CO3 PROJECT

BIO INSPIRED ALGORITHMS

OUR TEAM

Group 4

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Age : 45 *Yrs*

Body Weight : 80 *Kg*

Volume Density : 200 *mL/Kg*

Insulin Sensitivity Factor : 20 *mg/dL per unit*

Carbs intake : 100 - 150 *g*

Insulin Dose : 1 - 10

Safe Glucose Range : 80 - 130 *mg/dL*

Metabolic Equivalent (met) : 4

r : 0.5 *mg/dL per kcal burned*

Exercise Duration : Rarely

Problem Statement

What insulin-meal-exercise daily plan keeps her glucose as close as possible to 100 mg/dL and in the safe range of 80 -130mg/dl?

Mathematical Modelling

Discrete Model

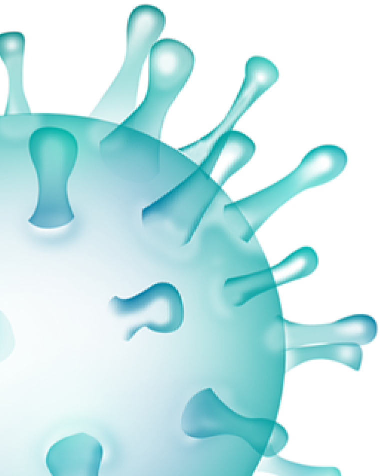
$$G_{\text{next}} = G_{\text{current}} + G_{\text{rise}} - G_{\text{drop}} - G_{\text{clear}} - G_{\text{ex}}$$

Mini Bergmann

$$\frac{dG}{dt} = G_{\text{meal}}(t) - X \cdot G - G_{\text{ex}} - G_{\text{clear}}(t)$$

$$\frac{dX}{dt} = -p2 \cdot X + p3 \cdot (I - I_b)$$

$$\frac{dI}{dt} = -n \cdot (I - I_b) + u(t)$$



Glucose Rise Due to Carbohydrates

$$G_{\text{rise}}(t) = \frac{C(t) \cdot k}{BW \cdot V_d}$$

Glucose Reduction Due to Insulin:

$$G_{\text{red}}(t) = D(t) \times S$$

Glucose Clearance Rate:

