**DiabetaCare**

**Smart Health Navigator for Type 1 Diabetes**

**Project Description:**

The "Personalized Diabetes Management System" is a data-driven platform designed to assist type 1 diabetic patients in effectively managing their blood sugar levels, dietary intake, and overall health. The system will provide real-time insights and recommendations by analyzing user-provided data on insulin intake, food routines, and blood sugar levels. It will leverage data science techniques and web-scraped information on food and insulin to generate personalized health recommendations, detect patterns, and provide actionable alerts to help users make informed decisions about their health. The system will be scalable and adaptable to evolving needs, ensuring continuous support for the user's health management journey.

**Objectives:**

1. **Blood Sugar Monitoring and Analysis:**

* Collect and store user-provided blood sugar level data at various times of the day.
* Analyze patterns in blood sugar levels based on insulin intake, food consumption, and other relevant factors.

1. **Dietary Recommendations:**

* Allow users to input their daily food routines, including specific meals and snacks.
* Provide personalized dietary recommendations based on historical data, aiming to maintain stable blood sugar levels.

1. **Insulin Management:**

* Enable users to input the type and amount of insulin they are taking.
* Analyze the relationship between insulin dosage and blood sugar levels to optimize insulin management.

1. **Pattern Detection and Insights:**

* Use data science to detect patterns in how different foods and insulin types affect blood sugar levels.
* Provide insights and recommendations, such as adjusting insulin dosage or moderating food intake, based on historical and current data.

1. **Health Alerts and Notifications:**

* Implement a system for generating real-time alerts and notifications, such as warnings about potential high or low blood sugar levels based on current input data.
* Recommend proactive actions to prevent adverse health outcomes.

1. **Scalability and Adaptability:**

* Design the system to be scalable and adaptable, allowing for the addition of new features and functionalities based on evolving needs.
* Ensure the platform can accommodate new types of data and user inputs, providing continuous and personalized health support.

1. **Integration with External Data:**

* Scrape and integrate data from online resources on food, nutrition, and insulin to enhance the accuracy and relevance of recommendations.
* Use this external data to build a more comprehensive understanding of how different factors influence blood sugar levels.

**Steps:**

**1. Project Setup and Initial Research**

* Objective: Set up the project environment and conduct initial research.
* Steps:
  + Set up the development environment: Install and configure tools like Python, Jupyter Notebook, and relevant libraries (e.g., Pandas, Scikit-learn, TensorFlow).
  + Research and gather data: Collect datasets related to diabetes, insulin types, food intake, and blood sugar levels. Identify credible sources for web scraping to gather additional data.
  + Explore and understand the data: Perform exploratory data analysis (EDA) to understand the relationships between variables such as food intake, insulin, and blood sugar levels.

**2. Data Collection and Preprocessing**

* Objective: Collect and preprocess data for the system.
* Steps:
  + Web scraping: Develop scripts to scrape relevant data from medical websites, forums, and databases that provide information on food, insulin, and blood sugar.
  + Data integration: Combine the scraped data with user-provided data (insulin intake, food routine, sugar levels).
  + Data cleaning: Handle missing values, normalize data, and ensure consistency across different data sources.
  + Feature extraction: Identify key features (e.g., types of food, insulin dosage, time of day) that impact blood sugar levels.

**3. Model Development for Blood Sugar Prediction**

* Objective: Build models to predict blood sugar levels based on food intake and insulin dosage.
* Steps:
  + Feature engineering: Create new features that may improve model performance, such as calculating the glycemic index of meals.
  + Model selection: Choose appropriate machine learning models (e.g., linear regression, decision trees, or neural networks) for predicting blood sugar levels.
  + Model training: Train the models using the processed data, tuning hyperparameters for optimal performance.
  + Model evaluation: Evaluate the models using metrics like mean squared error (MSE) or mean absolute error (MAE) to ensure accuracy and reliability.

**4. Development of Personalized Recommendations System**

* Objective: Develop a system that provides personalized recommendations for managing blood sugar levels.
* Steps:
  + Pattern analysis: Use data mining techniques to identify patterns between food intake, insulin usage, and resulting blood sugar levels.
  + Recommendation engine: Implement algorithms that suggest adjustments to insulin dosage or food intake based on historical data and current inputs.
  + Contextual alerts: Develop a system that alerts the user about potential risks (e.g., high sugar levels) and suggests preventive measures.

