COLOGNE COBOTSLAB

Promoting autonomy in care:
Combining sensor technology and
social robotics for health monitoring

Caterina Neef and Anja Richert
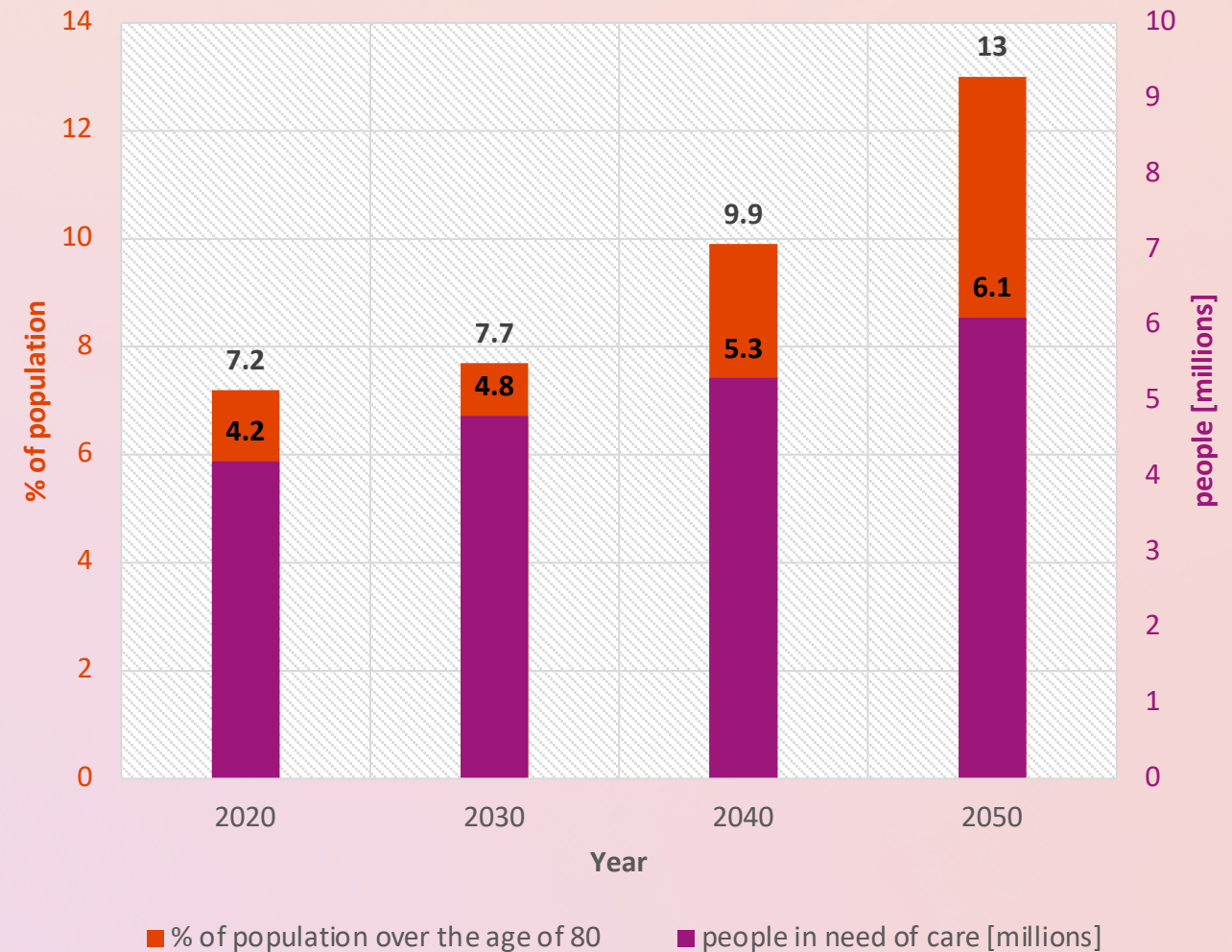
Cologne Cobots Lab

TH Köln, Cologne, Germany

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Motivation

- **Demographic transition** in Germany and around the world
  - More **elderly people in need of care**, cared for
    - At home by relatives and nurses
    - In nursing homes
- Important to support and unburden both elderly and caregivers
- One option: use of **assistive technologies** such as
  - **Social robots** for personal interactions
  - Wearable and non-wearable **sensors for health monitoring**
- **Goal:** support **autonomy** of elderly and increase **quality of care**