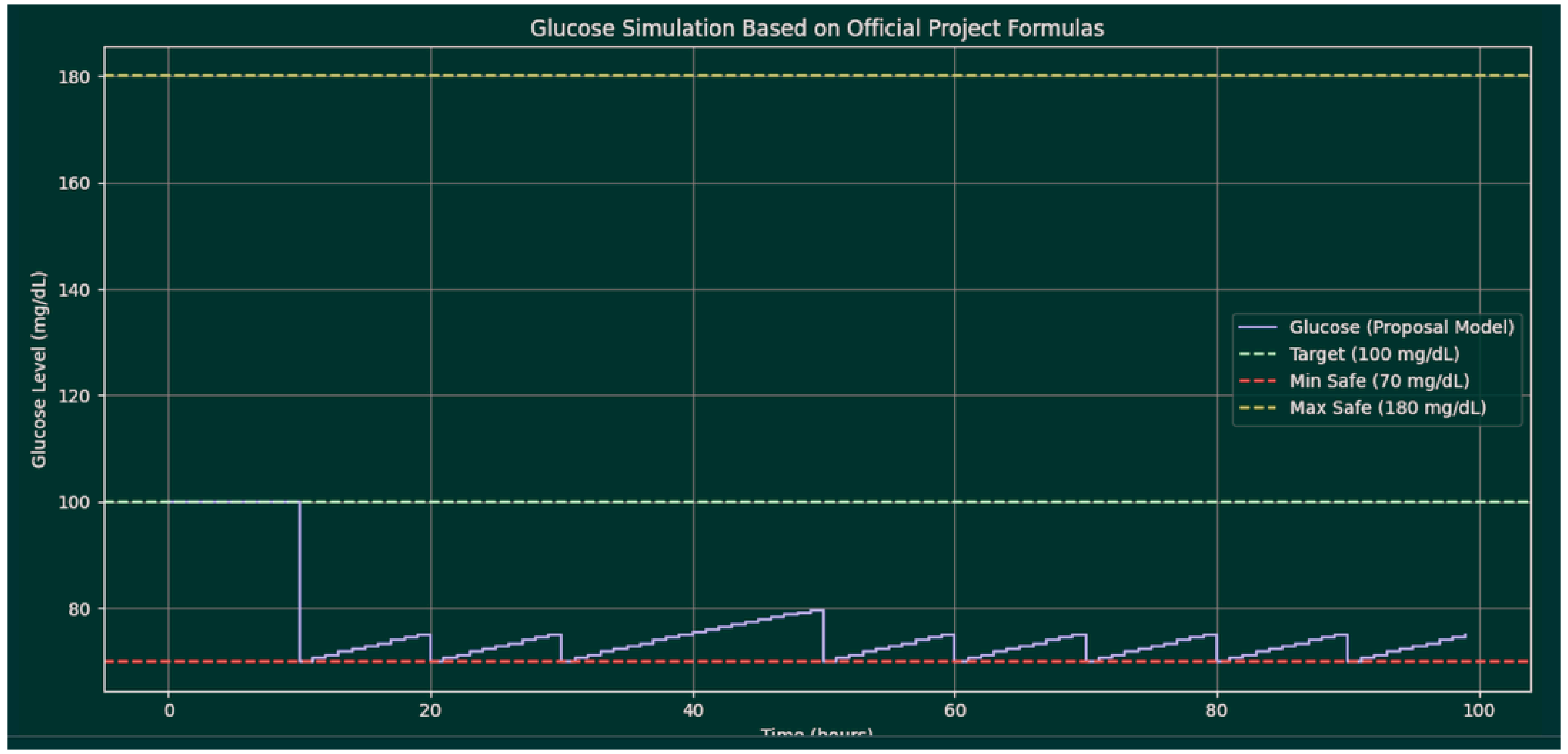
$$G_{\text{clear}}(t) = \frac{(G(t) - G_{\text{target}})}{4} \times T$$