**5. User Interface Development**

* Objective: Create a user-friendly interface for data input and visualization.
* Steps:
  + Frontend development: Build a responsive web interface using React.js or similar frameworks where users can input their daily routines and view recommendations.
  + Data visualization: Integrate libraries like D3.js or Chart.js to display trends, patterns, and recommendations in an easy-to-understand format.
  + Progress tracking: Develop features that allow users to track their health metrics over time, providing insights into their progress.

**6. Testing and Refinement**

* Objective: Ensure the system works accurately and efficiently.
* Steps:
  + System testing: Perform unit testing, integration testing, and user acceptance testing (UAT) to identify and fix issues.
  + Refinement: Continuously improve the algorithms based on user feedback and additional data.
  + Scalability considerations: Design the system to be scalable, allowing for future expansion, such as adding more health metrics or integrating with wearable devices.

**7. Future Enhancements**

* Objective: Plan for future improvements and additional features.
* Steps:
  + Integration with wearable devices: Explore integration with devices like continuous glucose monitors (CGMs) or fitness trackers.
  + Advanced analytics: Implement more advanced machine learning models, such as deep learning or reinforcement learning, for more accurate predictions.
  + Dietary database expansion: Continuously update the food and insulin databases with new information to improve the accuracy of the system.

**Day by Day Process:**

**1. Switching to individual chat on Chat GPT for creating datasets:**

**Project:**   
The objective of the "DiabetaCare: Smart Health Navigator for Type 1 Diabetes" project is to monitor and manage blood sugar levels, dietary intake, and insulin usage by analyzing how different foods and insulin dosages impact blood sugar levels. The system will provide real-time recommendations based on historical data and internet-sourced information.

**Building Datasets:**

1. **Food Dataset:**

Research and compile data on various food items, including carbohydrate content, glycemic index, and other relevant nutritional information.

Create a dataset that includes daily food items you consume, tracking their carbohydrate content and other necessary data for monitoring blood sugar levels.

1. **Insulin Dataset:**

Collect and store data on the type and amount of insulin you are taking.

Analyze how different insulin types and dosages impact your blood sugar levels.

1. **Daily Monitoring Dataset:**

Create a daily dataset that logs your food intake, insulin usage, and blood sugar levels at various times of the day.

Use this data to identify patterns and provide insights into how your daily routine affects your blood sugar levels.

**Process:**

**1.Insulin Sensitivity Factor(ISF):**

This indicates how much 1 unit of insulin lowers blood sugar, typically expressed as mg/dL per unit of insulin.

* 1. **ISF Calculation**

1. Ensure Stable Blood Sugar

2. Record Pre-Meal Blood Sugar

3. Record Insulin Dosage

4. Record Your Meal

5. Wait 3-4 Hours and measure Post-Meal Blood Sugar

6. Calculate the Blood Sugar Drop

7. Use the Formula,

**Insulin Effect = Actual Increase − Expected Increase**

**ISF = Insulin Effect/ Units of Insulin Taken**

1. Example calculation,

**Step 1: Understand the Insulin (Insugen 30/70) Action first**

* **Insugen 30/70** is a mixed insulin, meaning it contains both short-acting (30%) and intermediate-acting (70%) insulin.
* **Onset of Action:** Within 30 minutes.
* **Peak Effect:** 2 to 8 hours.
* **Duration:** Up to 12 hours.

**Step 2: Record the Relevant Data**

* **Fasting Blood Sugar (Pre-Meal):** 266 mg/dL
* **Insulin Dosage:** 30 units
* **Food Consumed:** Two poori with sambar (we will estimate its impact below)
* **Post-Meal Blood Sugar (3 Hours Later):** 322 mg/dL

**Step 3: Estimate the Blood Sugar Impact from Food**

**Carbohydrate Content:** Let’s estimate that two poori with sambar might contribute approximately 60 grams of carbohydrates.

