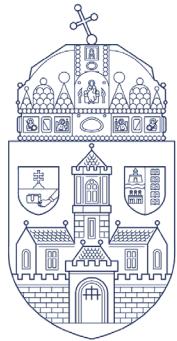




European  
Research  
Council



ÓBUDAI EGYETEM  
ÓBUDA UNIVERSITY

# Latest developments in diabetes- *Development of a digital twin -based diabetes decision support system*

Dr. Eigner György

Project ID: 2019-1-3-1-KK-2019-00007

Project title: Innovációs szolgáltató bázis létrehozása diagnosztikai, terápiás és kutatási célú kiberorvosi rendszerek fejlesztésére



NEMZETI KUTATÁSI, FEJLESZTÉSI  
ÉS INNOVÁCIÓS HIVATAL

AZ NKFI ALAPBÓL  
MEGVALÓSULÓ  
PROJEKT



ÓBUDA UNIVERSITY

EKIK - UNIVERSITY RESEARCH  
AND INNOVATION CENTER





## blood glucose prediction

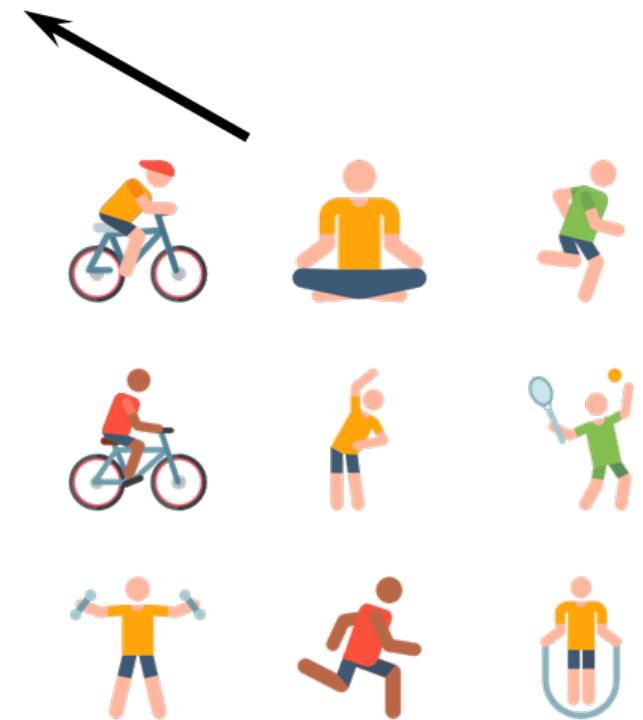
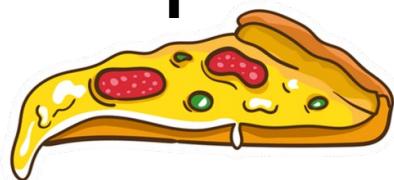
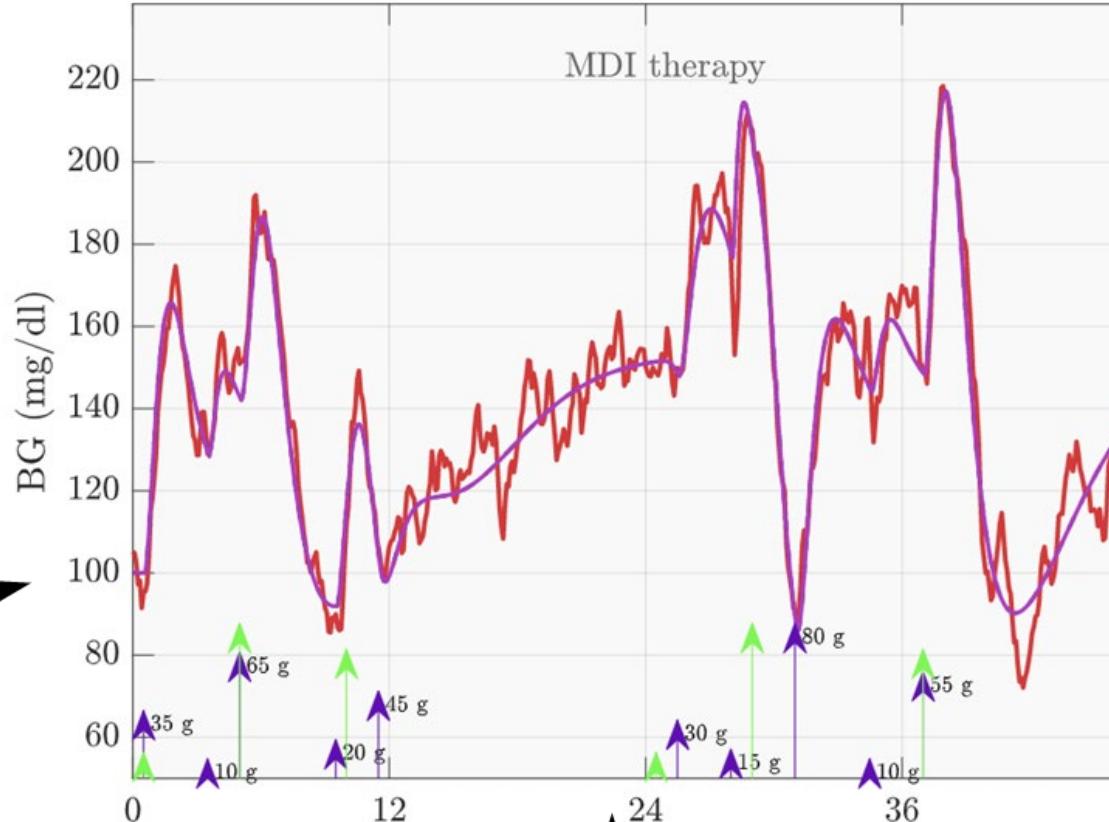
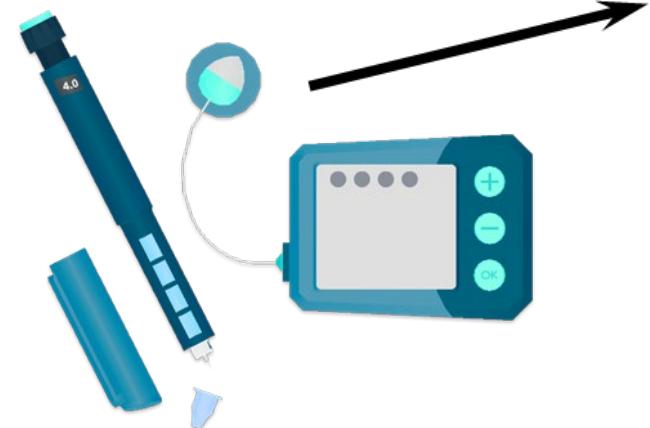
**artificial pancreas**

