UNIVERSITÀ DI PISA

ChillIn: Detecting and Locating Stress in Urban Settings

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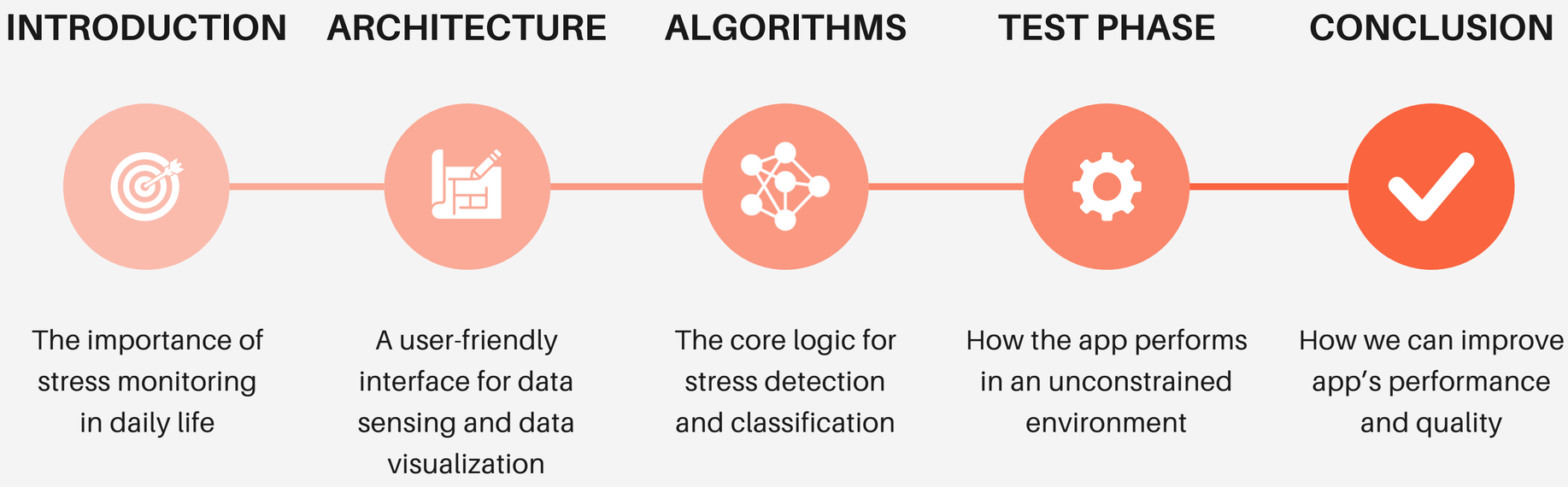
Roadmap


INTRODUCTION
ARCHITECTURE
ALGORITHMS
TEST PHASE
CONCLUSION
The importance of stress monitoring in daily life
A user-friendly interface for data sensing and data visualization
The core logic for stress detection and classification
How the app performs in an unconstrained environment
How we can improve app’s performance and quality

Introduction

The importance of stress monitoring in daily life

Stress in urban settings

Detecting stress

Stress is one of the principal causes that affects quality of life in urban areas:

- noise pollution
- economical pressure
- social pressure

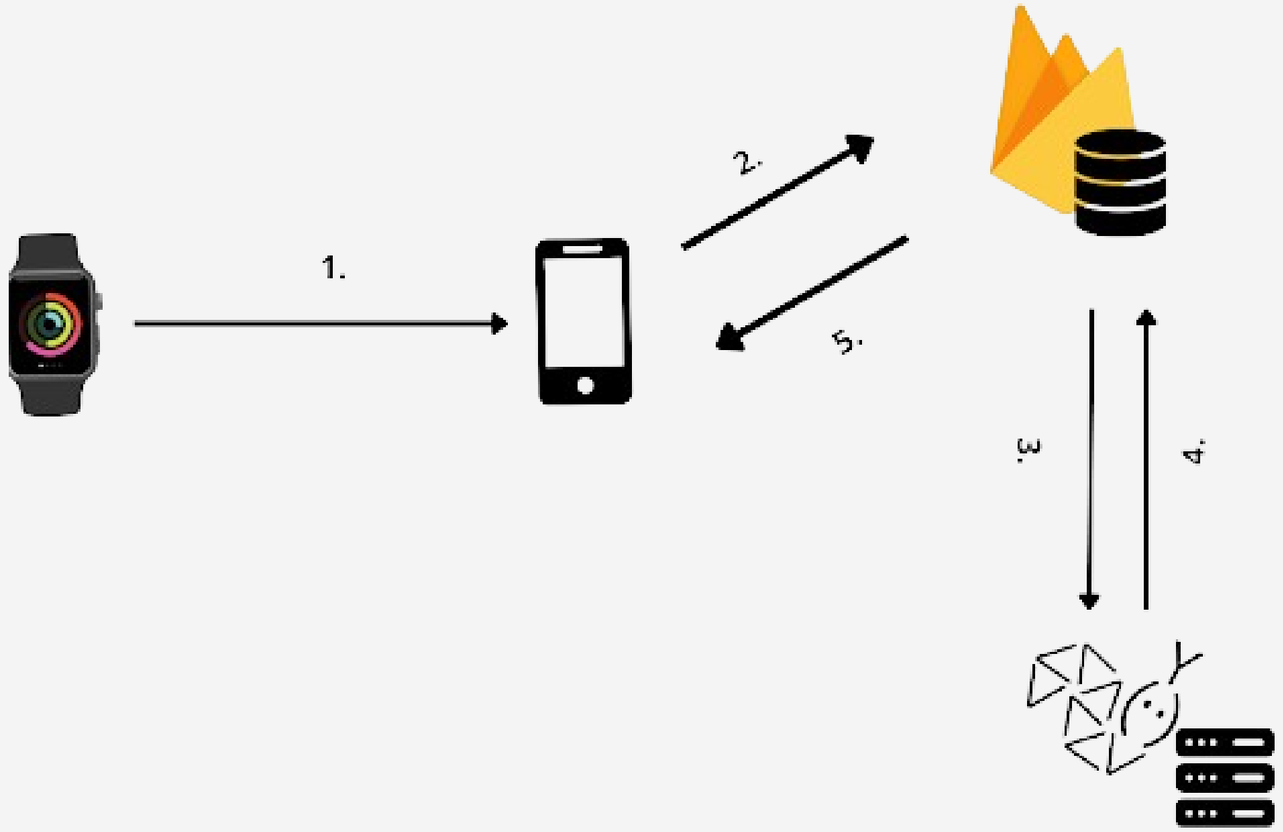
Locating stress

Pinpoint a general point of stress in a city, thus highlighting the most stressed areas.
Urban planners can gain invaluable insights into the dynamics of urban stressors.