* **Poori:** Roughly 15-20 grams of carbs per poori.
* **Sambar:** Could add some additional carbohydrates.

**Step 4: Calculate the Expected Blood Sugar Increase**

* **Carb to Blood Sugar Conversion:** Typically, 1 gram of carbohydrate can raise blood sugar by about 4 mg/dL.
* So, 60 grams of carbs would theoretically raise your blood sugar by,

**60 × 4 = 240 mg/dL**

**Step 5: Consider the Insulin's Role**

* **Initial Blood Sugar:** 266 mg/dL
* **Expected Blood Sugar Increase Due to Food:** 240 mg/dL
* **Expected Blood Sugar after the meal without insulin:**

266+240=506 mg/dL

* **Actual Post-Meal Blood Sugar:** 322 mg/dL

**Step 6: Determine the Insulin’s Effect**

* The difference between the expected post-meal blood sugar (506 mg/dL) and the actual post-meal blood sugar (322 mg/dL) gives us the blood sugar reduction due to insulin:

**506−322=184 mg/dL**

**Step 7: Calculate the Insulin Sensitivity Factor (ISF)**

* **ISF Formula:**

ISF = Blood Sugar Reduction / Units of Insulin Taken

* **Apply the Values:**

ISF = 184(mg/dL) / 30 units ≈ 6.13 mg/dL per unit

**Conclusion:**

* The Insulin Sensitivity Factor (ISF) is approximately **6.13 mg/dL per unit**. This means that, on average, 1 unit of Insugen 30/70 lowers your blood sugar by about 6.13 mg/dL.
  1. **Problem in the above calculation:**

The insulin's peak hour itself last for 8hours and only 3 hours were finished on my post test this means that there is still remaining units which is there to yet decrease the sugar level right if so then how can you divide by the entire dosage?

To refine the calculation, we should estimate the proportion of insulin that would be acted on the given time (first 3 hours in this case) and use that for the ISF calculation.

* 1. **Bell curve or Gaussian Distribution:**

The insulin action follows a somewhat bell-shaped curve during the peak phase, with the most rapid utilization of insulin occurring in the middle of this phase (around 4-6 hours).

**Formula for Insulin Utilization over time:**

The bell curve (Gaussian function) is represented as:

* I(t) is the insulin utilization rate at time t.
* A is the total insulin administered (30 units in this case).
* μ is the peak time of insulin action (5 hours).
* σ is the standard deviation that determines the spread of insulin action over time (we assume 2 hours).
* t is the time at which you want to calculate the insulin utilization.
* The value of e (Euler's number) is approximately **e ≈ 2.71828**

**Step 1: Define Parameters**

* Total insulin **A** = 30 units.
* Peak time **μ** = 5 hours.
* Standard deviation **σ** = 2 hours.

**Step 2:** **Substitute into the Formula**

Calculate the insulin utilization at different times t using these values. We'll first break the formula into parts to make it easier to calculate.

1. Denominator of the first part,

2. First part of the equation,

So the equation becomes,

**Step 3:** **Calculate Insulin Utilization at Different Times**

With the help of the formula let's break down how the insulin consumption rate is calculated, especially for Insugen 30/70, which has an action duration of 10 hours, with the peak action occurring between 2 to 8 hours.

**1.At t = 1 hour:**

Assuming 1 unit consumed at hour 1, then the percent of insulin consumed at hour 1 will be,

**Similarly calculating for 10 hours will result in the following table,**

| **Time (Hour)** | **Insulin Utilization (%)** | **Cumulative Insulin Utilized (%)** |
| --- | --- | --- |
| **1 hour** | 3% | 3% |
| **2 hours** | 6% | 9% |
| **3 hours** | 12% | 21% |
| **4 hours** | 17% | 38% |
| **5 hours** | 20% | 58% |
| **6 hours** | 17% | 75% |
| **7 hours** | 12% | 87% |
| **8 hours** | 6% | 93% |
| **9 hours** | 4% | 97% |
| **10 hours** | 3% | 100% |

* 1. **Recalculating ISF with insulin utilization rate:**

**Step 1: Estimate the Carbohydrate Content of the Food**

**Two Pooris:** Approximately 30 grams of carbohydrates.

**Sambar:** Approximately 10 grams of carbohydrates.

Total carbohydrate intake = 30g (Poori) + 10g (Sambar) = **40 grams** of carbohydrates.