**model predictive control  
reinforcement learning**

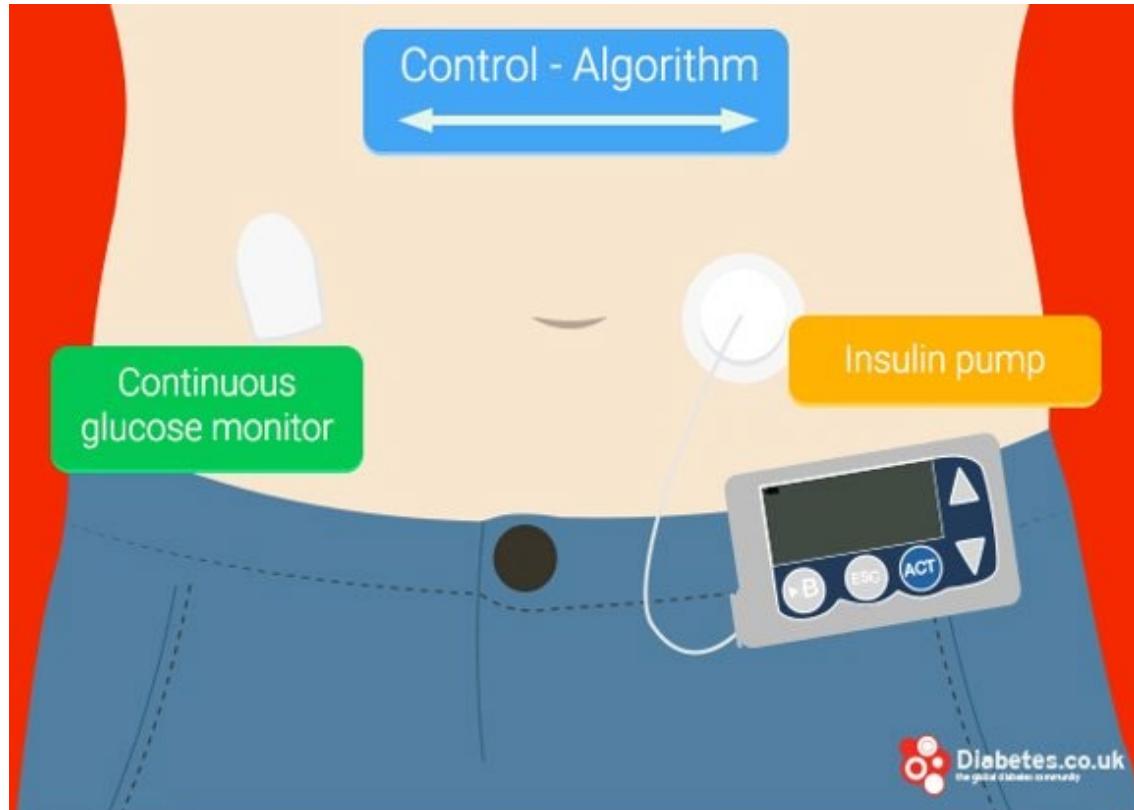
**parameter estimation**

**gesture recognition**

**physical activity modeling**

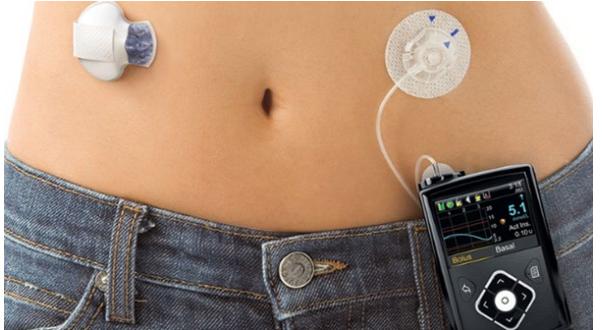


# Automated insulin dosing- artificial pancreas





Minimed 670G  
(2016)



Tandem t:slim x2



Minimed 780G

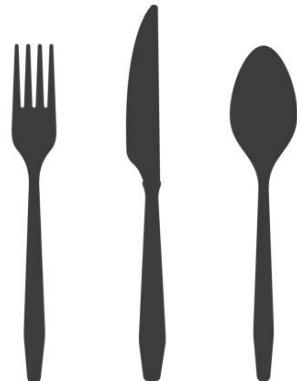
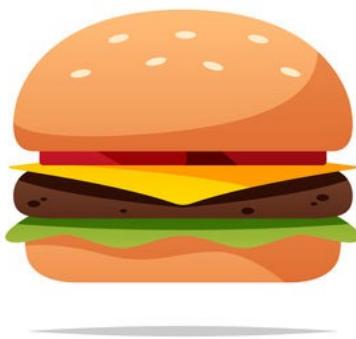


Omnipod 5  
(2022)





## Gesture detection

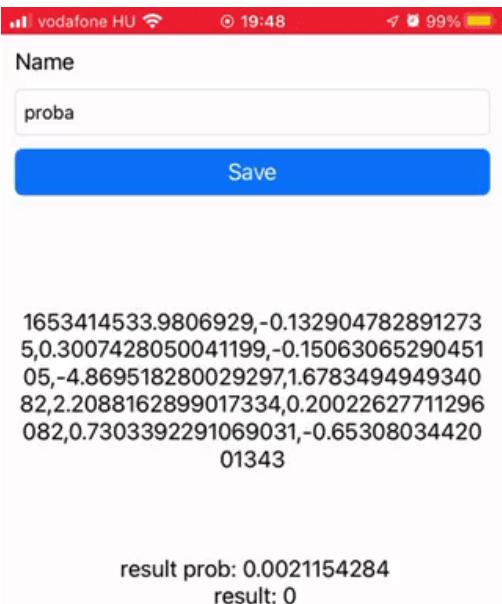


Automatic detection vs.  
manual logging

- Need for reducing  
“administrative burden”



## Gesture detection



- Detection based on accelerometer data
- Running experimental application on Android and iOS devices
- Data collected from activity trackers





## Physical activity

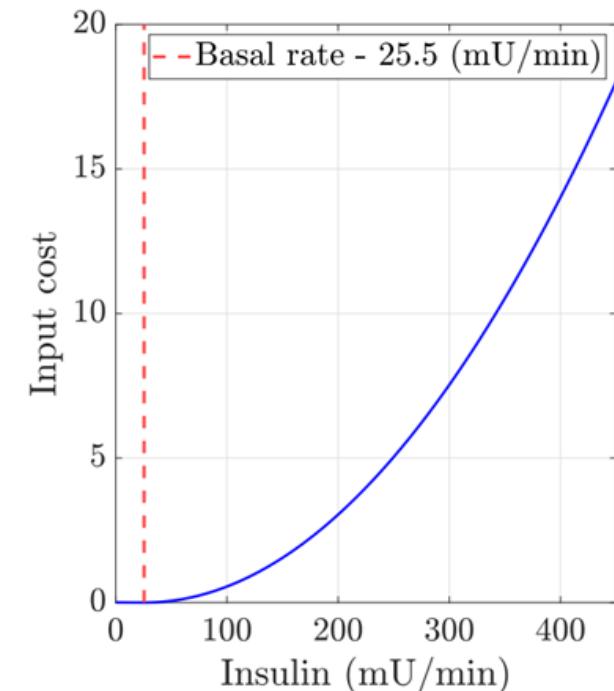
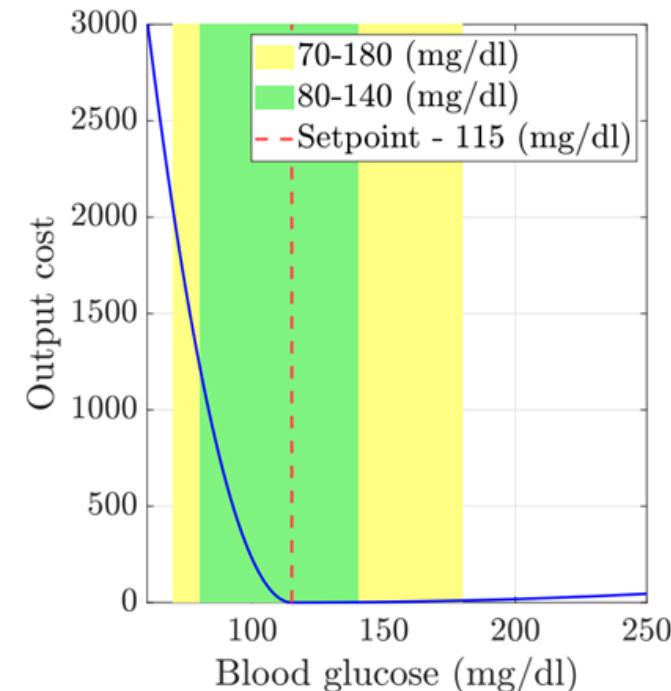
- Possible parameters in models:
  - HR [1/min]- Heart Rate
  - $\dot{V}O_2^{\max}$  [ml/kg/min] - maximum oxygen uptake
  - PAMM [%]- Percentage of Active Muscle Mass
- Our studies:
  - HR is used through EGP (Endogenous Glucose Production)
  - EGP equation from Ormsbee et al.:

$$EGP = \gamma \cdot HR + \delta \cdot \frac{\alpha \cdot HR}{(220 - HR)^\beta}$$

