/dL → Green ON<br>**Hyperglycemic (High):** BG > 130 mg/dL → Red ON |

# Original MVP Pivot

**Originally,** our team aimed to build a *wearable/portable device* that could monitor an individual's blood glucose value throughout the day, based on PPG signals, and have *three different LED bulbs* for each of the three blood glucose scenarios (high, normal, low).

**But,** we pivoted our MVP to be plugged into their computer and at the user's desk, and have either a green or red LED bulb (red → high OR low, green → normal) determined based on a HR instead of PPG signals from the sensor.

## Rationale

- ❏ The PPG sensor **worked best** and **most consistently** with **finger tip** readings rather than on the **wrist.**
- ❏ Due to the **bulkiness**, **mode-of-measurement, and hardware-software connection** of the device, it would **not be practical** to wear all the time.
- ❏ According to the U.S. Department of Education, **71% of working age adults** use a computer at work, so it is realistic for the device to be connected to the computer.

# Demonstration Time!

Demonstration Video Link: HERE

# Future Improvements

1. Having a higher or same $R^2$ accuracy value while depending on less ML features.
2. Integrated GUI to house all 3 systems for less manual coordination between systems.
3. Transition to a portable design by including a battery and cloud storage.
4. Take the average HR from the PPG sensor over a period of time rather than relying on just the first data point.

# Lessons Learned/Knowledge to Pass On

## 02. MVP

### 01. General Lessons

1. PPG Sensor/LED: Ensure that the LED used corresponds with the wavelengths that the PPG sensor uses (red LED for red wavelengths, etc.)
1. Find hardware/software that already exists on the market rather than trying to build hardware components from the ground-up.
2. ML:
2. If within budget, buy more than one hardware component in case component gets damaged during testing/development.
    - Choose the simplest ML model to avoid further issues with complexity (choosing Regression models vs Random Forest/Decision Tree Classifiers).
    - Ensure the dataset chosen has a sufficient amount of data to allow for accurate training of the model.
    - Avoid AutoML training to have better control over features and overall model training (avoid AutoML on Vertex AI and other ML platforms on Azure).
3. Be open to changes during the R&D process and allow for flexibility.
4. Have more regular team meetings to discuss project scope and individual contributions at the start.
3. CAD: refer to open source files rather than trying to design the objects from scratch.

# Thank you!

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