UNIVERSITY OF PADOVA
DEPARTMENT OF INFORMATION ENGINEERING

Biomedical Wearable Technologies
for Healthcare and Wellbeing

Research applications

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Outline

- **IMPACT**
- DEEP
- AIRPREDICT
- TimeRun

Clinical Trials

- Essential instrument to test newly developed solutions for disease management and care
- Multiple patients in parallel
- Data gathering for assessment of the examined methodology

Data Gathering

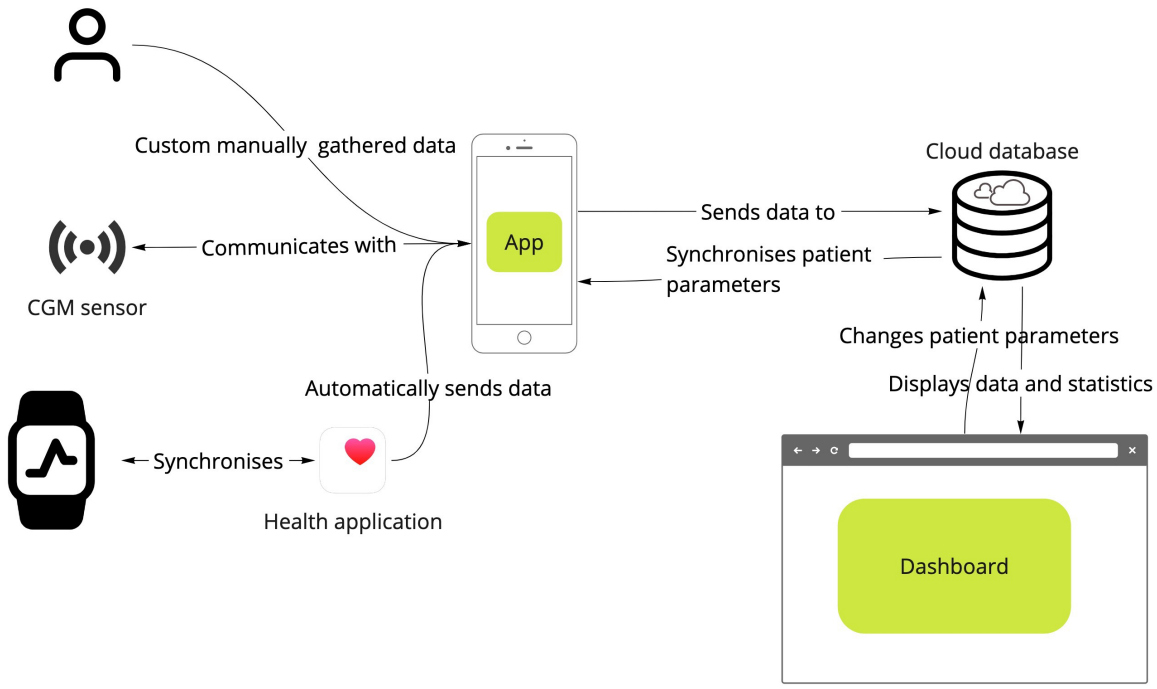
- Different sources (automatic sensors, manual input,…) and format (numeric, raw text description,…)
- Lack of standardization of data schema
- Need of normalization before data availability for research purposes

Our solution

- During my master thesis I have developed and briefly tested a mobile platform built in Flutter
- The platform allows for conduction of simple clinical trials
- It integrates automatic data collection from different sources