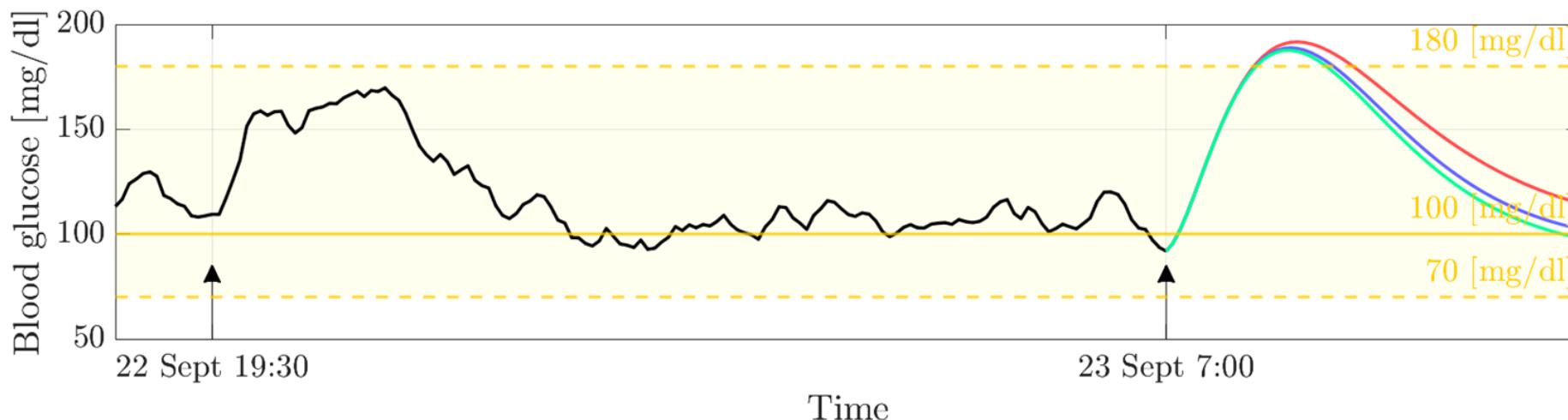
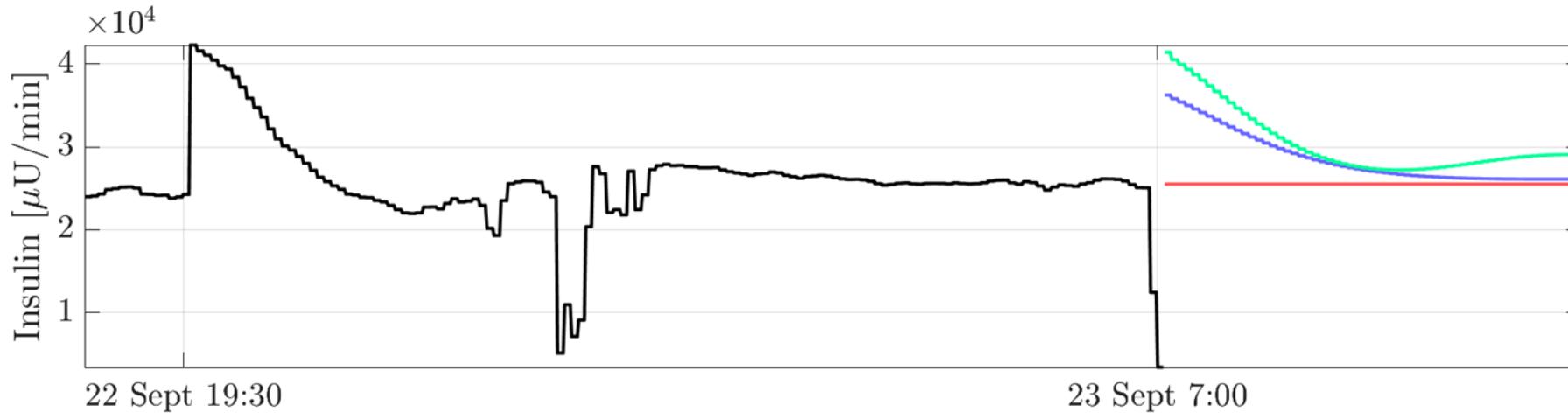


## Model predictive control

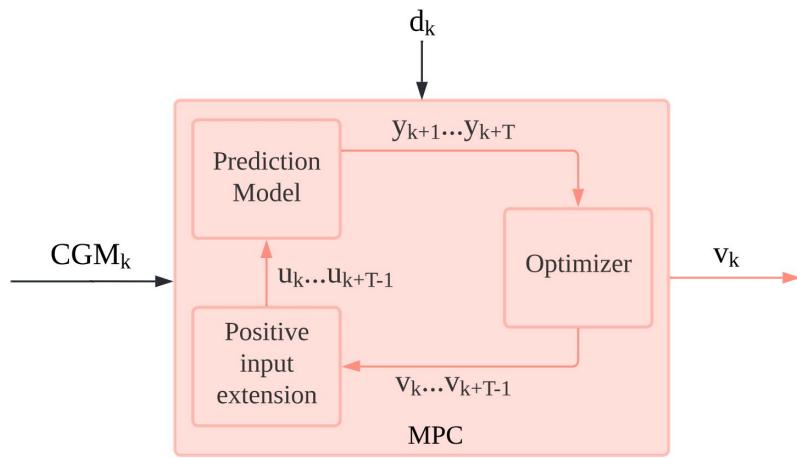
- mathematical model -> blood glucose predictions
  - insulin delivery
  - glucose absorption
- minimizes a cost function over a finite horizon