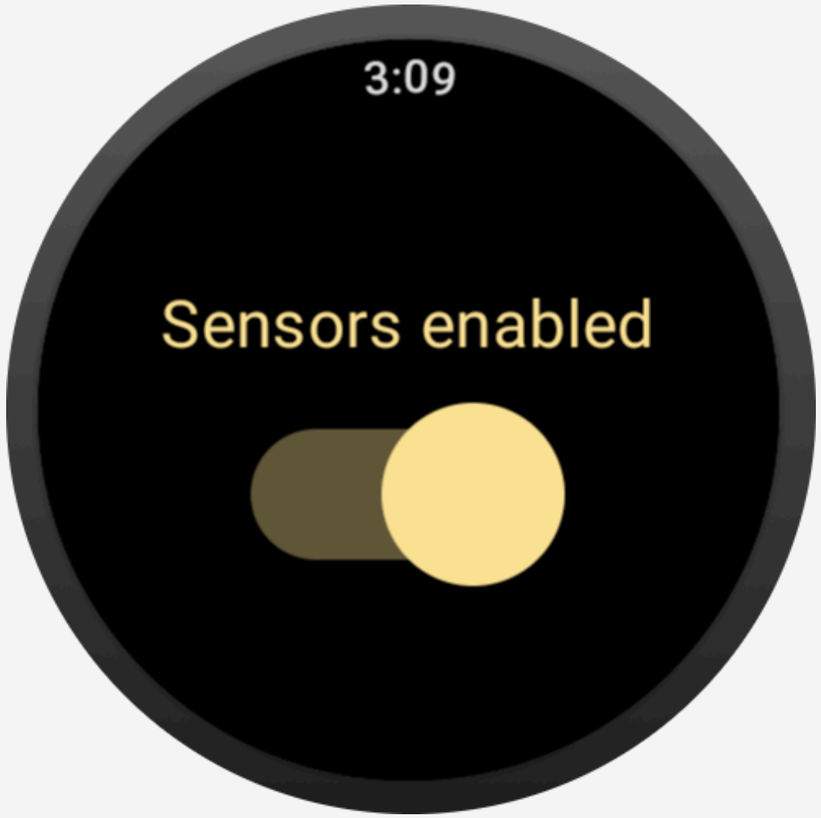
Architecture

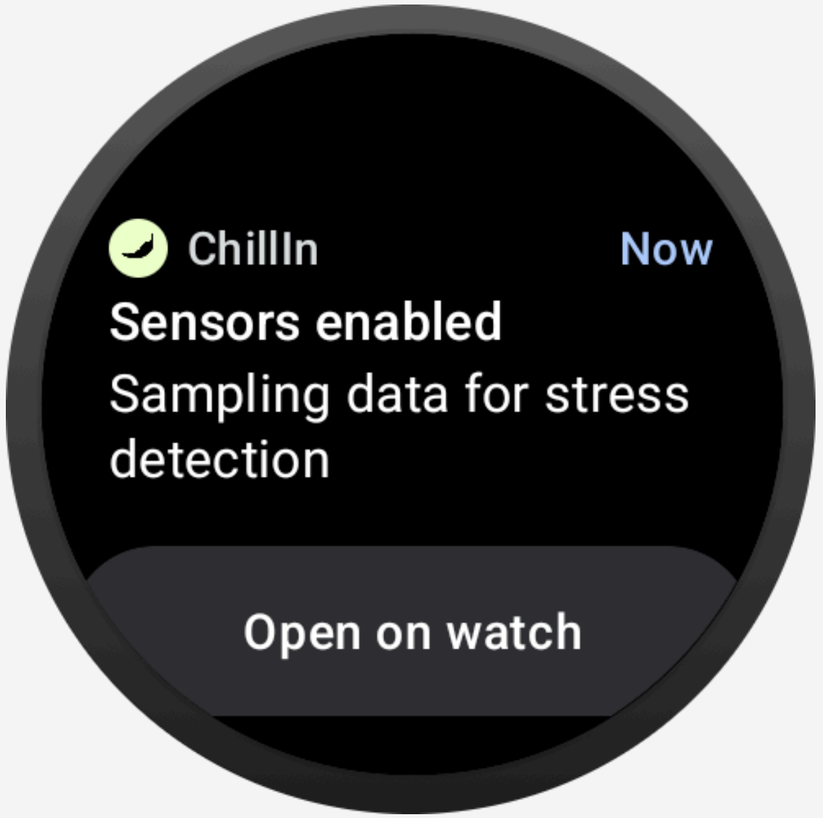
A simple user-friendly interface for data sensing and data visualization

Architecture scheme



Wearable app interface





Wearable and sensors

ElectroDermal Activity (EDA)

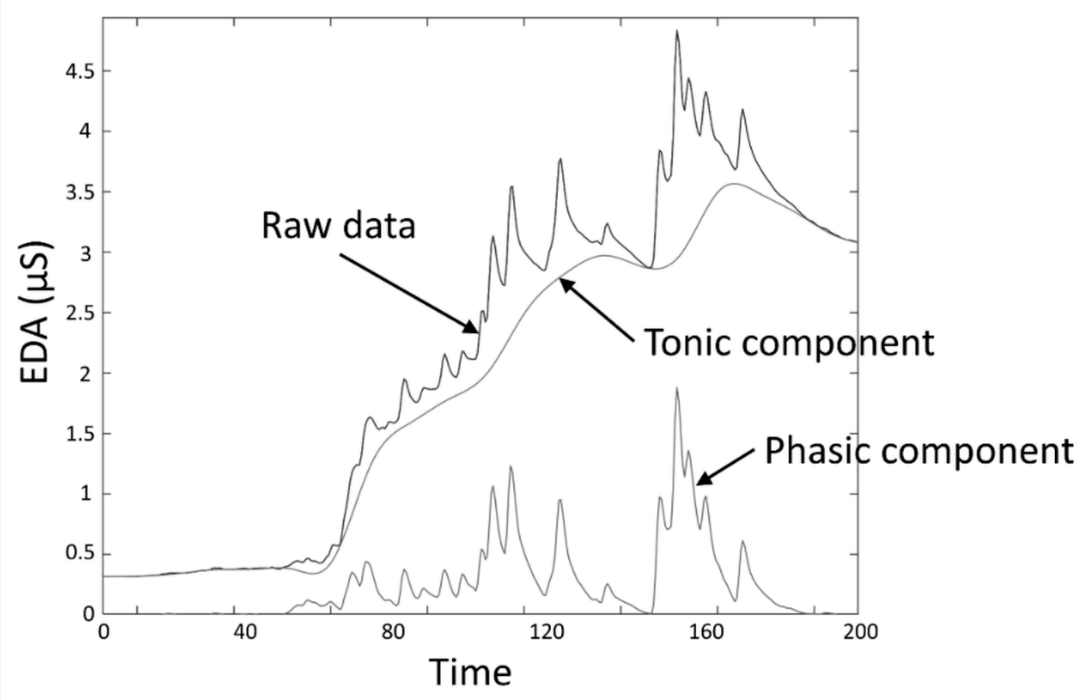
Skin Temperature

Heart Rate

EDA filtering

Remove noise → Butterworth low-pass filter (cutoff freq. of 0.45 Hz)

