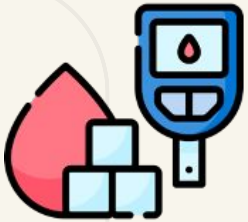
Insulin Control for Diabetes Mellitus

Group 3

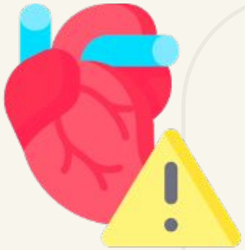
April 11, 2023

Diabetes Mellitus 1.



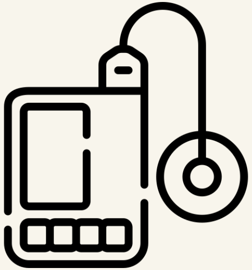
Diabetes is a chronic metabolic disorder that is characterized by sustained elevated blood glucose levels

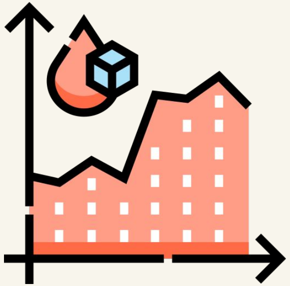
Around 451 million people globally have diabetes, and this figure is projected to grow to 693 million by 2045. Additionally, 1.5 million deaths are directly attributed to diabetes each year



Mismanagement can lead to complications such as cardiovascular disease, kidney failure, blindness, and neuropathy

Current Methods of Treatment [2, 3.]





Insulin Injections

Limitations:

- Requires constant patient monitoring and management
- Difficult to accurately dose and time insulin
- Can lead to hypoglycemia or hyperglycemia

Insulin Pumps

Limitations:

- Only provides basal insulin, not bolus insulin for meals
- Requires frequent adjustments
- Potential for mechanical failures, leading to insulin delivery issues

Continuous Glucose Monitoring

Limitations:

- Can have accuracy issues
- Requires calibration with fingerstick blood glucose measurements
- Sensor site irritation and discomfort

Closed Loop Insulin Control System with PID Controller

Overview:

- A fully automated system that continuously monitors blood glucose levels
- Adjusts insulin delivery in real time based on patients needs

Components:

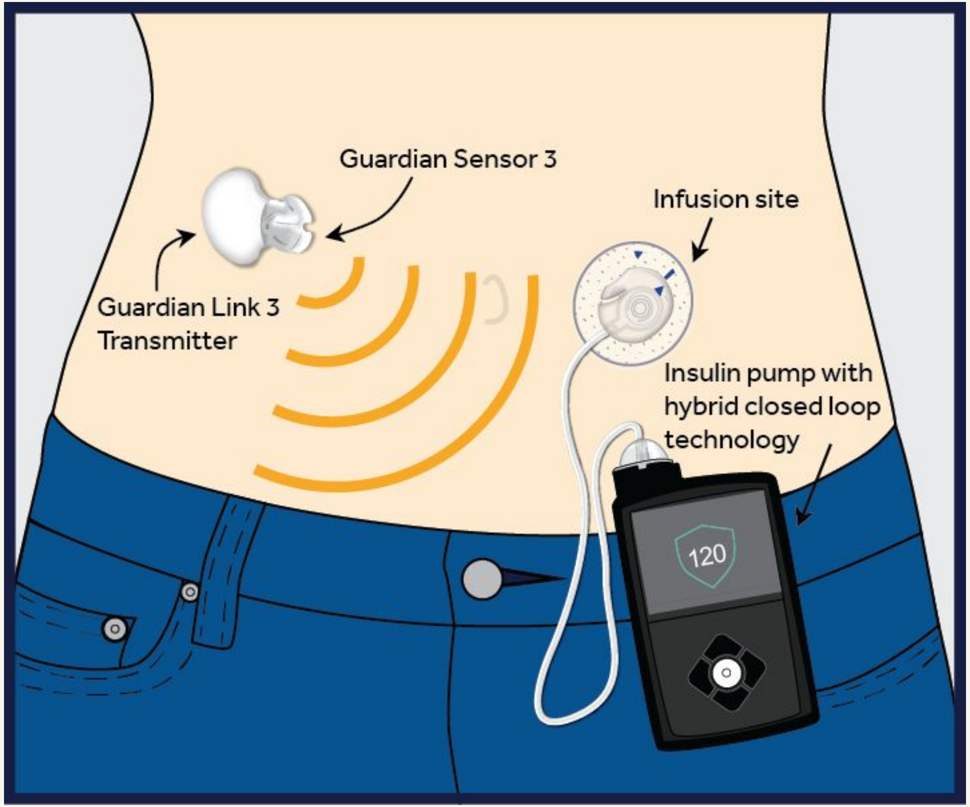
- Continuous Glucose Monitor
- Insulin Pump
- Control Algorithm