Calories Burned

$$G_{\text{exercise}}(t) = C_{\text{burn}}(t) \times R$$

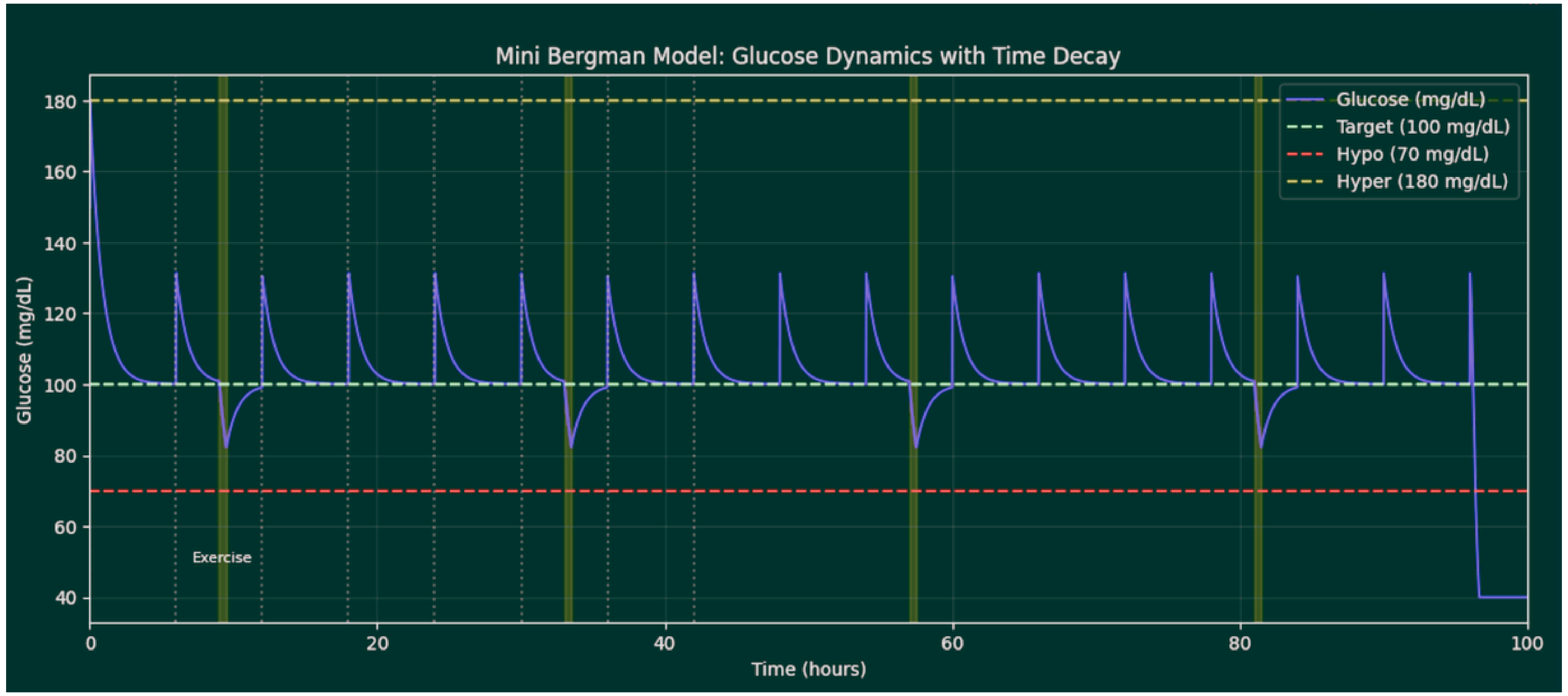
$$C_{\text{burn}}(t) = BW \times MET \times \text{Duration}(t)$$