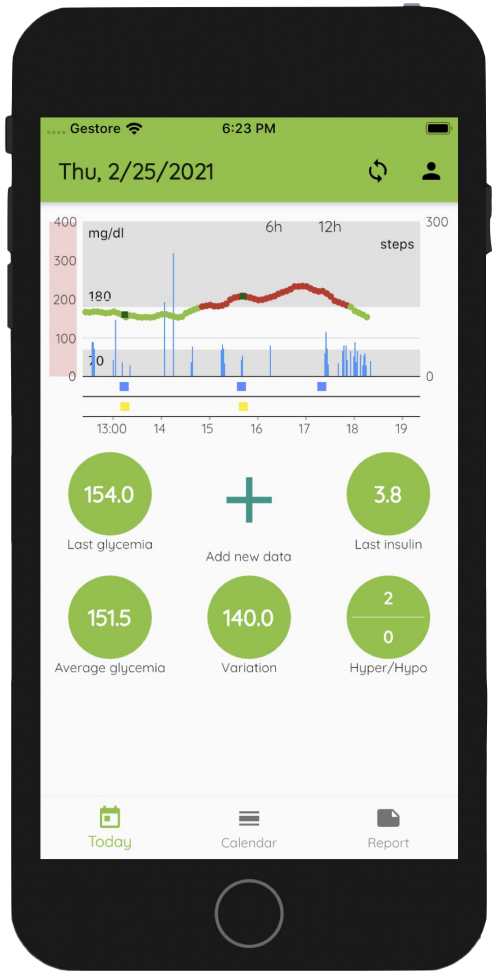
Platform structure

- Cloud database
- Mobile application with wearable devices integration
- Monitoring interface for real-time monitoring



Mobile application

- iOS application
- Dexcom© G6 sensor integration
- HealthKit integration
- Manual data logging
- Statistics over different time periods
- PDF report creation and sharing capabilities



Today view with graph and statistics

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Context of the DEEP platform

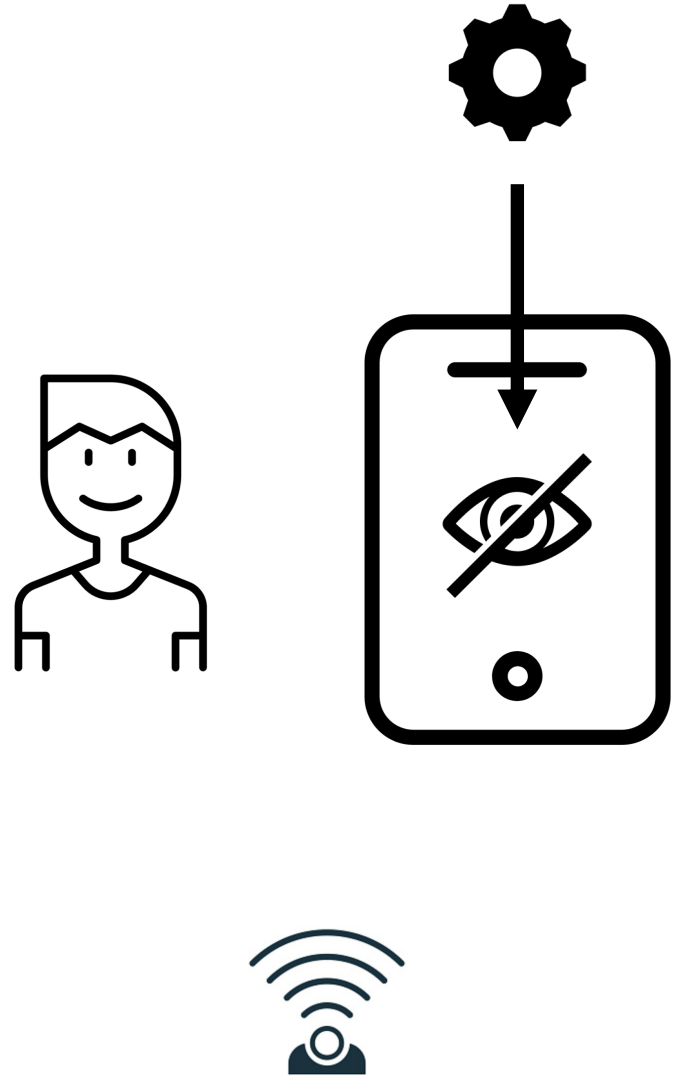
- Adaptation of the IMPACT platform to the study
- Post bariatric surgery patients with post-prandial hypoglycaemic events
- Objectives:
  - Understand and predict blood glucose dynamic in this population
  - Predict hypoglycaemic events
  - Therapy effects on glucose fluctuations

Multiple data types to be gathered

- Blood glucose
- Meal intakes (kind and quantity)
- Hypoglycemia symptoms
- Physical activities (steps automatically collected)
- Drug intakes with comments and informations
- Sleep cycles