Advantages of PID Control in Closed Loop Systems:

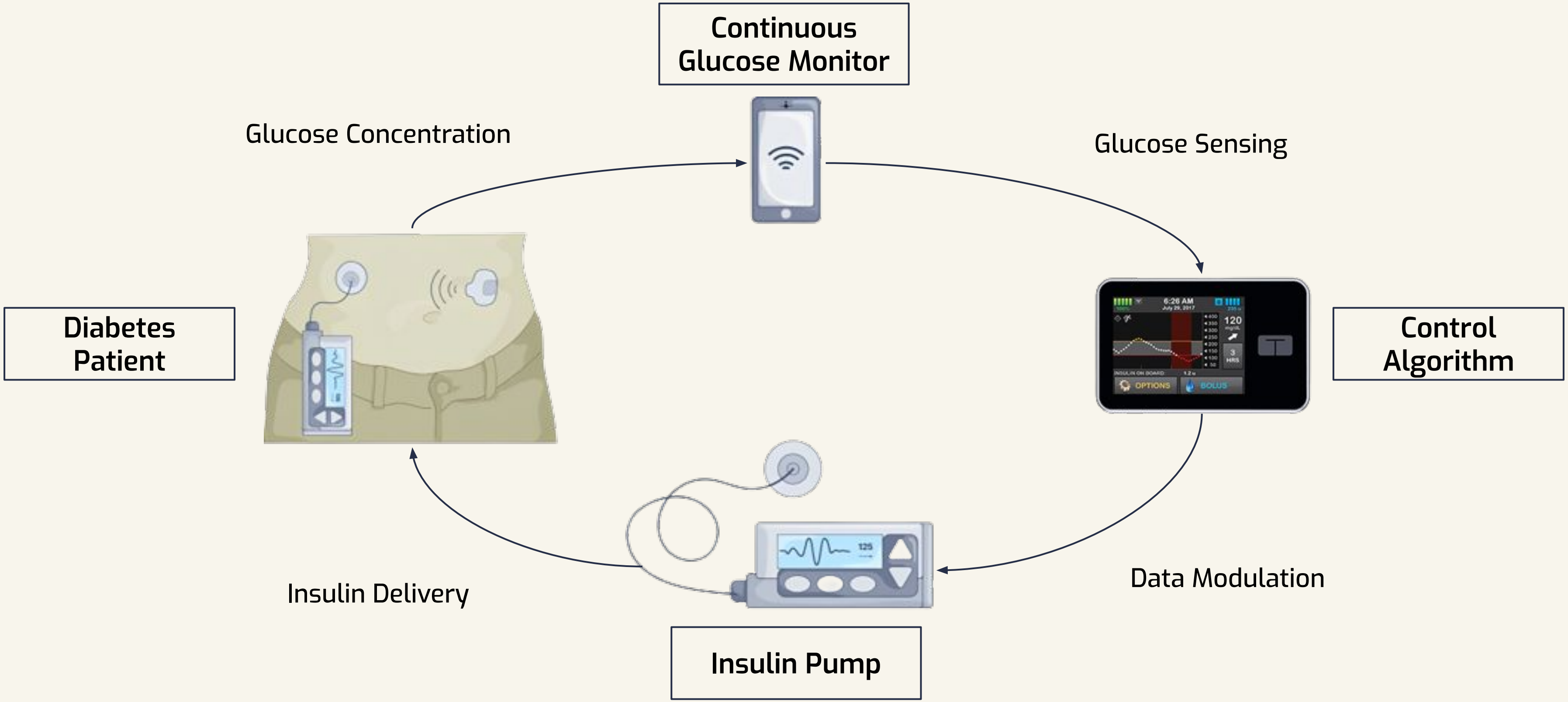
- Improved glycemic control
- Reduced need for constant patient monitoring and management
- Improved automation for better glucose control overnight and during daily activities
- Enhanced patient safety and quality of life

Artificial Pancreas Device

5.