Source: German Federal Ministry of Health, July 2020, „Zahlen und Fakten zur Pflegeversicherung", Link

Demographic transition in Germany

Legend:
- % of population over the age of 80
- people in need of care [millions]

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Related Work

- **Loza-Matovelle et al. 2019[1]**

  - Architecture of robot and sensors for elderly care

- **Boumans 2020[2]**

  - Use of patient-reported outcome measures with social robot

- **Yusif et al. 2016[3]**

  - Largest concern regarding assistive technologies: privacy, trust and added value

→ It is **essential** to **develop** technologies **together with users**

[1] Loza-Matovelle, D.; Verdugo, A.; Zalama, E.; Gómez-García-Bermejo, J. An Architecture for the Integration of Robots and Sensors for the Care of the Elderly in an Ambient Assisted Living Environment. Robotics 2019, 8, 76.
[2] Boumans, R.; van Meulen, F.; Hindriks, K.; Neerincx, M.; Olde Rikkert, M. A Feasibility Study of a Social Robot Collecting Patient Reported Outcome Measurements from Older Adults. International Journal of Social Robotics 2020, 12, 259–266.
[3] Yusif, S.; Soar, J.; Hafeez-Baig, A. Older People, Assistive Technologies, and the Barriers to Adoption: A Systematic Review. International Journal of Medical Informatics 2016, 94, 112–116.

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Sensor-robot ecosystem

Proposed architecture as a

✓ base for the **sociotechnical development** of an **ecosystem** comprised of

✓ **health care sensors** and

✓ a **social robot** to

✓ **promote the autonomy** of **elderly people** in need of care

Sensors:

Continuous Measurement
- Temperature
- Heart Rate

Interval Measurement
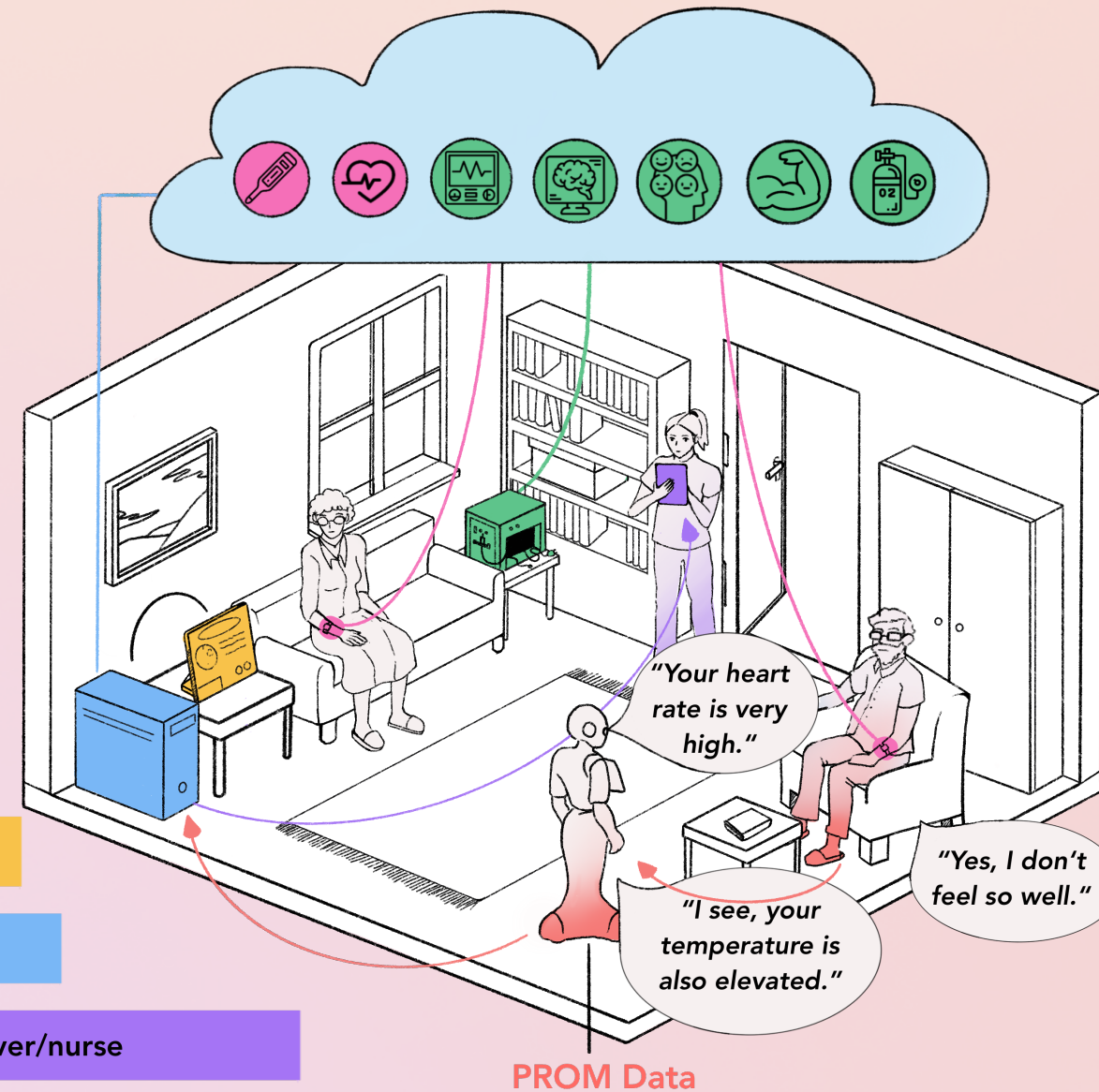- EKG
- EEG
- EDA
- EMG
- SpO2