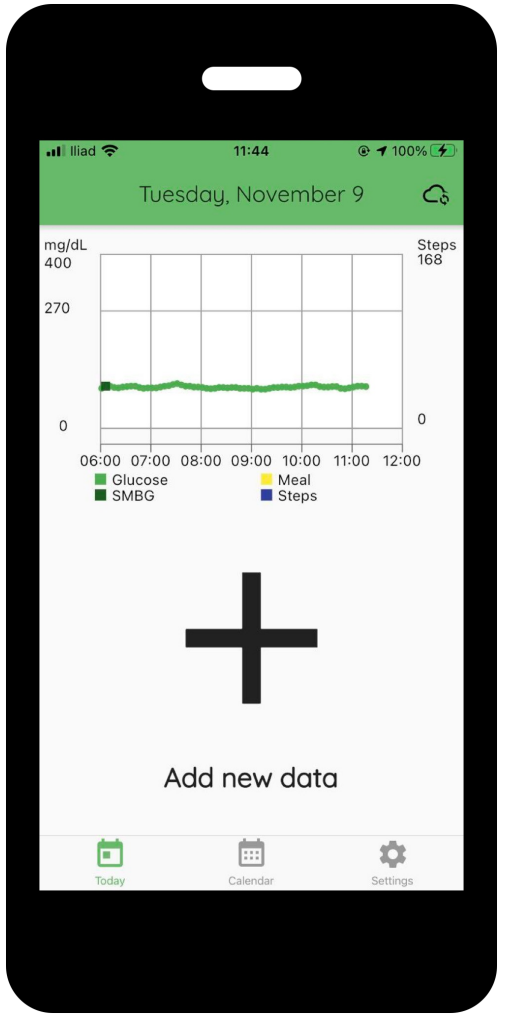
Real time capabilities

- Data collection from multiple devices
  - Continuous Glucose Monitoring sensor (CGM)
  - Fitness trackers (Apple health integration)
- Patient monitoring via web interface
- Simple real-time algorithms to be tested
- Change trial settings
  - Blinding of CGM data



Mobile application

- Real time communication with multiple wearable sensors
- Completely customisable in theme and features
- Able to run simple real time algorithms
- Active custom notifications for specific events