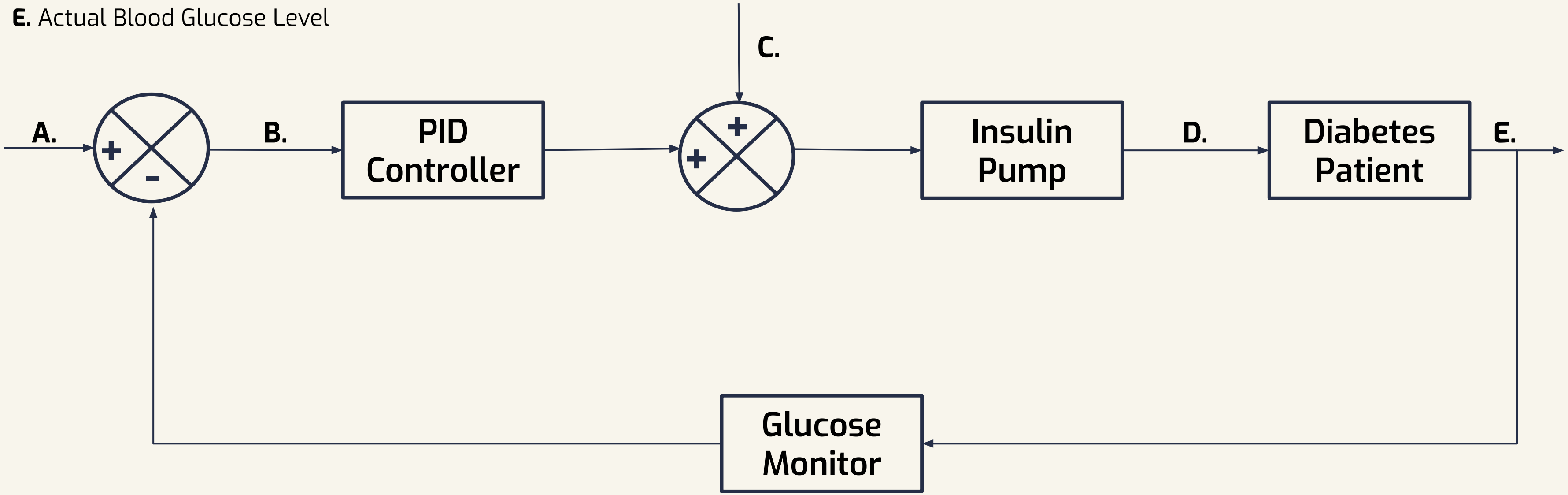


Closed-Loop Insulin Control System

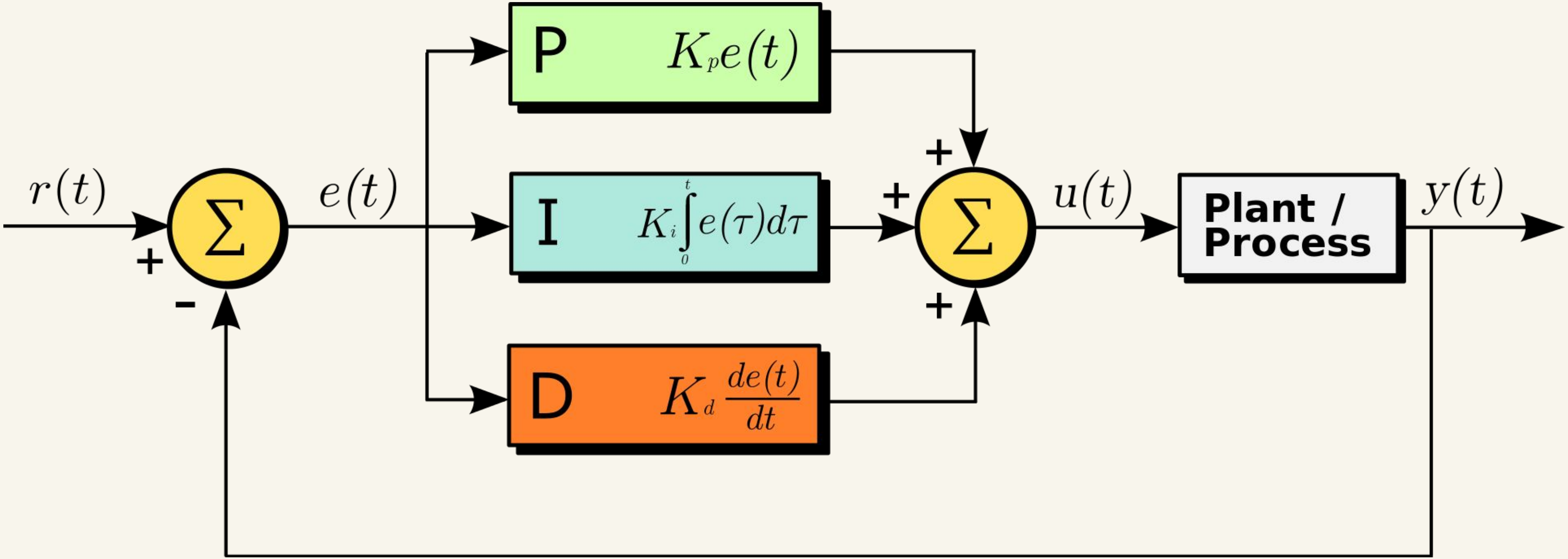


Insulin Control System Block Diagram

Key:
A. Desired Blood Glucose Level
B. Blood Glucose Discrepancy (Error)
C. Food Intake
D. Insulin Rate
E. Actual Blood Glucose Level