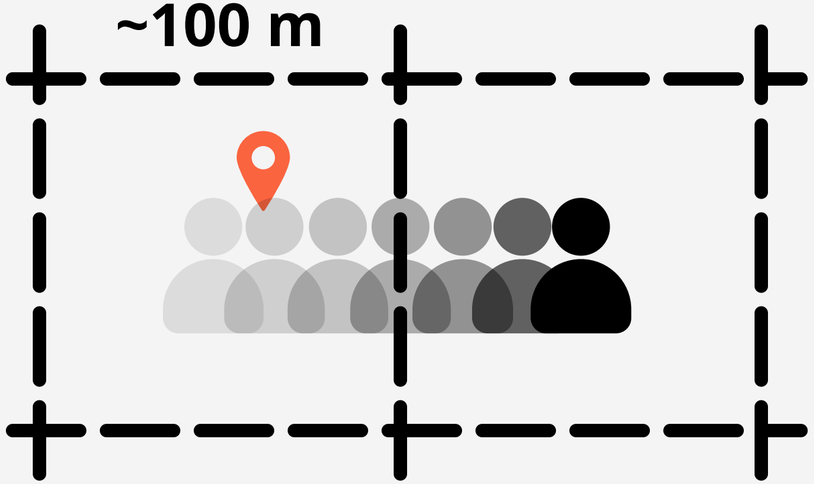
extrapolate phasic part → Butterworth high-pass filter (cutoff freq. of 0.05 Hz)



We only need the phasic component to detect stress

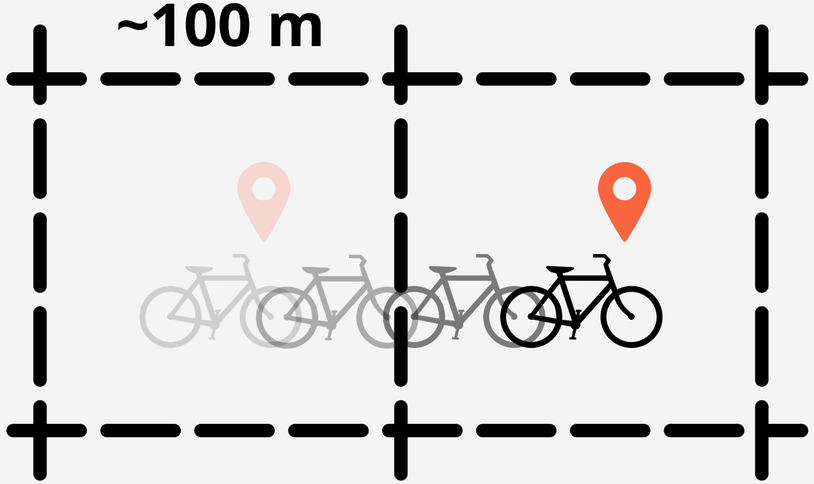
GPS location

Static approach



- Update with a constant frequency
- Problem when user moves too rapidly

Dynamic approach



- Update frequency changes according to user speed.
- High accuracy, while also keeping power consumption low.

Data Layer Comparison

	Data Client	Message Client	Channel Client
Data size greater than 100 kb	Yes	No	Yes
Can send messages to nodes that aren't currently connected	Yes	No	No
Communication pattern	Shared network-based resource	1:1 message passing (with response)	1:1 streaming