Social robot Pepper

Local Sensor Network

Health monitoring dashboard

Data processing unit/server

Health assessment report for caregiver/nurse

"Your heart rate is very high."

"I see, your temperature is also elevated."

"Yes, I don't feel so well."

PROM Data

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Sensor-robot ecosystem

1. **Wrist-worn wearable devices** continuously measure skin temperature and heart rate

2. **Stationary sensors** acquire EKG, EEG, EDA, EMG, SpO2 in interval measurements

3. Through conversation with the **social robot** Pepper (SoftBank Robotics) and use of **PROMs**, the subjective well-being of the user is determined

4. Data is visualized in **health monitoring dashboard**, user/caregiver is notified when data is alarming

5. Data is collected and processed in **data processing unit**

6. **Health assessment report** is generated for caregiver/nurse

Sensors:

Continuous Measurement
- Temperature
- Heart Rate

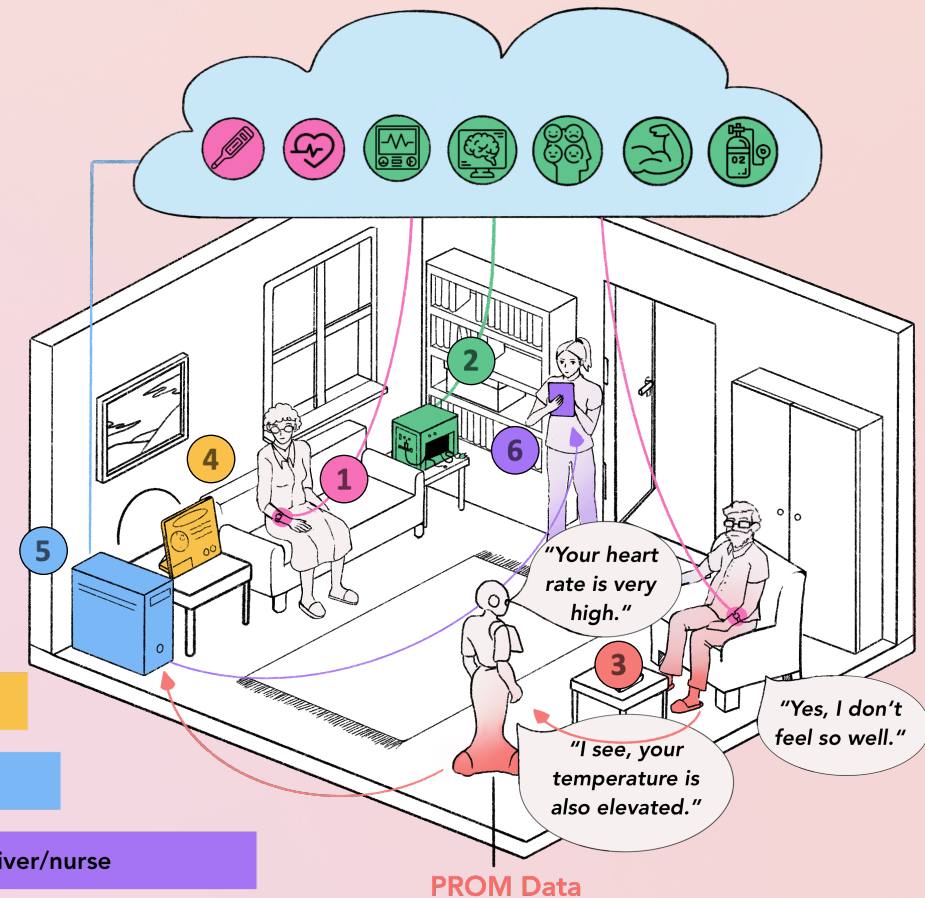**Interval Measurement**
- EKG
- EEG
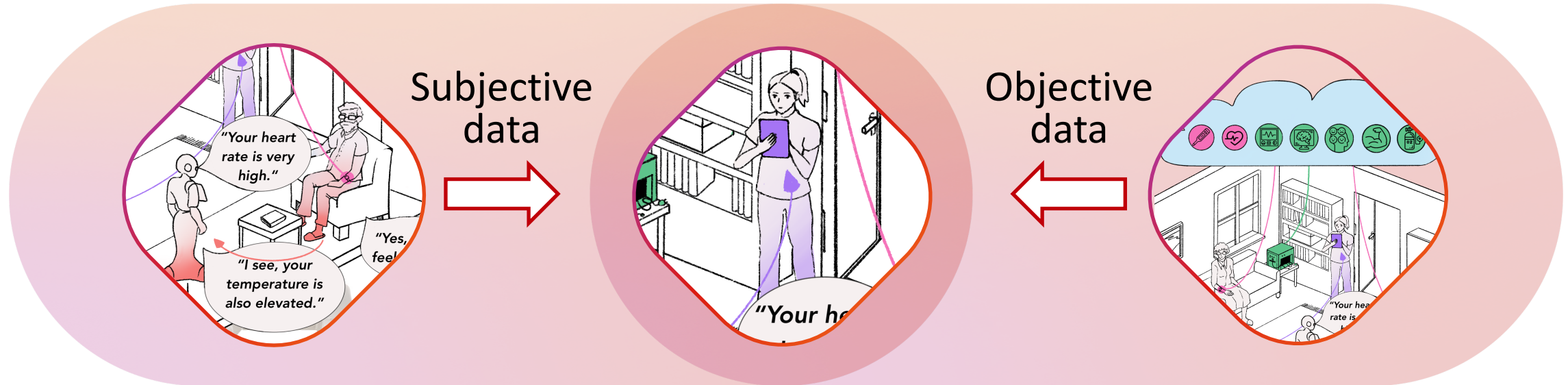- EDA
- EMG
- SpO2

Social robot Pepper

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Sensor-robot ecosystem

Subjective data →