## Model predictive control

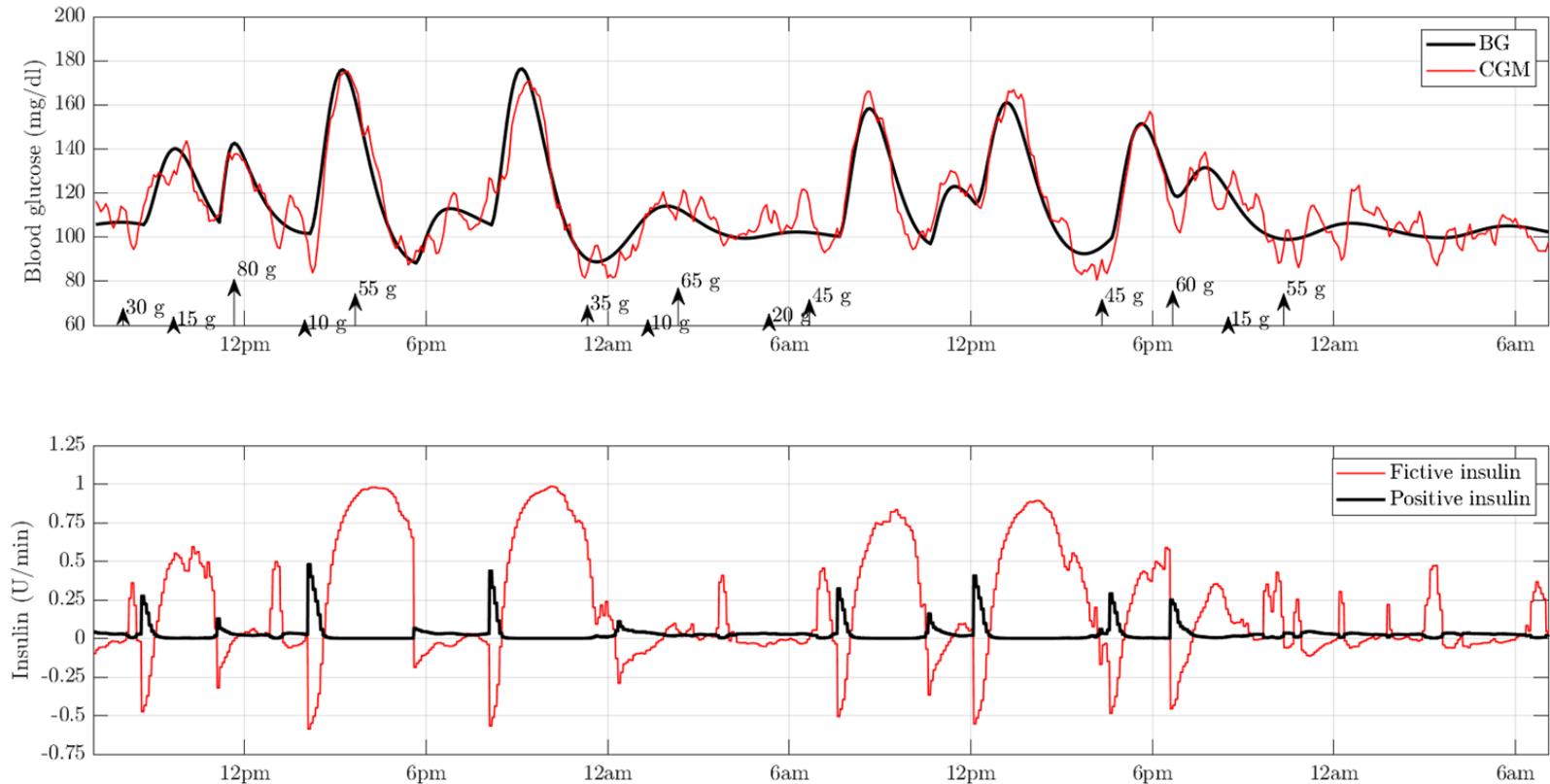


# Positive input extension



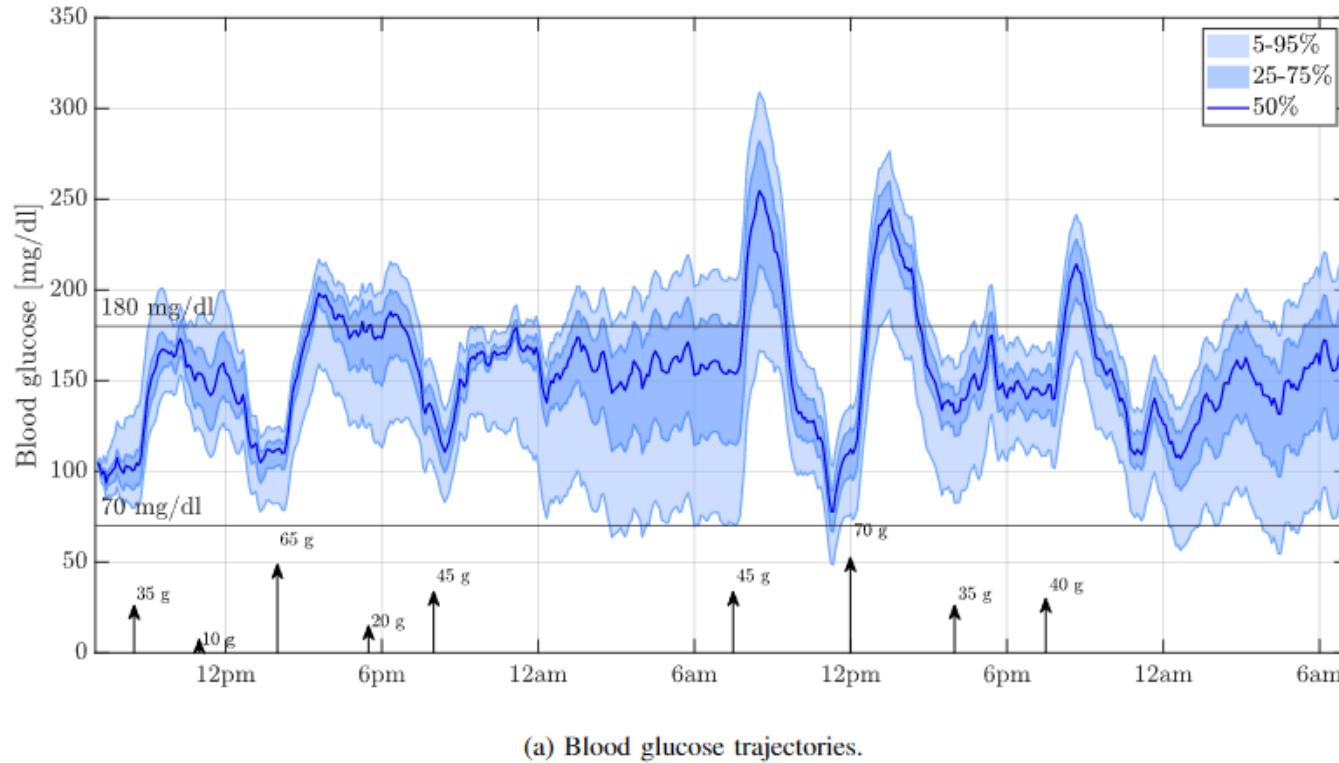
$$\dot{u} = -u \cdot v$$

original input      fictive input