**Step 2:** **Estimate the Blood Sugar Increase from Carbohydrates**

Estimated Blood Sugar Increase from Carbs = 40 grams × 4 mg/dL per gram = **160 mg/dL**

**Step 3:** **Calculate Expected Blood Sugar Without Insulin**

Without insulin, the blood sugar level would have increased by 160 mg/dL due to the food. Adding this to your fasting blood sugar,

Expected Blood Sugar **(No Insulin)** = 266 mg/dL + 160 mg/dL = **426 mg/dL**

**Step 4:** **Calculate the Actual Blood Sugar Reduction**

The actual blood sugar after 3 hours was 322 mg/dL, so the insulin reduced the blood sugar by

Blood Sugar Reduction by Insulin = 426 mg/dL − 322 mg/dL = **104 mg/dL**

**Step 5: Calculate the Insulin Used**

From the above table, 21% of the 30 units of insulin was used in those 3 hours,

Insulin Used = 0.21 × 30 units = **6.3 units**

**Step 6: Calculate the Insulin Sensitivity Factor (ISF)**

Finally, calculate the ISF, which is how much 1 unit of insulin lowers your blood sugar,

**2. Estimating Blood Sugar with ISF**

After 3 hours on calculating my post sugar level (322 mg/dl) i ate my lunch which includes 150 grams of white rice with sambar. lets take the ISF as 10 mg/dl and its been 1.5 hours since i ate my lunch now calculate my blood sugar level.

**Given Data**

* **Fasting Blood Sugar**: 266 mg/dL
* **Blood Sugar After 3 Hours**: 322 mg/dL
* **Insulin Taken**: 30 units
* **ISF**: 16 mg/dL per unit
* **Lunch**: 100 grams of white rice with sambar
* **Time After Lunch**: 1.5 hours
* **Insulin Usage During the 1.5 Hours Post-Lunch**: 35% of the insulin
* **Carbohydrate Impact**: 100 grams of white rice (approximately 60 grams of carbohydrates)

**Step 1: Calculate the Carbohydrate Impact of Lunch**

* Estimated Blood Sugar Increase from Carbs = 60 grams × 4 mg/dL per gram = 250 mg/dL

**Step 2: Calculate Insulin Usage for the 1.5 Hours Post-Lunch**

* Time since the insulin taken is 3 + 1.5 hours = **4.5 hours**
* At t = 4.5 hours,

**Step 3: Calculate the Blood Sugar Reduction Due to Insulin**

Reduction = 5.8 units × 16 mg/dL per unit = **92 mg/dL**

**Step 4: Estimate Blood Sugar Increase Due to Lunch**

Since your blood sugar was 322 mg/dL before lunch, the total impact of lunch should be added to this,

Estimated Blood Sugar Before Lunch Impact = 322 mg/dL + 240 mg/dL = **562 mg/dL**

**Step 5: Adjust for Insulin Action**

Now, reduce this value by the insulin action,

Estimated Blood Sugar After Lunch = 562 mg/dL − 92 mg/dL = **470 mg/dL**

**Final Blood Sugar Level**

After 1.5 hours post-lunch, considering the insulin action and carbohydrate intake,

The estimated blood sugar level would be approximately **470 mg/dL**.

**3. Important Considerations on ISF**

* Since ISF is a dynamic value that varies daily, it is best practiced to create a dataset dedicated to ISF, add various ISF data points from different days, calculate and update this dataset, and then calculate the ISF based on the average of these various ISF points.