Mathematical Modelling



Discrete Model

Mini Bergmann



Constraints

01 Glucose level constraints

$$G_{min} \leq G + G_{rise} - G_{red} - G_{clear} - G_{burn} \leq G_{max}$$

02 Insulin dose constraints

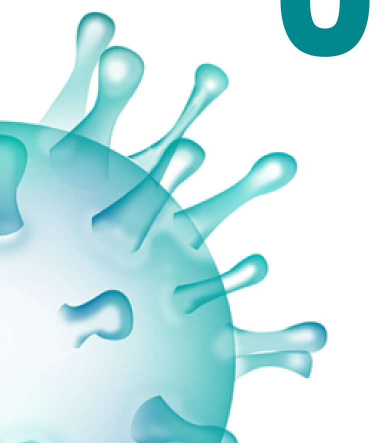
$$D_{min} \leq D \leq D_{max}$$

03 Carbohydrate intake constraints

$$C_{min} \leq C \leq C_{max}$$

04 Exercise constraints

$$0 \leq T \leq T_{max}$$



Objective Function

$$\frac{1}{T}\sum_{t=1}^{T}\left|G(t) - G_{\text{target}}\right|$$

$$+ \text{penalty}$$

Grid Search

Systematic Parameter Search

Defined Search Space

Computationally Expensive

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(1.0, 101.525)
```

Constant Constraints

Parameter	Possible Values
Insulin Dosage	[2, 4, 6, 8] (4 values)
Carb Intake	[30, 50, 70] (3 values)
Exercise Duration	[20, 40] (1 values)
Exercise Time	[6 AM, 9 AM, 12 PM] (1 values)

Dynamic Constraints

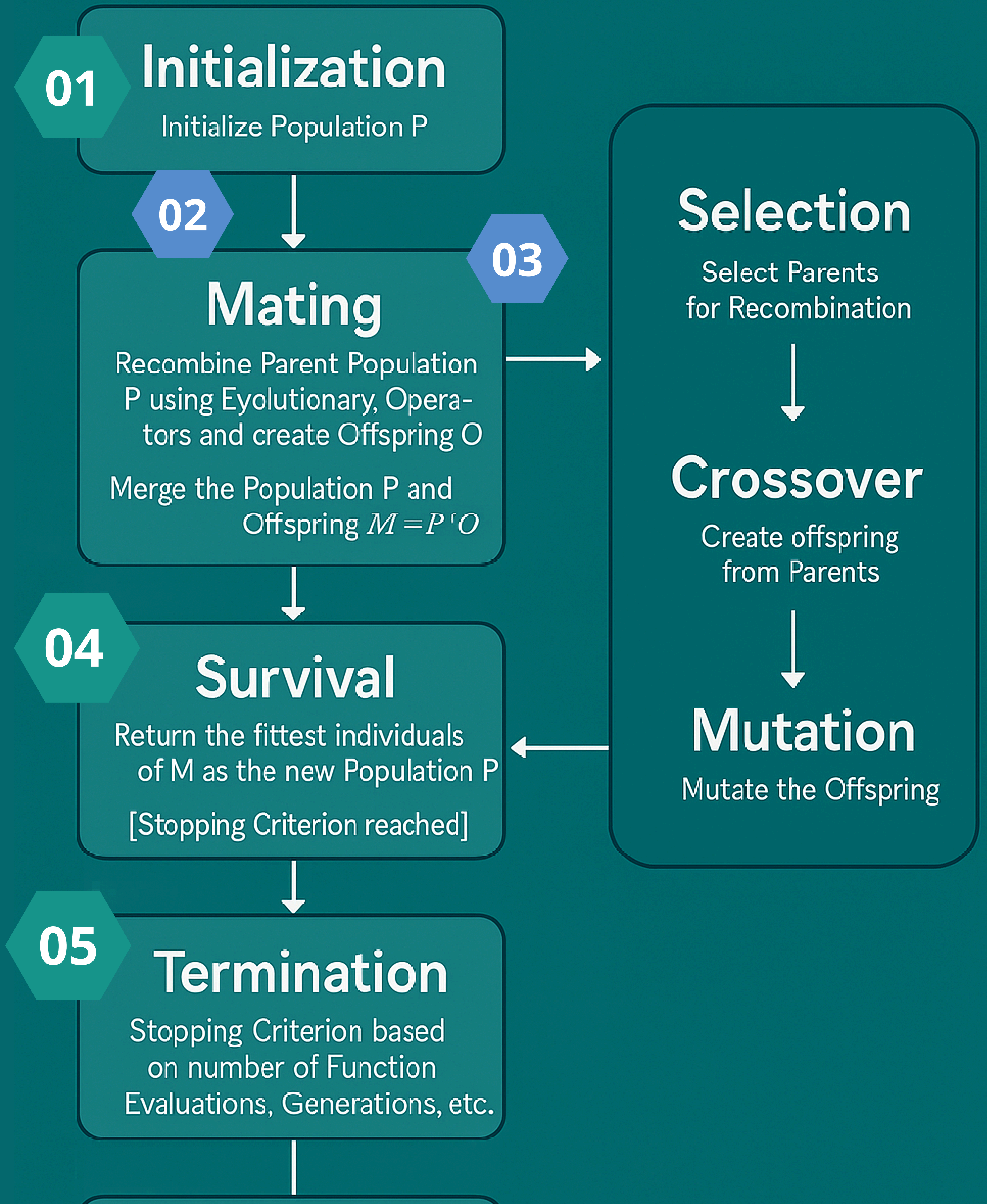
Parameter	Possible Values
Insulin Dosage	20 values (0.5 to 10 in 0.5 steps)
Carb Intake	30 to 80 (random integer)
Exercise Duration	20 to 60 minutes (random)
Exercise Time	Any hour in a 24-hour cycle (random)