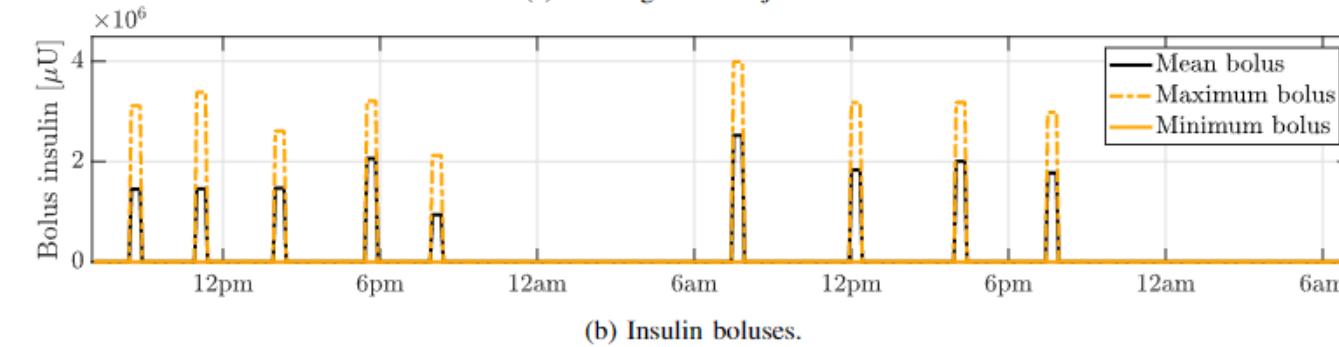




## Bolus advisor

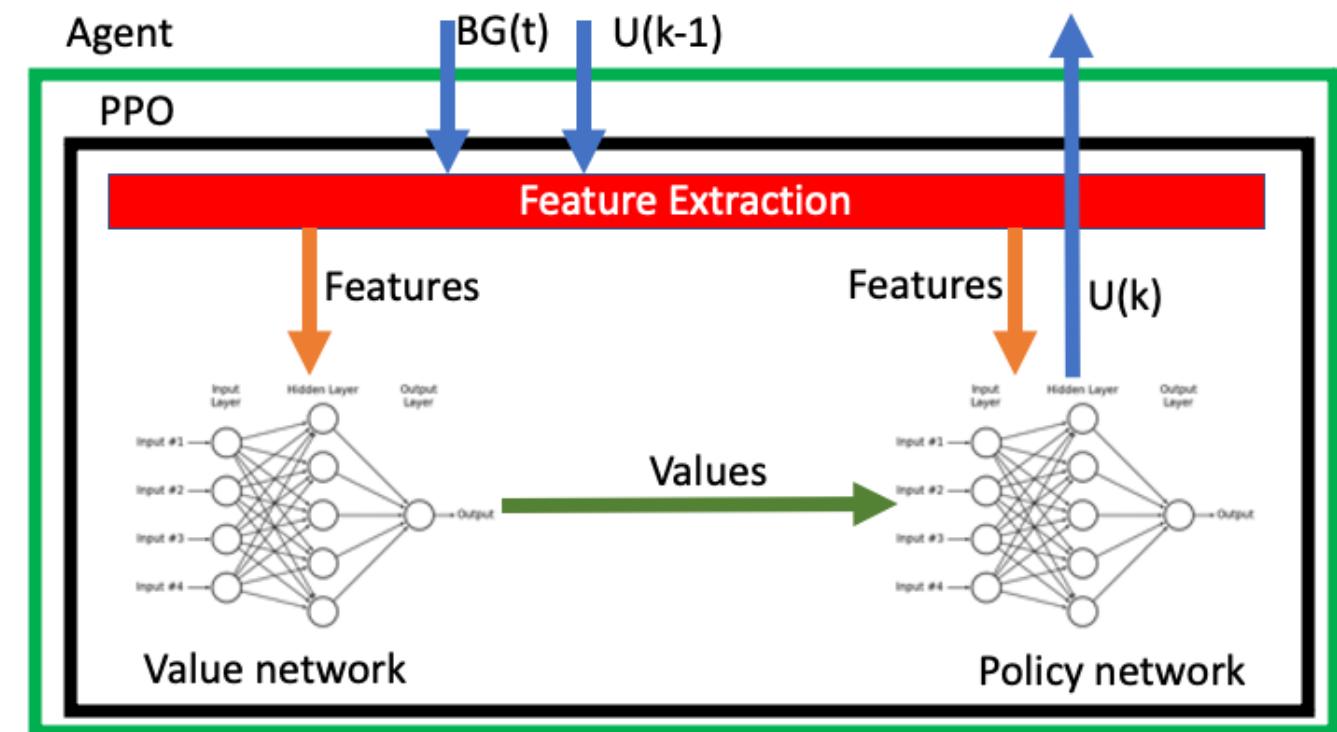
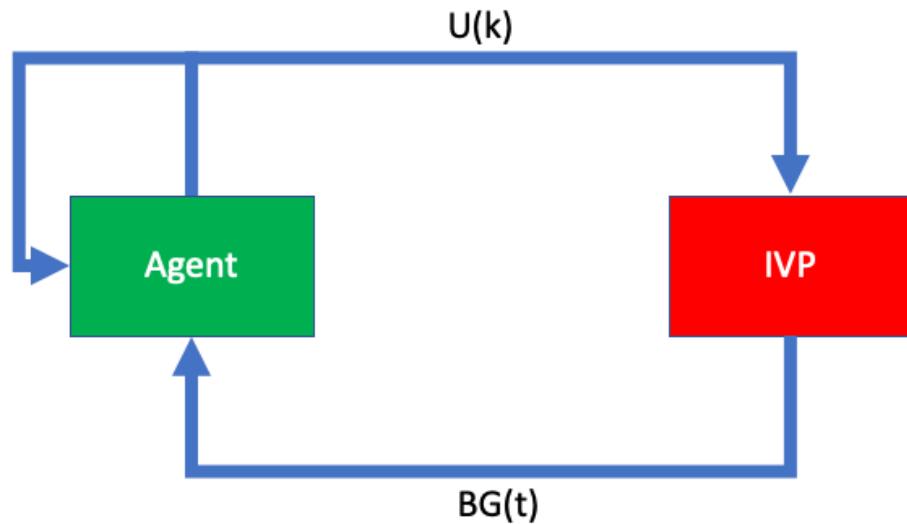


(a) Blood glucose trajectories.

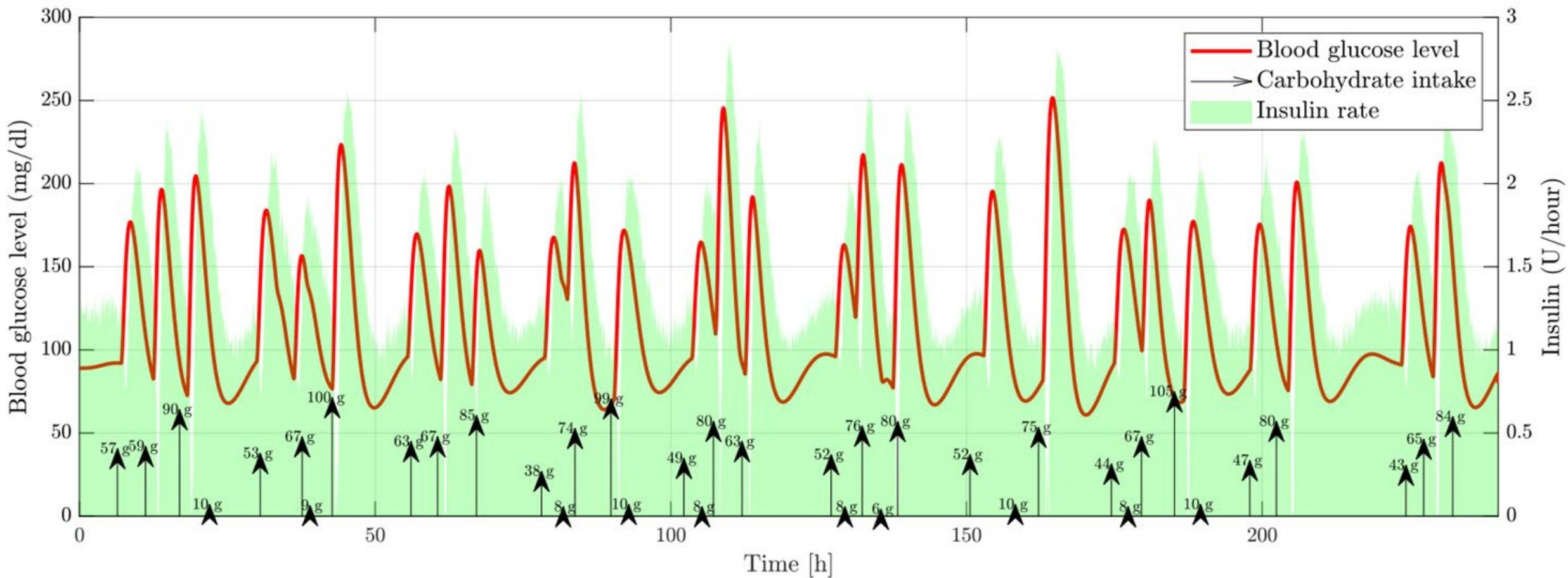


(b) Insulin boluses.