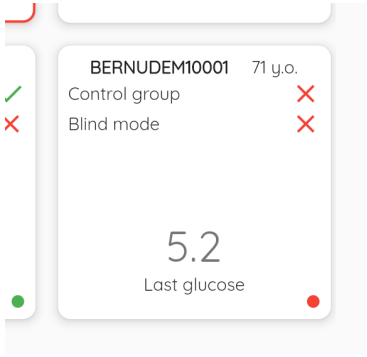


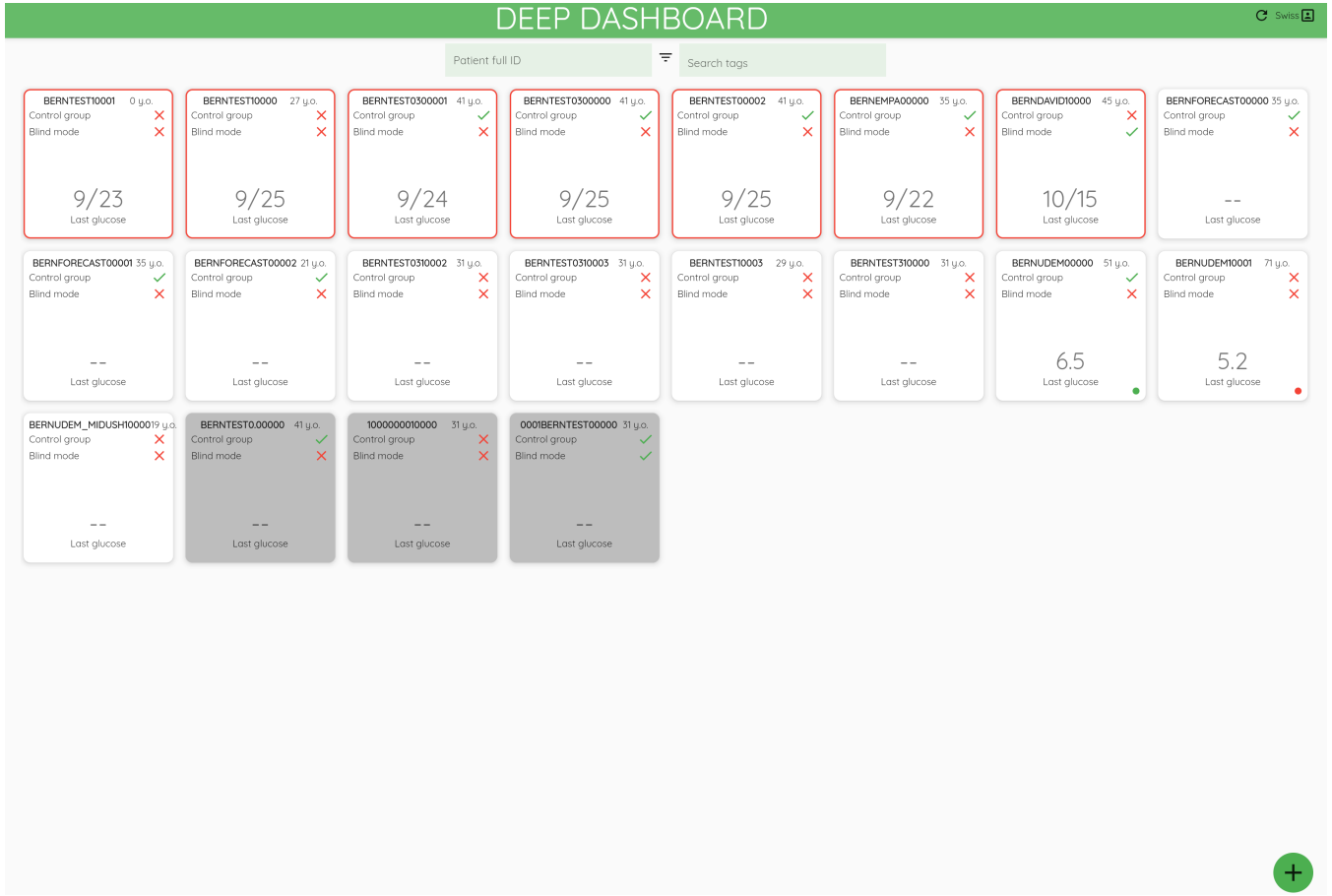
Web interface

- Overview of all enrolled patients
- Per patient details and statistics
- Daily analysis page
- Custom features
- Custom trial settings

Patients overview

- Landing page for the clinician website.
- Alerts and status of patients at a glance
- Enrolment of new patient





Live demo

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Air Pollution

- **Air pollution** is a **global issue** that has a significant impact on human health
- The quality of air is an environmental factor that **affects non-transmissible illnesses** such as respiratory and neurodegenerative diseases.

Asthma

- **Asthma** is a disease characterised by **diffuse inflammation of the airways**
- Relapses, i.e. **exacerbations**, are defined as an **acute and severe loss of disease control** requiring urgent treatment.

The Problem

Problem

- **Exposure to air pollution is a crucial risk factor** for asthma exacerbation
- Hence, air pollution can significantly impact the quality of life of asthma patients
- **Preventing exacerbation episodes is critical** in improving the prognosis of asthma
- **Current** state-of-the-art **predictive models** for asthma exacerbation mostly **do not consider risk factors related to pollution**
- A **dynamic personal exposure assessment** can enable real-time personalized predictions of exposure-induced adverse events

The Planned Approach

- Develop a new **smart monitoring system**, consisting of
  - **Wearable** and **portable** Internet-of-Things **sensors**
  - **Mobile** and a **web** applications
  - **Cloud** database (IMPACT)
  - **Data analysis** and **Machine Learning**
- The monitoring system will be tested in a population of asthma patients followed at the Respiratory Disease Clinic of University of Padova (DCTV).