Data Frame

Timestamp

Long
8 Bytes

Skin Temperature

Float
4 Bytes

Electrodermal Activity

Float
4 Bytes

Heart Rate

Float
4 Bytes

Latitude

Double
8 Bytes

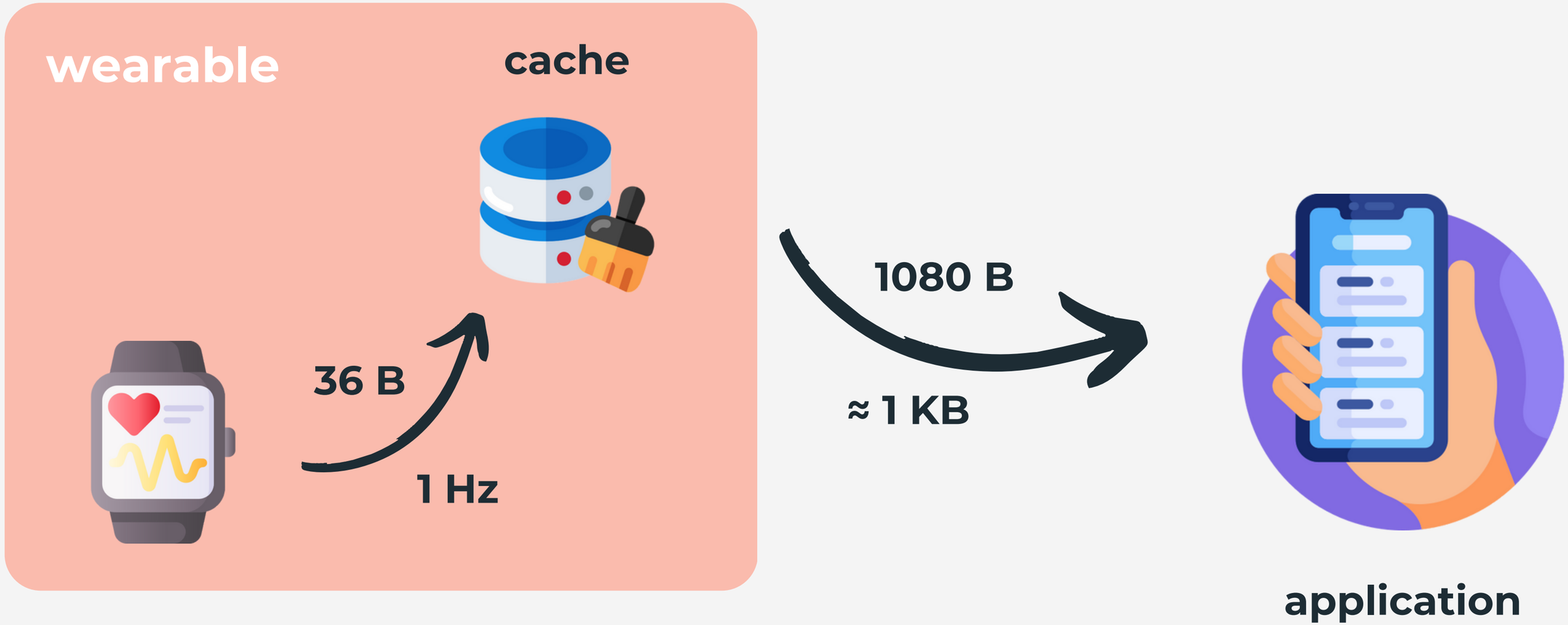
Longitude

Double
8 Bytes

---

36 Bytes per sample

Data Flow



Data Flow

Firebase Data management

ARCHITECTURE
FIREBASE

Raw Data

Firestore Document DB

Service Application

Last 30 sampling

Real Time KV DB

Most recent Raw Data

Derived Data

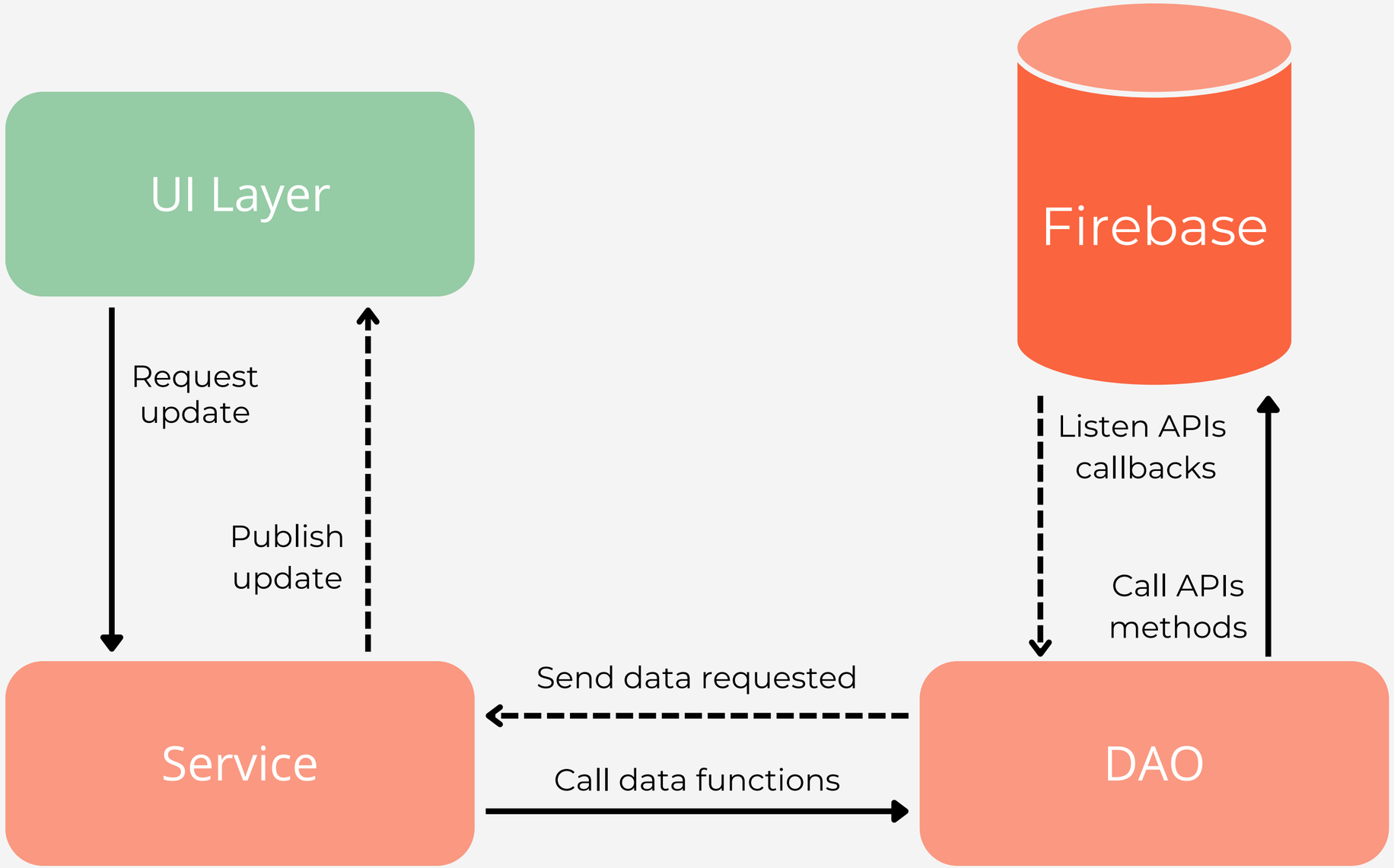
Python Server


```
"account":
{"admin@admin.com":{
   "name": "admin",
    "RawData":{
        "1715282197164":{
                  "edaSensor": 2321.3,
                  "heartrateSensor": 73,
                  "latitude": 43.712,
                  "longitude": 10.783,

 "skinTemperatureSensor": 30.109375
        },
    "DerivedData":{
        "1715282197164":{
                  "binterval":
[75.40226338417125, 76.5190824589481],
                  "stress_score": 0.4
        }
    }   }
}
},
```