PID Controller Block Diagram



PID Controller Mechanism

Overview:

- Proportional-Integral-Derivative (PID) Controller: a closed loop feedback mechanism
- Optimizes system behavior by adjusting input based on error between desired and actual output

Proportional (P) Component:

- Minimizes immediate error between desired and actual glucose levels
- Proportional Gain (K_p) multiplied by error term

Integral (I) Component:

- Eliminates steady-state error
- Integral Gain (K_i) multiplied by the integral of the error over time

Derivative (D) Component:

- Improves the transient response by reducing overshoot
- Derivative Gain (K_d) multiplied by the rate of change of error

Controller Limitations

PID Controller

Proportional Control

- May not decrease steady-state errors if K_p is too low
- Can lead to Oscillations if K_p is too high

Integral Control

- Integrator Windup
- Slower response if the gain is too low
- Increases overshoot

Derivative Control

- May amplify noise, if gain is too high

Refining the Controller

PID Controller

Proportional Control

- Optimization of K_p value
- Addition of integral action

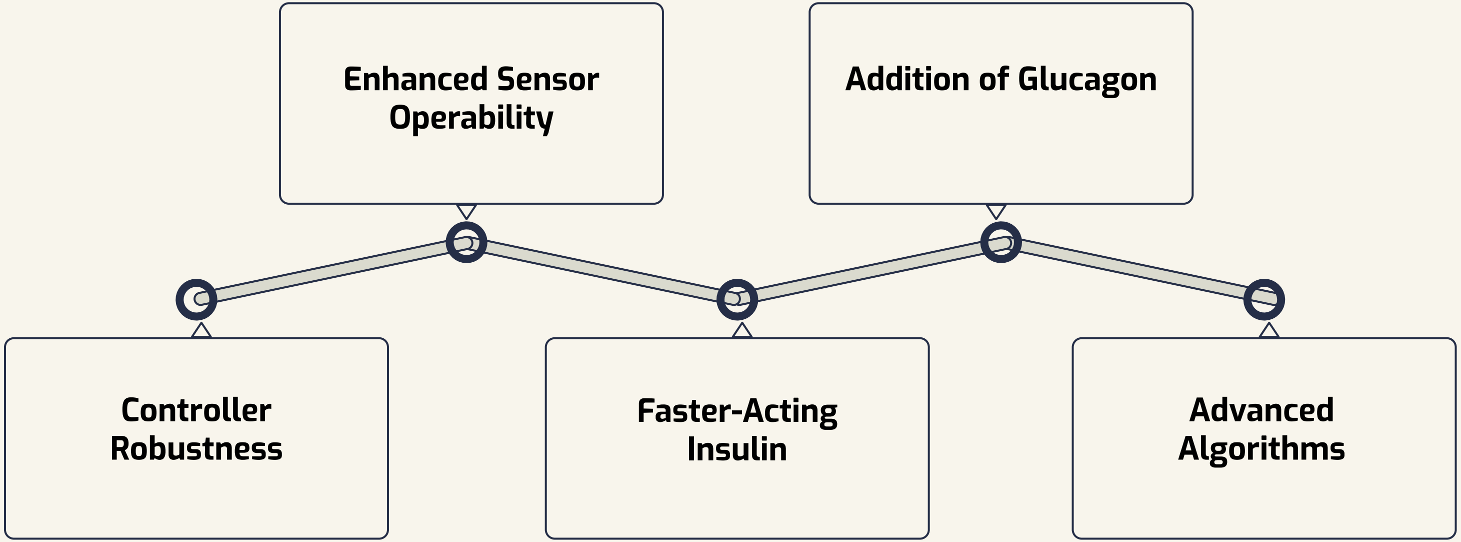
Integral Control

- Anti-Windup Scheme
- Conditional integration
- The Proportional Band

Derivative Control

- Electronic signal filter

Future Work


Enhanced Sensor Operability
Addition of Glucagon
Controller Robustness
Faster-Acting Insulin
Advanced Algorithms

Thank You!

Questions?

References

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