Objective data ←

PROM data

- Use of patient-reported outcome measures (PROMs)
- Elderly person answers questions regarding health and well-being in conversation with social robot
- **Subjective health data** is acquired

Health Assessment Report

- Combination of **objective PROM data** and **subjective sensor data** allows generating a **health assessment report** for both elderly person and caregiver

Sensor data

- **Continuous measurement** of temperature, heart rate
- **Interval measurements** of EKG, EEG, EDA, EMG, SpO2
- **Objective health data** is acquired

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Results
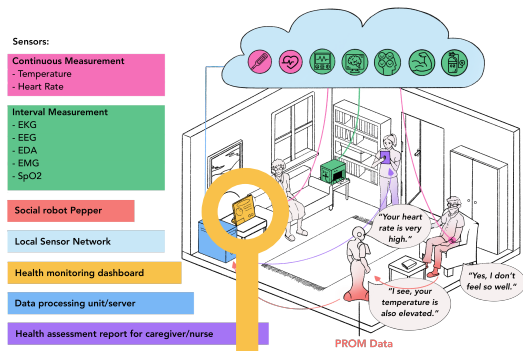
Example of **health monitoring dashboard**

→ Generated using ThingsBoard[1]

1. **Heart rate** (optical measurement) and **skin temperature** are continuously measured using a wrist-worn device and are **visualized in real time**

2. **EKG** is visualized when it is acquired in **interval measurements**, can be used to determine heart health, can also be sent to nurse/doctor

3. **Historical data** can be selected for visualization

→ To visualize data of **other sensors**, **additional widgets** can be created and **customized**