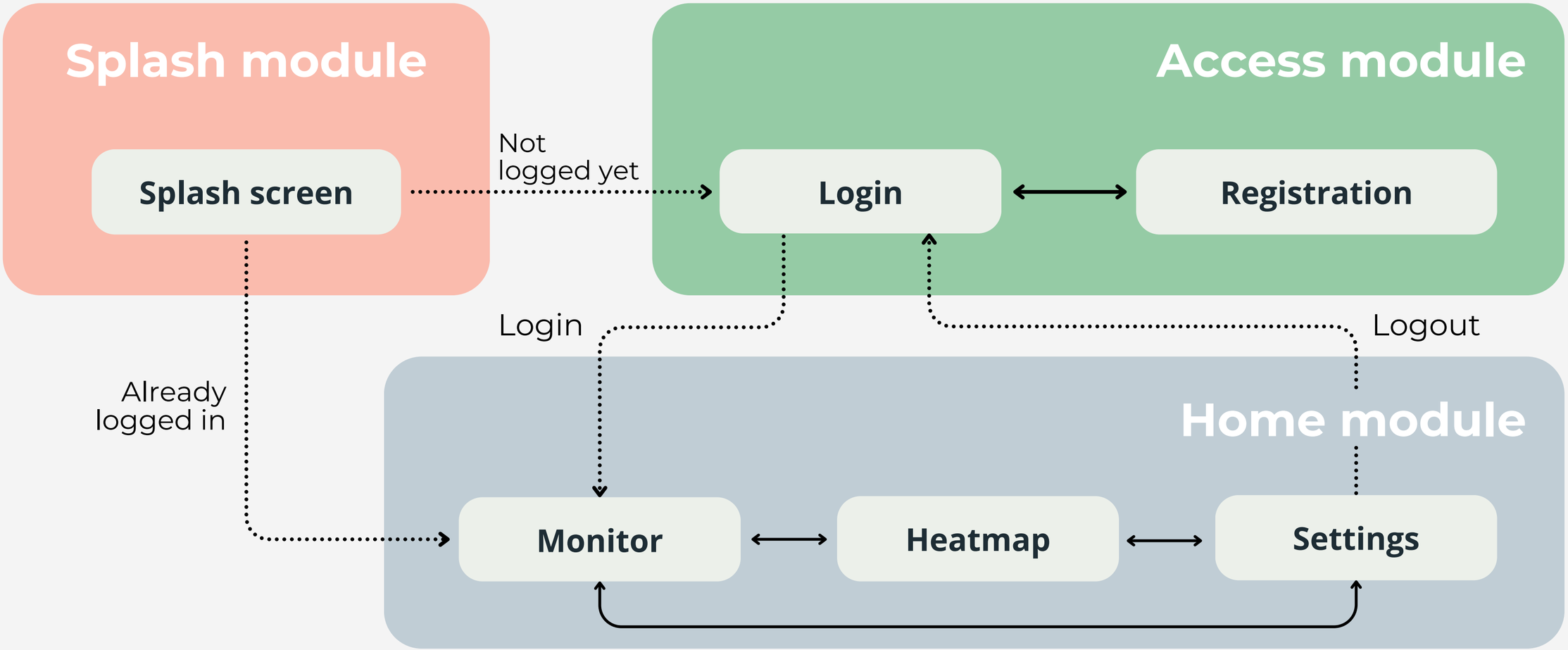
```
"Map":
    {
     "43_15, 10_339":{
          "days":{
            "2024-05-11":{
               "hours":{

 "hour":19,

 "stress_score": 11
                        }
                    }
                }
            }
```

```
https://chillinapp-a5b5b-default-rtdb.europe-west1.firebasedatabas
account
    emanuelerespino@@gmail@com
        RawData
            1715606836668
                edaSensor: -974.0593872070312
                heartRateSensor: 70
                latitude: 43.721
                longitude: 10.388
                skinTemperatureSensor: 33.7890625
```