```
([1.06181697481293, 1.3539310172571222, 0.8713409140803351, 0.5032565403561309], [44, 61, 78, 30], 11, 20)
```

Why Genetic Algorithm?

Feature	Grid Search	Genetic Algorithm
Dynamic Insuline Adjustments	❌ Hard to implement efficiently	✅ Adjusts insulin adaptively
Meal Timing Constrains	❌ Static, doesn't adapt	✅ Adapts meal-insulin timing dynamically
Exercise Optimization	❌ Fixed values only	✅ Learns best times/intensity dynamically
Computational Efficiency	❌ Explodes with more constraints	✅ Learns efficiently over generations

Genetic Algorithm



Genetic Algorithm

01 INITIALIZATION

02 FITNESS

03 MATING (Selection & Crossover)

04 SURVIVAL (Mutation)

05 TERMINATION

Grid Search vs Genetic Algorithm

Difference	Grid Search	Genetic Algorithm
Method	Brute-force method: tries every combination from a pre-defined grid	A bio-inspired, evolutionary method that uses selection, crossover, mutation to improve solutions over time
Start	Define a grid of values	Start with random population of solutions
Evaluation	Try all combinations	Evaluate fitness of each individual
Improvement	No learning - just exhaustive	Select best → crossover → mutate → repeat
Stopping	When all combos are tested	After fixed number of generations

Results

with GA more possible Day plans with same Fitness score

```
=== Optimal Solution ===
Carb Intake Schedule: [50, 60, 80, 30]

Total Glucose Deviation: 16.57

=== Glucose Levels at Each Time Step ===
Time 8: 101.54 mg/dL
Time 12: 97.17 mg/dL
Time 18: 94.31 mg/dL
Time 21: 92.92 mg/dL
```

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Best Deviation Score: 428.20
Meals: [(233, 34), (574, 61), (1186, 41)]
Insulin: [(75, 8.2), (468, 8.5), (1209, 9.3)]
Exercise: [(1184, 12, 7.5)]
```