# Reinforcement learning



## Reinforcement learning

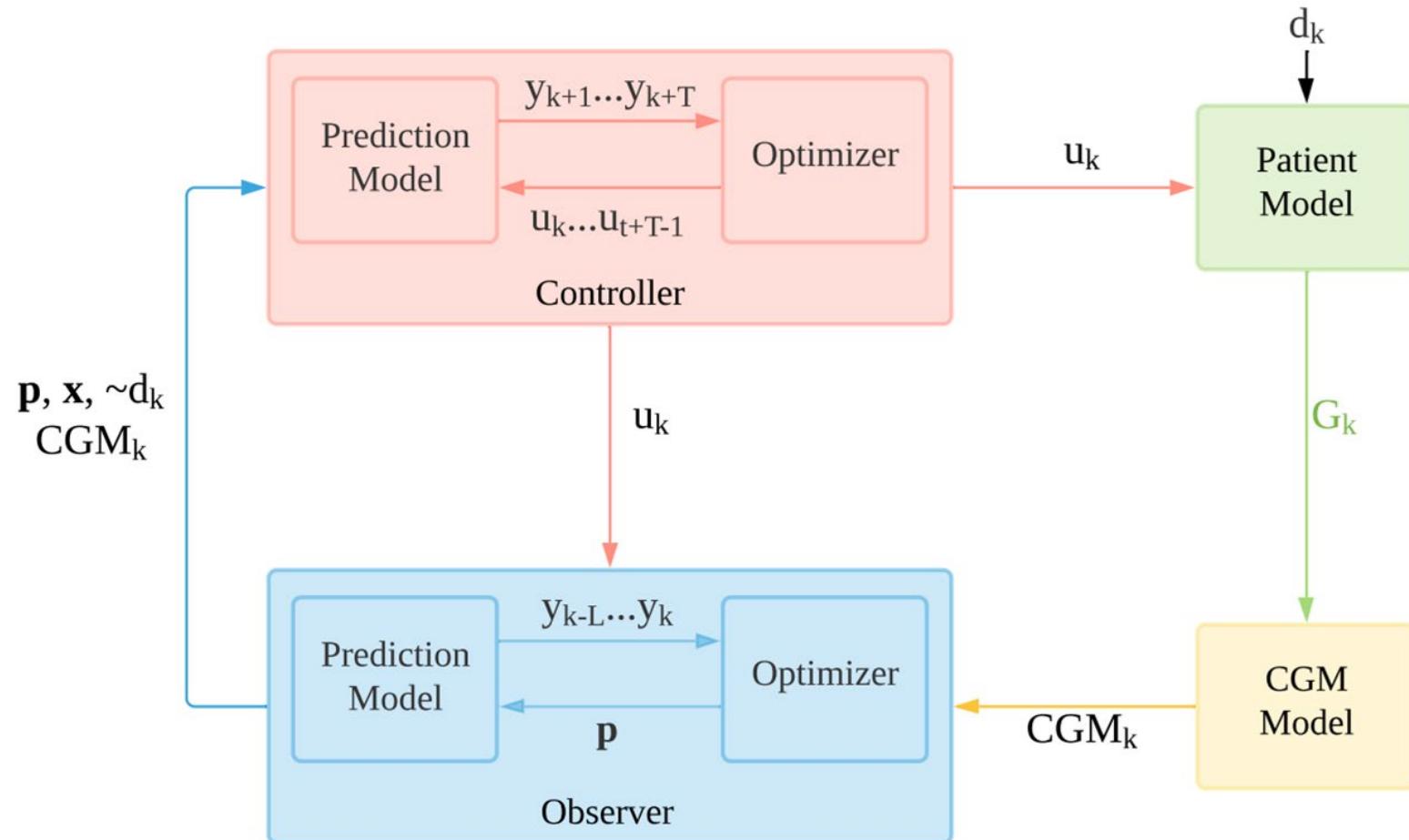


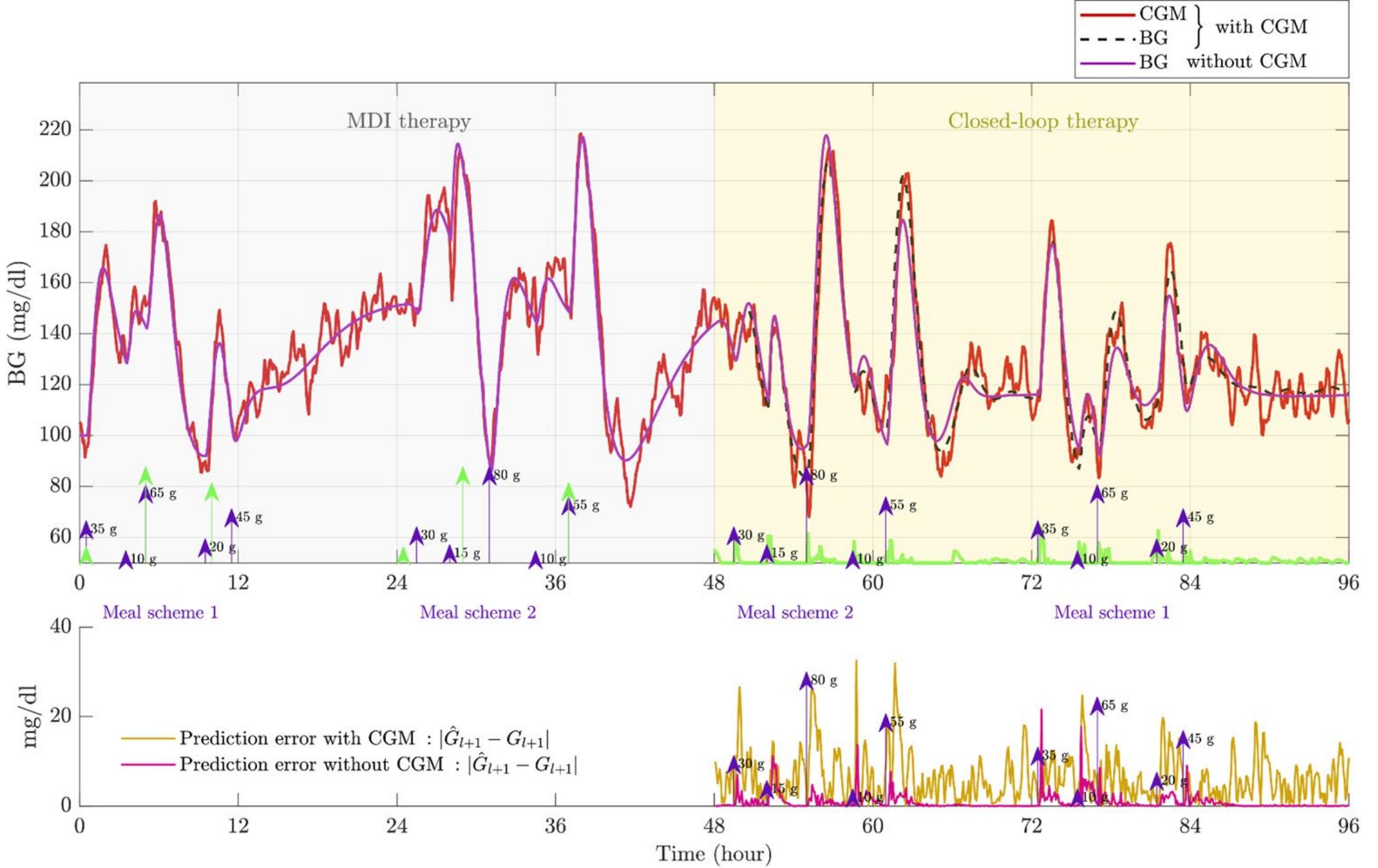
## Closed-loop control

Model  
Predictive  
Controller

+

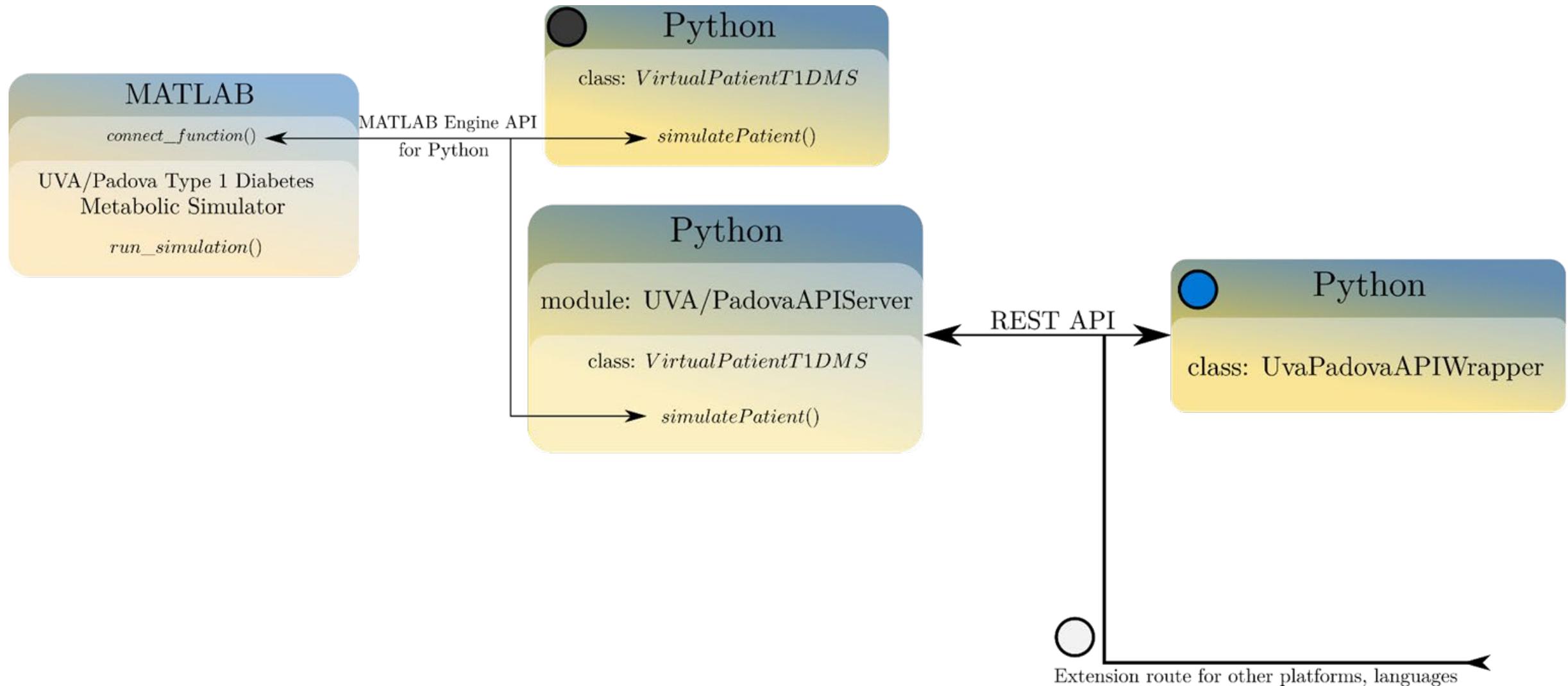
Moving  
Horizon  
Estimation





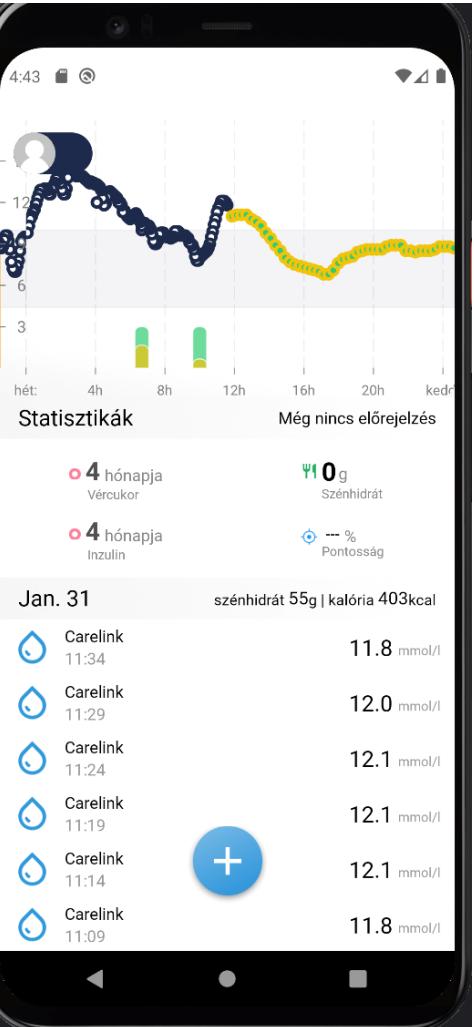


# UVa/Padova T1DM simulator





# Personalized therapy and predictions



- Experimental feature on Android and iOS devices
- Web-based UI for clinicians
- Collects data automatically from Medtronic's Carelink system



# Web-based UI for clinicians

Szimuláció

Kiválasztott időszak

Alternatív adatok

- Alvás  
Tól: 2023-02-16 - 22:00 - Ig: 2023-02-17 - 08:00 [Delete]
- Étkezés  
2023-02-17 - 08:30 - 40g CH - 30g fehérje - 10g zsír [Delete]
- Inzulin bevitel  
2023-02-17 - 08:35 - Hasba - Rövid hatású - 4egység [Delete]
- Mozgás  
2023-02-17 - 10:00 - 50 perc - Közepes intenzitás [Delete]

Inzulin      Étkezés      Mozgás      Alvás

Dátum\* [Calendar]

Idő\*  
--:--

Szénhidrát (g)\* [Info]