Service Layer



Mobile App Design

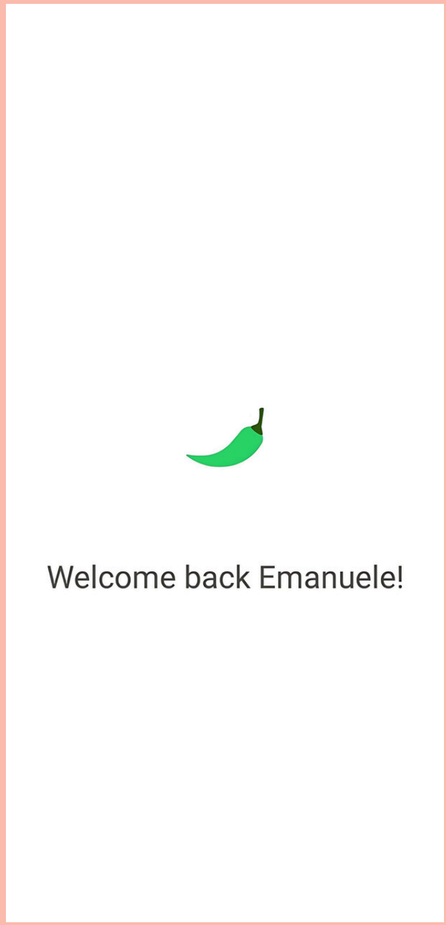


Account management

Splash module

Splash screen

Faster login through
Firebase authentication

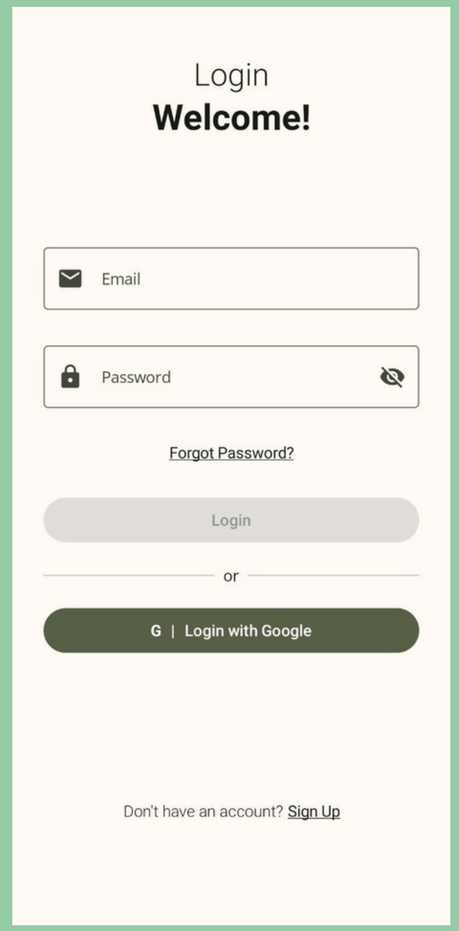


Account management

Access module

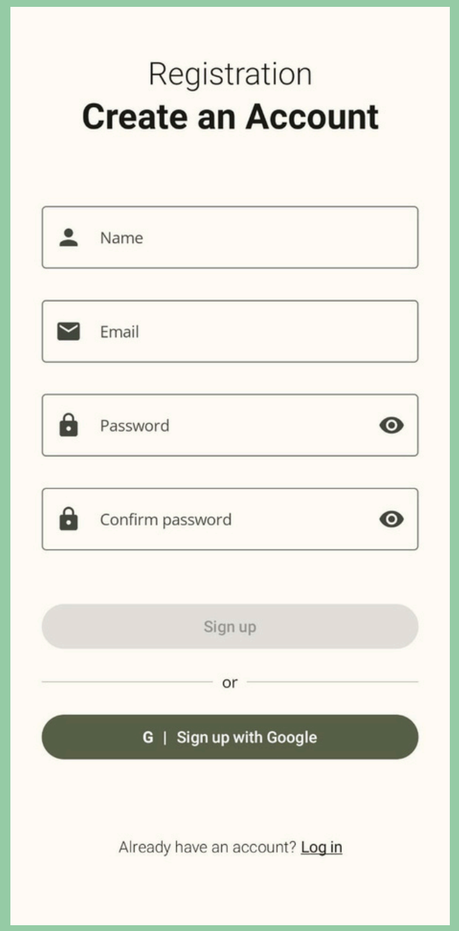
Login

A simple login page using email



Registration

To use the application an account is needed

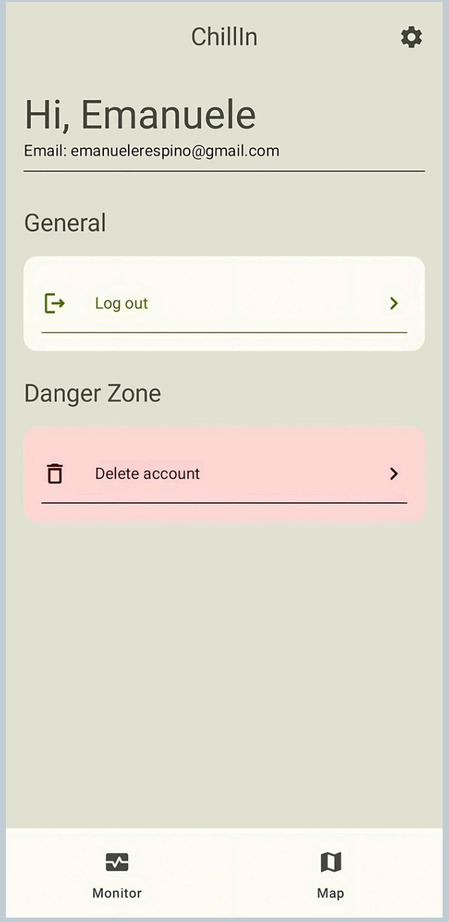


Account management

Home module

Settings

Provides basic account management operations

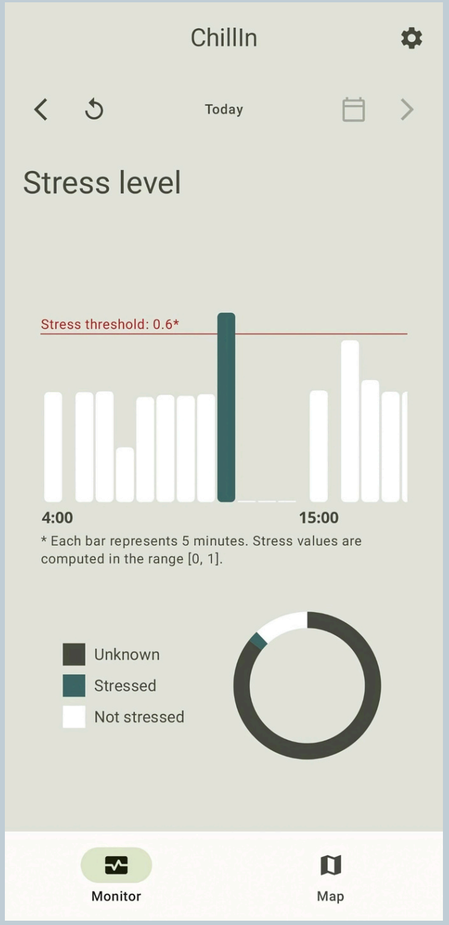


Data visualization

Monitor

Stress level

Bar chart and percentage of stress levels detected



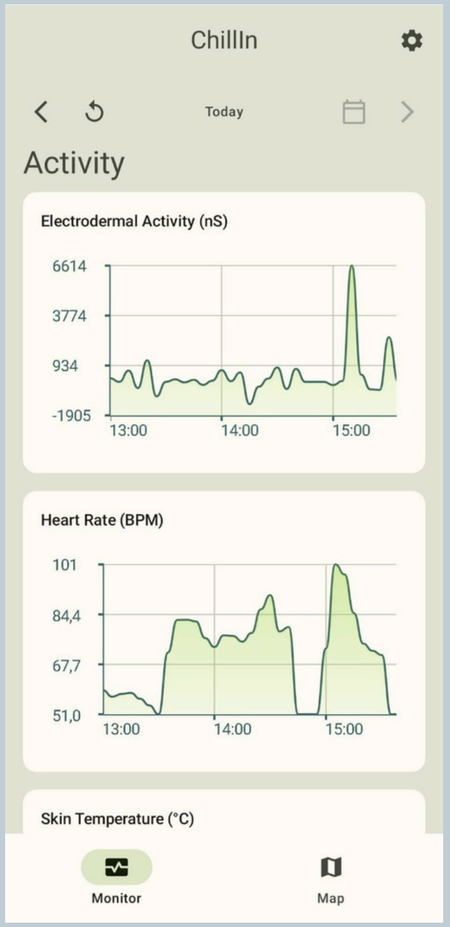
Activity

Line charts for physiological data:

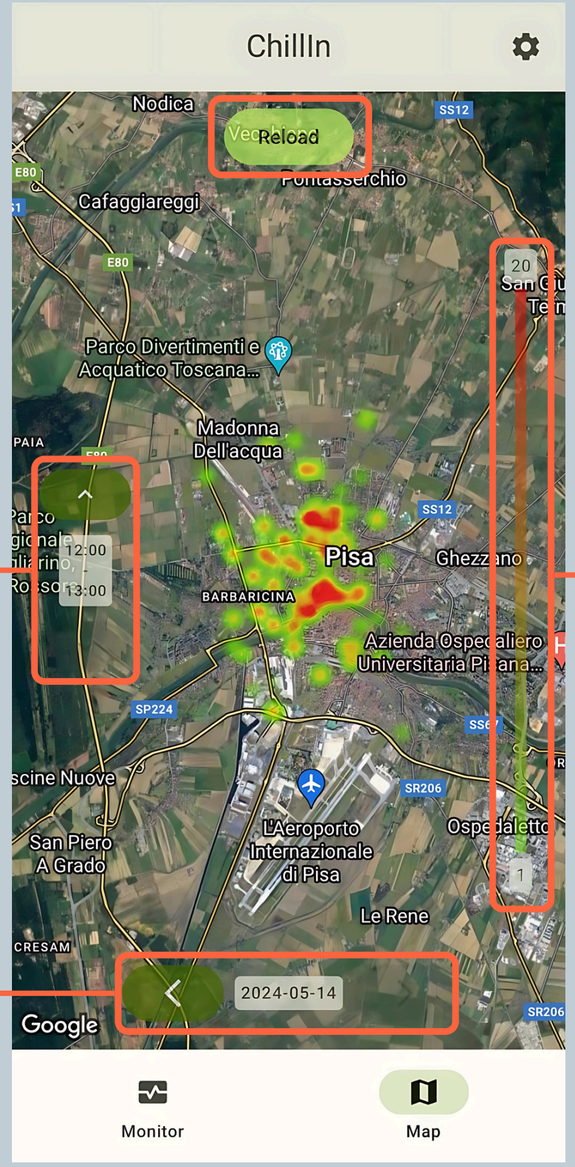
EDA

Heart Rate

Skin Temperature



Heatmap



Search buttons

Discover stress hotspots specifying an **hour** of a certain **day**.

Reload button

Update the heatmap in the specific area displayed

Stress bar

Shows minimum and maximum hotspots values in the area

UI Implementation

Jetpack Compose

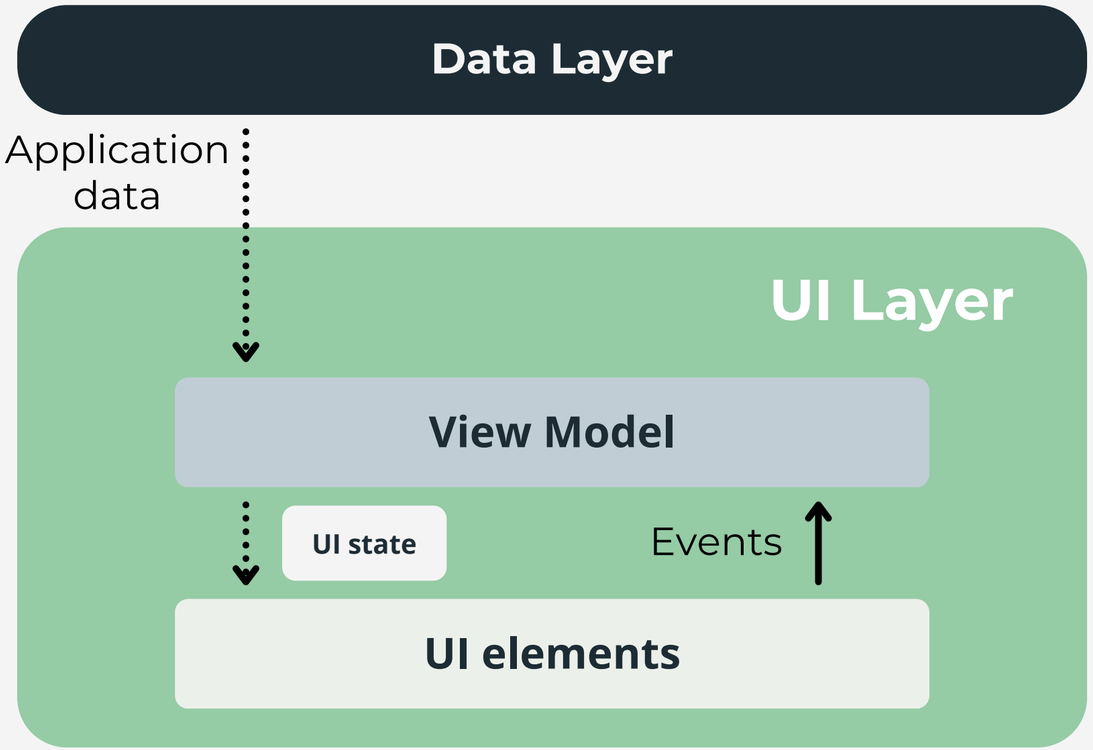
A modern toolkit that provides a declarative approach to generate UI interfaces.

Modular approach

It promotes a more organized, maintainable, and scalable codebase.

Google Maps integration

Heatmap is provided through an inflated view which exploits a Google Maps API.