SAMUEL THOMPSON

Age : 60 Yrs

Body Weight : 85 *Kg*

Volume Density : 150 *mL/Kg*

Insulin Sensitivity Factor : 10 *mg/dL per unit*

Carbs intake : 50 - 100 *g*

Insulin Dose : 1 - 10 *Units*

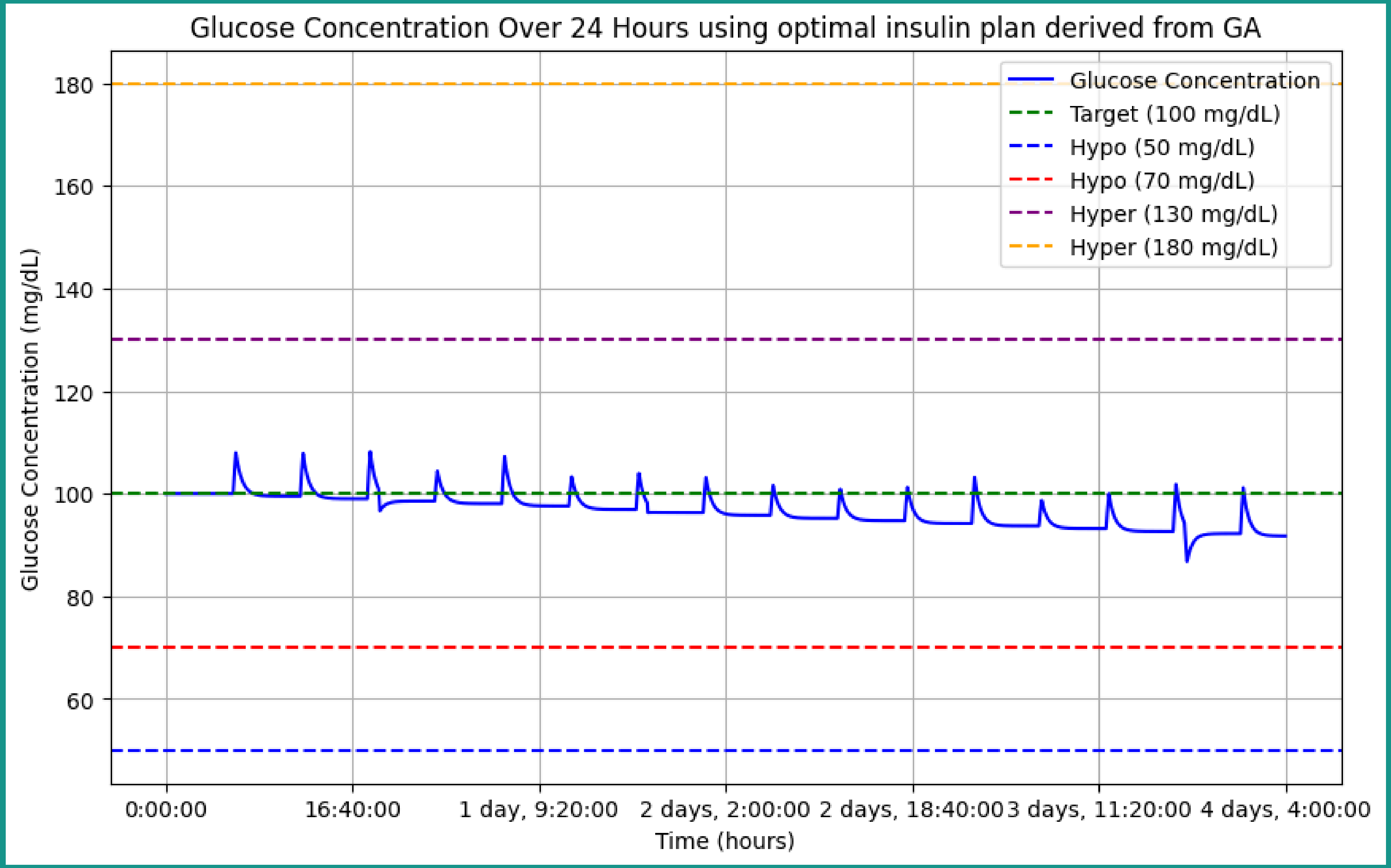
Safe Glucose Range : 80 - 130 *mg/dL*

Metabolic Equivalent (met) : 4

Exercise Duration : 15 - 60 *min*

r : 0.1 *mg/dL per kcal burned*

Results



Optimizing Insulin Dosage

Optimized Time

✅ Best Plan Found:
Meal Times: [134, 433, 933] min
Insulin Times: [194, 754, 908] min
Exercise Time: 930 min
Exercise Duration: 30 min
Exercise Intensity (MET): 2.68
Glucose Deviation Score: 403.33

GA completed in 58.86 seconds
Total combinations explored: 2500
Best Deviation Score: 416.31

Plan 1
Score: 416.31 | REM: 2.15
Meals: [(170, 35), (550, 32), (1130, 31)]
Insulin: [(277, 7.8), (628, 3.5), (1126, 3.9)]
Exercise: [(962, 15, 2.9)]

Search Space like quadrillions of possible plans

LISA

Age : 30 Yrs

Body Weight : 60 *Kg*

Carbs intake *: 50 - 80 g*

Meal Plan: Plant-based (*Vegan*)

Volume Density : 200 *mL/Kg*

Insulin Sensitivity Factor : 50 *mg/dL per unit*

*I*nsulin Dose : 0 *Units*

Exercise Duration : 60 - 90 *min*

r : 0.5 *mg/dL per k*

LISA

RESULTS !?

Fun Exercise To Try😜

Conclusion

Further refinement is possible

Small steps make big problems solvable

Future work could include testing additional algorithmic strategies

THANK YOU!

QUESTIONS?