[1] thingsboard.io

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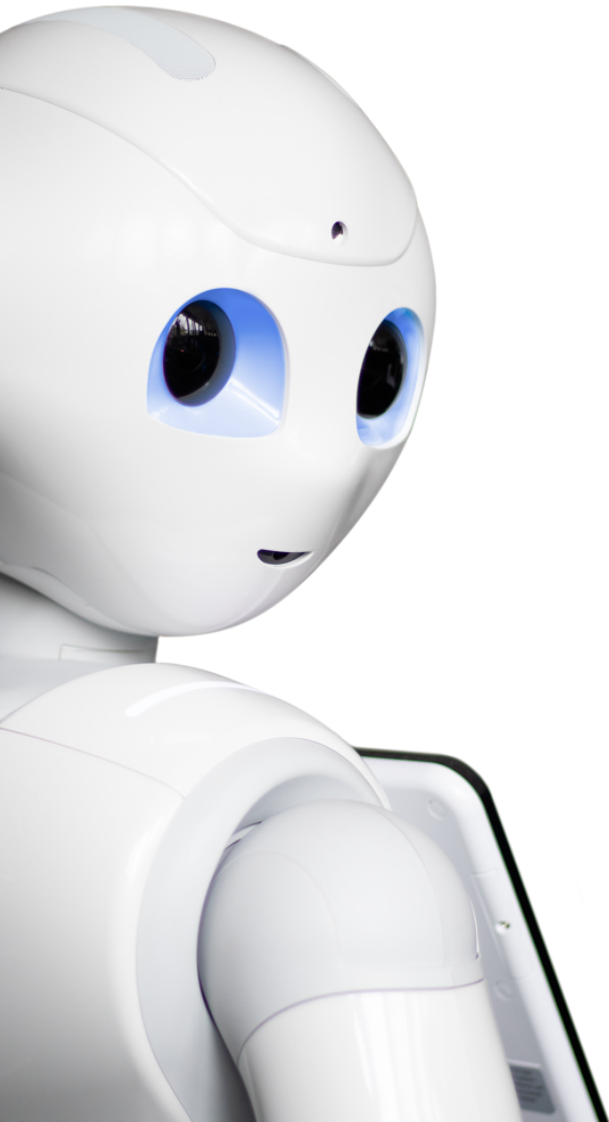**TH Köln**
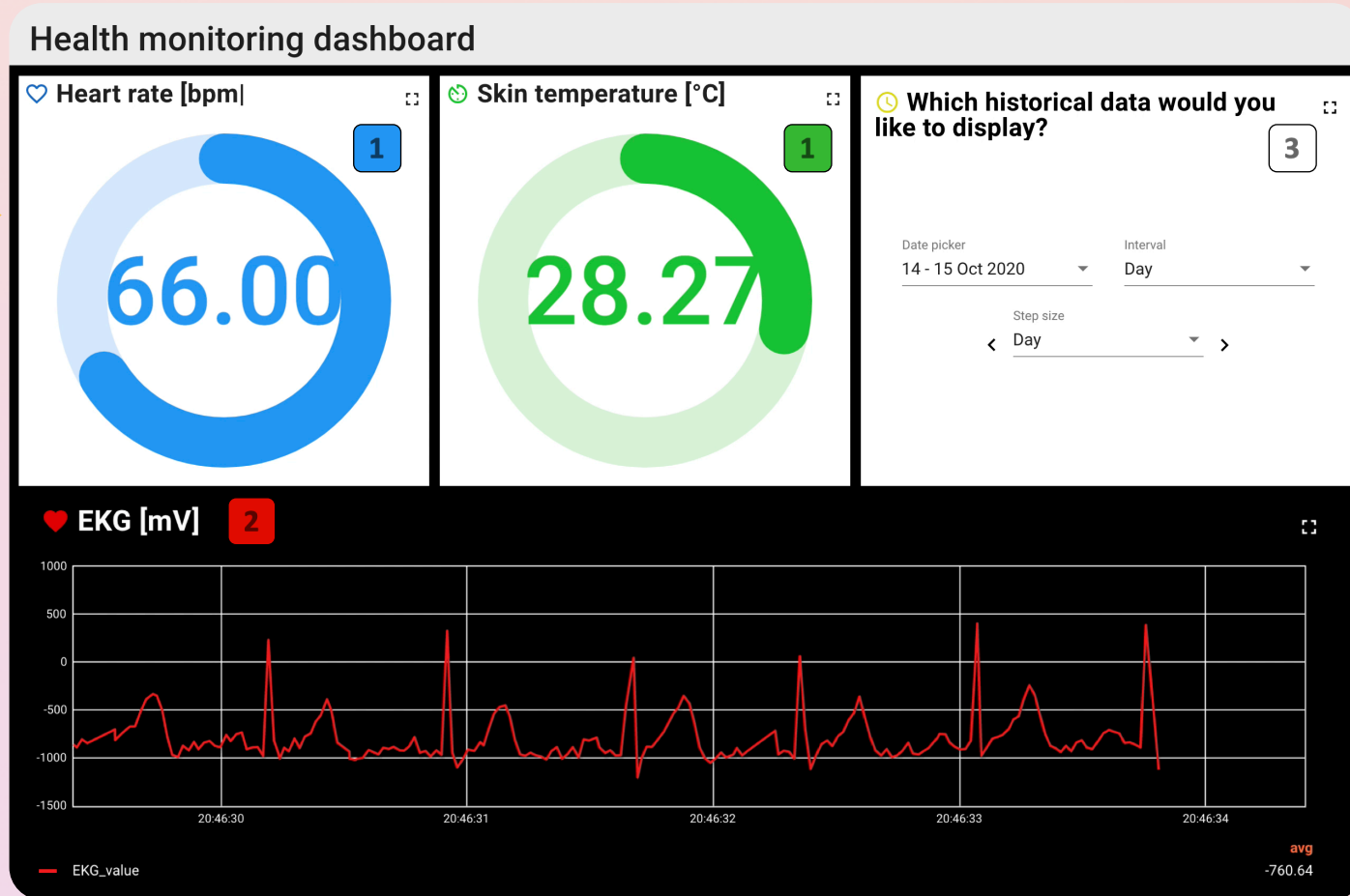
Discussion and Future Work
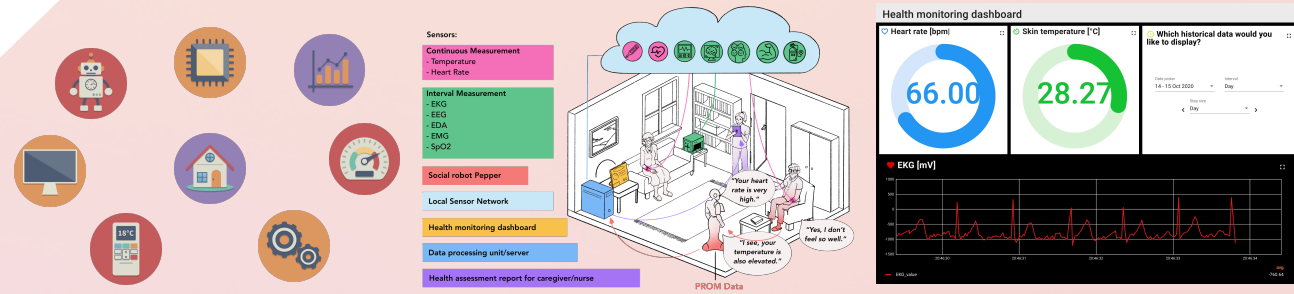
Proposed architecture provides **basis for integration of sociotechnical perspective** into **development of sensor-robot ecosystem**, by answering the **following research questions:**

1. Which are the **most important PROMs** and **sensors** to detect **specific health** and **care situations**? How **individually different** is this?

2. (How) can we **combine PROMs** and **different sensors** to **increase the quality of care** of **elderly users** in their **homes**?

3. In which way, if at all, does this combination **reduce the burden** of care of both the **elderly users** and **their caregivers** (both trained and untrained)?

4. To which degree can these **results be transferred** to **other age groups** and **care situations** (e.g. nursing homes)?

→ By **integrating users in development of ecosystem**, mentioned **concerns** (privacy, trust, added value of technologies) can be **addressed and alleviated**

Future work:

- Integrate **more sensors** into ecosystem, e.g. for **fall detection, activity monitoring, emotion recognition, on-wrist blood pressure measurement**

- Test **robustness of system** through **long-term measurements** in realistic settings

- Investigate how well system works, when **only user** interacts with it → **reduce maintenance** and ensure **long-term user satisfaction**

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Questions? Comments?

Please get in touch!

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