Fehérje (g)\*

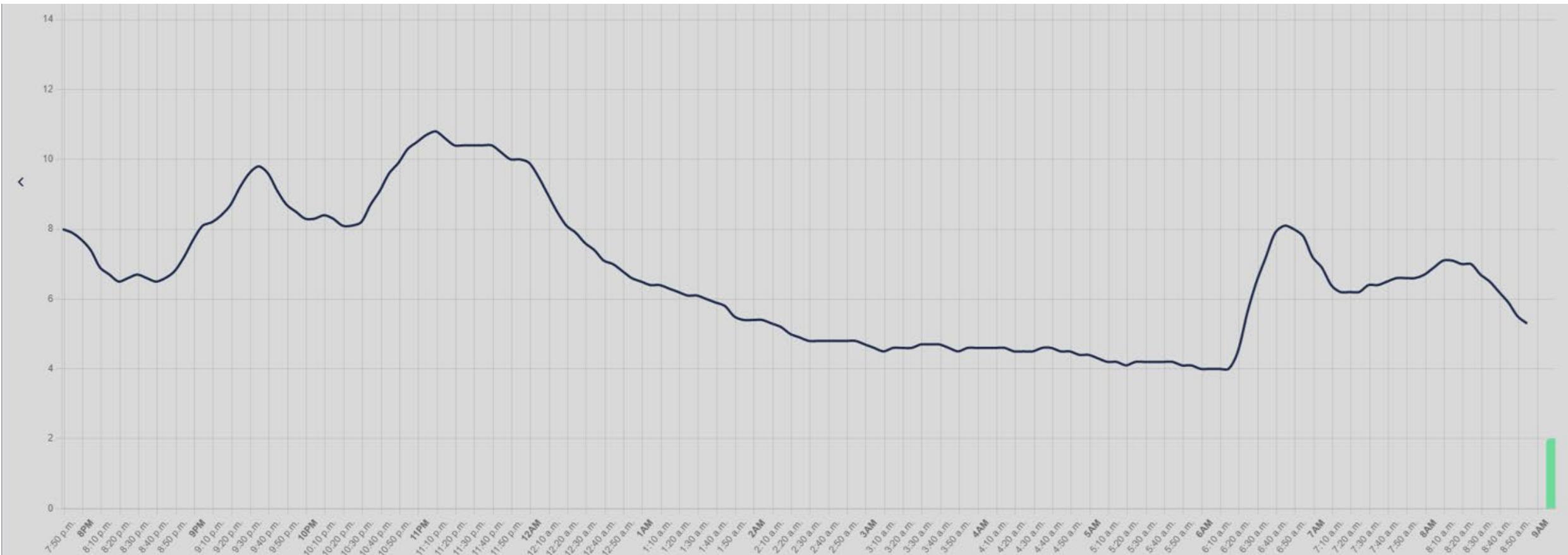
Zsír (g)\*

Hozzáad

Mégse      Szimuláció futtatása

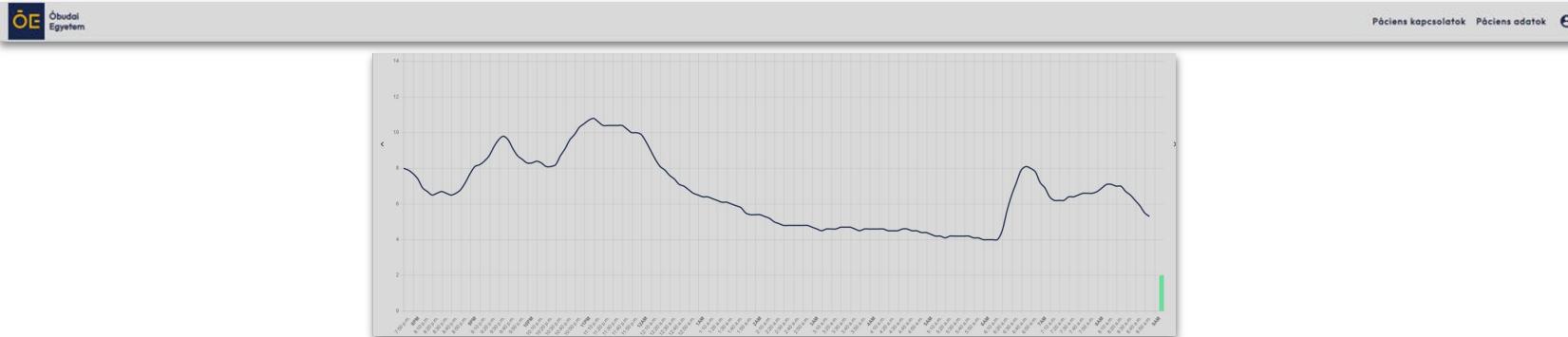


# Web-based UI for clinicians





# Web-based UI for clinicians



Vércukor 2023-02-15 07:44 8 mmol/L

Vércukor 2023-02-15 07:49 7.9 mmol/L

Vércukor 2023-02-15 07:54 7.7 mmol/L

Vércukor 2023-02-15 07:59 7.4 mmol/L

Vércukor 2023-02-15 08:04 6.9 mmol/L

### Részletek

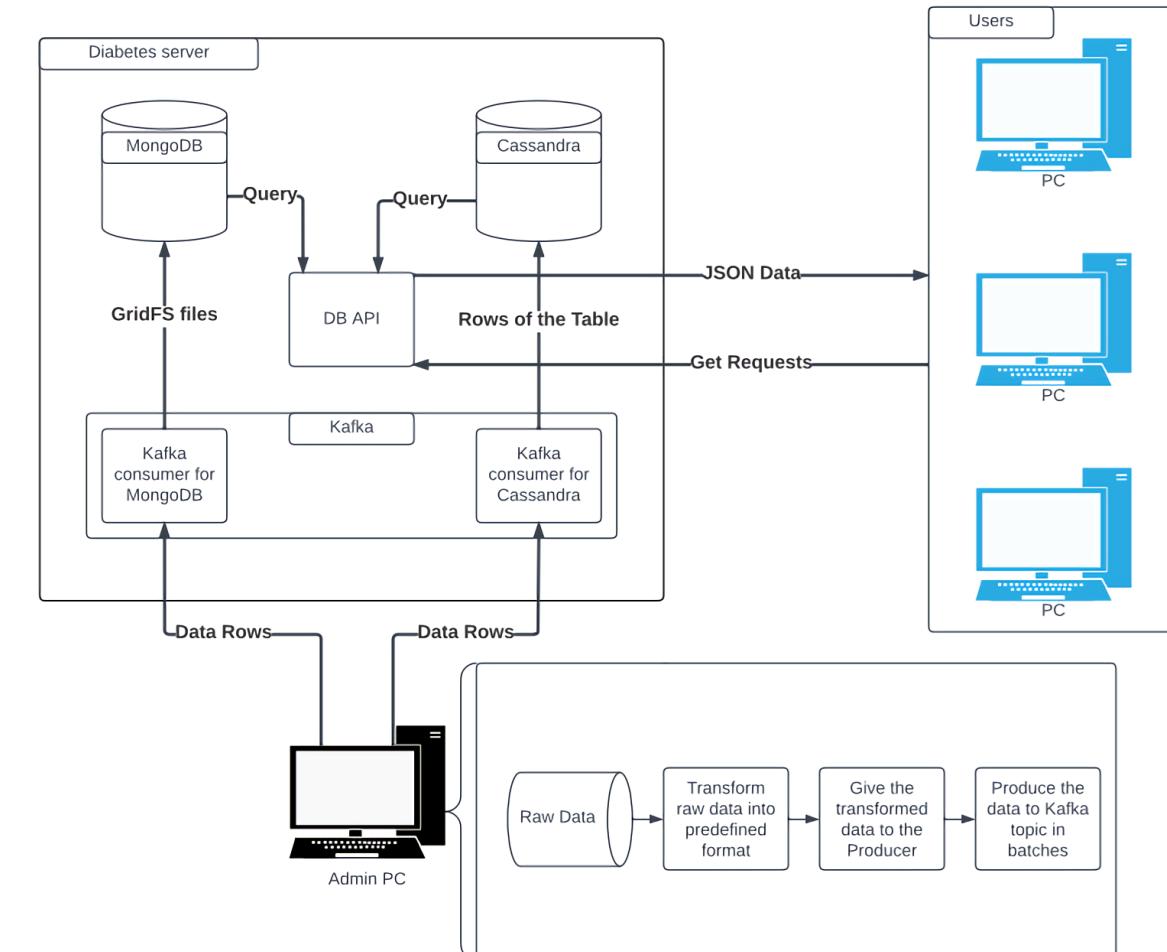
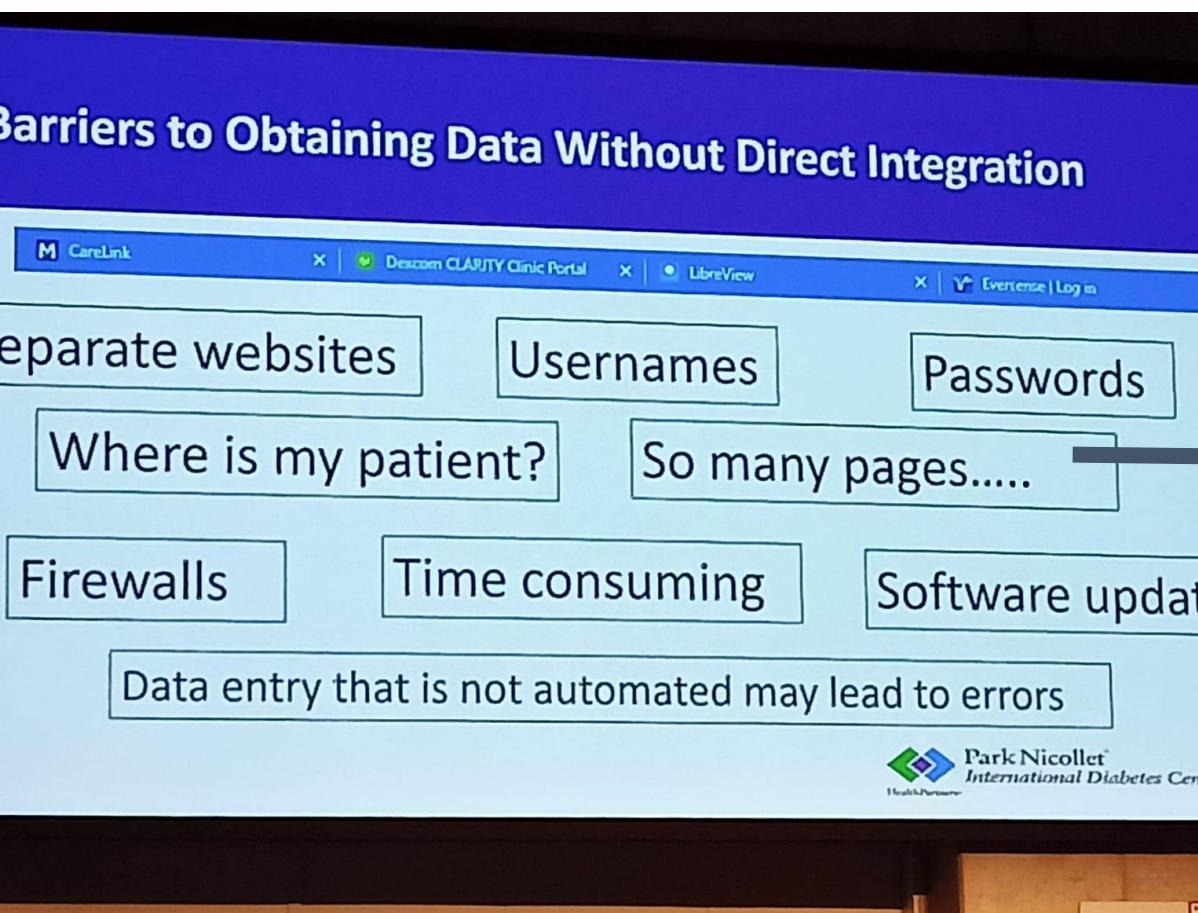
### Predikciók

Vércukorszint

Szimuláció



## Unified database



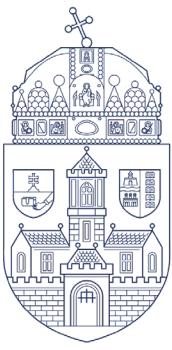


## Future projects

- Clinical study involving two hospitals: relationship between blood glucose levels and physical activity
- Validation of control methods in UVa/Padova simulator
- Deployable cloud application



European  
Research  
Council



ÓBUDAI EGYETEM  
ÓBUDA UNIVERSITY

Thank you for your attention!