IoT Sensors

- **Atmotube PRO**
  - Portable air quality monitoring device
  - Measures
    - pollutant concentrations,
    - weather indices, total volatile organic compounds,
    - temperature, humidity, and pressure
- **Fitbit Charge 5**
  - Smartwatch that captures
    - heart rate
    - physical activity information.
    - Stress
    - SpO2
- **MIR Smart One**
  - Pocket-sized, personal spirometer
  - Measures
    - Peak flow rate (PEF)
    - Forced expiratory volume (FEV1)

Mobile Application

- **Personal Exposure Tool**

  Leveraging Bluetooth Low Energy (BLE) communication and Web APIs, wearable/portable sensor data is gathered to compute the Personal Exposure (i.e Inhalation).

- **Asthma Diary**

  User can report an Asthma Attack, the Spirometry test done daily and also the Asthma Control Test (ACT). Logs can be visualized in the asthma diary page.

Clinical Web Dashboard

- **Patients enrolment for the trial**

  Create a new patient within the IMPACT platform, hence enrol a new asthmatic patient into the Airpredict trial.

- **Monitor Patients' Asthma Control**

  Possibility to check the exposure and asthma related trends for each patient that had sync their data with the IMPACT Cloud Database.

Data Analysis and Machine Learning

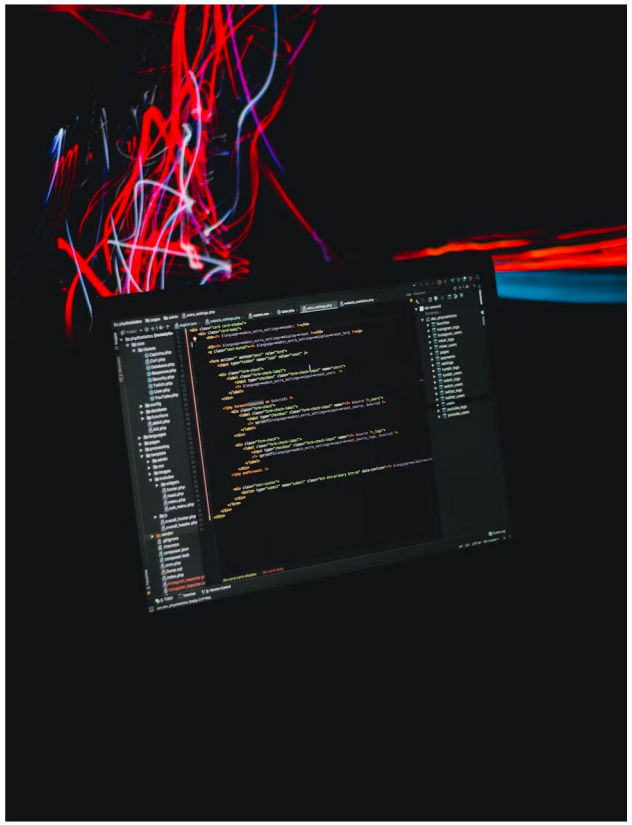
Collected patient-generated and environmental data will be used

- **Find the factors influencing asthma exacerbations**

  Identification of the air pollution exposure factors that most increase the risk of asthma exacerbations.

- **Artificial Intelligence predictive modeling**

  The development of AI predictive models to predict the risk of future exacerbations in asthma patients, considering clinical and environmental factors.



Live demo

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Setting

- Master thesis project of last year's BWTHW student
- Accuracy comparison between multiple smartwatches to be used in future studies
  - Apple Watch 8
  - Garmin Vivoactive 4
  - Fitbit Charge 5
  - Withings Scanwatch

Gold standard

- Polar H10
- ECG sensor considered one of the most accurate[1] on the market
- Simple bluetooth integration

[1] https://www.polar.com/sites/default/files/static/science/white-papers/polar-h10-heart-rate-sensor-white-paper.pdf

Protocol of the study

- 10 participants
- Running activity to span over all heart rate zones
- Two minutes of run for each heart rate zone
  - Running speed is guided by the master thesis student giving instructions to the participant to keep the heart rate in the required zone
  - Use of a mobile app built by the student to monitor the participant in real time

Practical demonstration