**3.1 ISF Dataset**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Date** | **Time** | **Pre-Meal Blood Sugar (mg/dL)** | **Food Consumed** | **Estimated Carbohydrates (g)** | **Insulin Dosage (units)** | **Post-Meal Blood Sugar (mg/dL)** |
| 2024-08-25 | 15:00 | 266 | Two Poori with Sambar | 40 | 30 | 322 |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Time After Meal (hrs)** | **Expected Blood Sugar Increase (mg/dL)** | **Actual Blood Sugar Reduction (mg/dL)** | **Active Insulin (units)** | **Calculated ISF (mg/dL per unit)** | **Notes** |
| 3 | 160 | 104 | 23.5 | 16 |  |

**3.2 ISF Automation**

Rather than utilizing the formula to manually calculate the ISF, this process is automated using code. The user fills in the dataset with inputs such as **Pre-Meal Blood Sugar (mg/dL), Food Consumed, Insulin Dosage (units), Post-Meal Blood Sugar (mg/dL),** **and Time After Meal (hrs).** The isf automation code is then executed, which calculates the isf and automatically fills the remaining columns in the dataset.

**4. Insulin Separation (New Problem)**

After looking into a few things, I discovered that Insugen 30/70 is a mixed insulin that contains both rapid and intermediate acting insulin. We calculated the insulin utilization per hour for a span of 12 hours, taking into account the insulin's lifetime. The problem here is that 30% of the rapid insulin begins to react within 30 minutes, peaks between 2 and 4 hours, and has a life expectancy of roughly 5 to 6 hours, based on assumption. The intermediate insulin, on the other hand, has a peak hour of 4 to 8 hours and begins to react within 1 to 2 hours, likewise based on assumptions. Based on these observations, I believe that looking at the rapid and intermediate insulin utilization separately is the best option and will provide a more accurate blood sugar prediction.

**4.1 Insulin Utilization for Rapid acting Insulin**

**1. Same Formula (refer 1.3 Gaussian curve)**

**2. General Assumptions**

* Rapid-acting insulin (30% of the dose)
* Starts acting: 30 minutes after injection.
* Peak action: 2 to 4 hours.
* Duration: 5 to 6 hours.

**3. Utilization Chart**

|  |  |  |
| --- | --- | --- |
| **Time (hrs)** | **Insulin Utilization (%)** | **Comment** |
| 0.5 | 5% | Start of rapid-acting action |
| 1 | 10% | Insulin activity increases |
| 2 | 25% | Peak action starts |
| 3 | 35% | Peak action continues |
| 4 | 15% | Declining after peak |
| 5 | 5% | Ending phase |
| 6 | 5% | Rapid insulin effect tapers off |

**4.2 Insulin Utilization for Intermediate acting Insulin**

**1. Same Formula (refer 1.3 Gaussian curve)**

**2. General Assumptions**

* Intermediate-acting insulin (70% of the dose)
* Starts acting: 1 to 2 hours after injection.
* Peak action: 4 to 8 hours.
* Duration: 12 hours.

**3. Utilization Chart**

|  |  |  |
| --- | --- | --- |
| **Time (hrs)** | **Insulin Utilization (%)** | **Comment** |
| 1 | 5% | Start of intermediate action |
| 2 | 10% | Insulin activity increases |
| 4 | 25% | Peak action starts |
| 6 | 30% | Peak action continues |
| 8 | 20% | Declining after peak |
| 10 | 5% | Insulin utilization tapers off |
| 12 | 5% | Ending phase |

**4.3 Example Insulin Utilization Calculation on Separated Charts**

**1. Calculate insulin used at 3hrs from its taken time**

Using the bell or gaussian formula (refer 1.3) calculate the units consumed at time 3hrs for rapid and intermediate acting insulin separately

**2. Calculation**

* **Total insulin units :** 30 units
* **Rapid acting insulin :** 30 x 0.3 = 9 units
* **Intermediate acting insulin :** 30 x 0.7 = 21 units
* **Rapid insulin utilization using Gaussian formula :** 4.49 units
* **Intermediate utilization using Gaussian formula:** 0.5 units
* **Total insulin utilized:** Rapid + intermediate utilization = 4.49 + 0.5 = **5 units**

**3. Conclusion**

So, using the separated insulin utilization charts it is calculated that **5 units** of insulin must have been utilized at the time of 3 hours from the insulin intake. Where as in the previous chart (refer 1.3 & 1.4) it is calculated that nearly **6.3 units** of insulin were utilized at the time of 3 hours from insulin intake. This clearly adds accuracy in blood prediction.