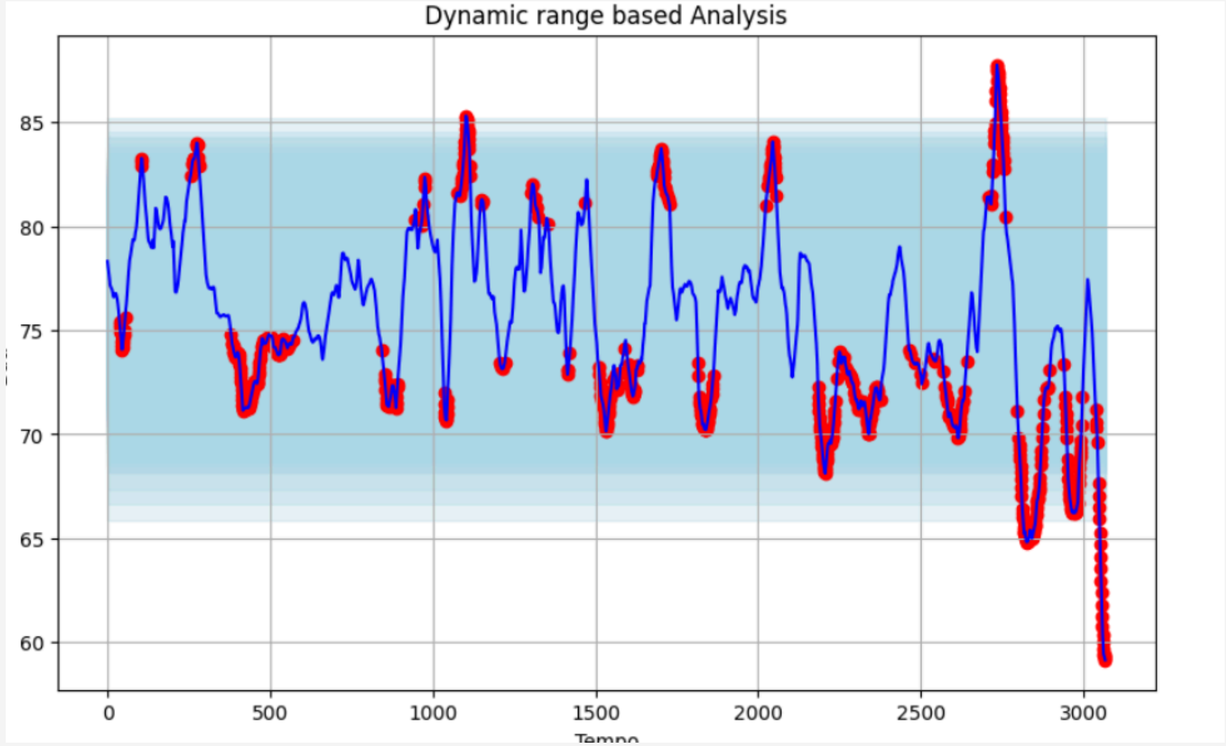


Algorithms

The core logic for stress detection and classification

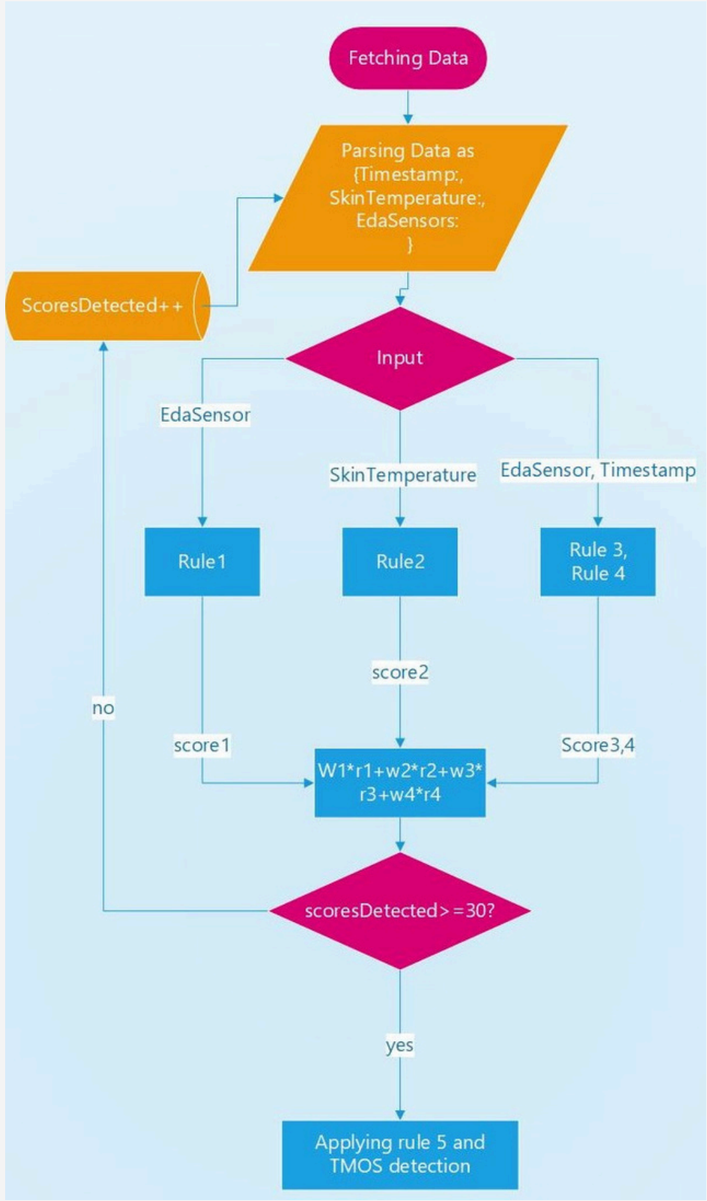
Range-based algorithm

- Bayesian Approach using Gibbs sampling
- sampling to dermine a heart rate range
- the hyperparameters obtained using the paper database



Rule-based algorithm

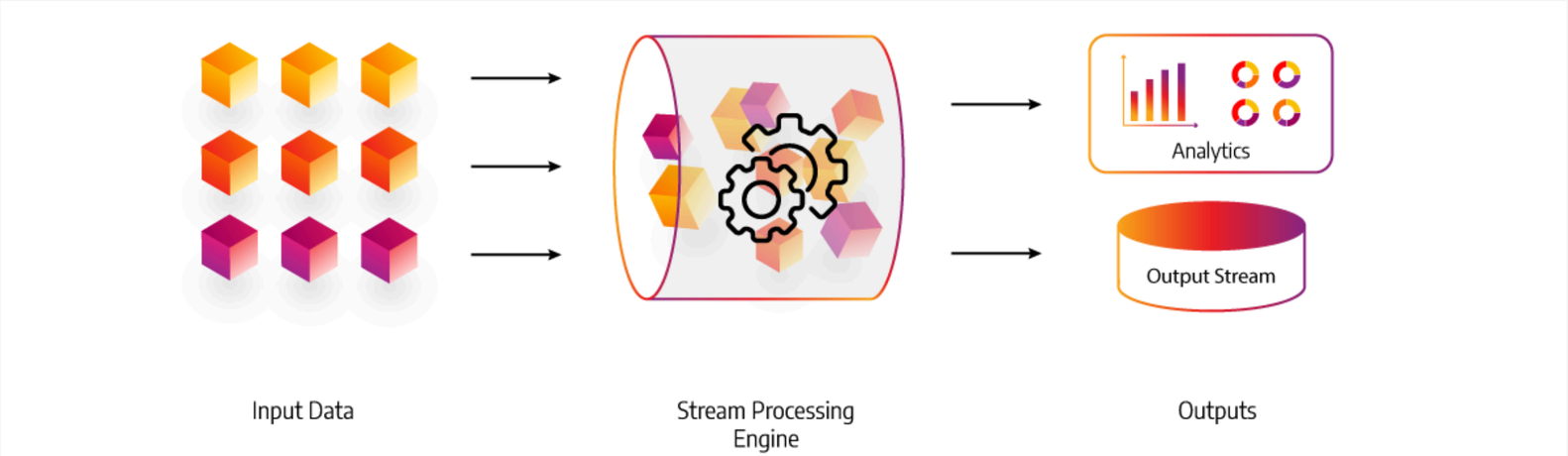
- Calculation: Uses EdaSensor and SkinTemperature data with five rules over 30 samples.
- Accuracy: Achieves 70% accuracy and 85% sensitivity.
- Storage: Sends stress scores to Firestore for analysis.



Data manipulation

Problem:

The two algorithms was implemented for a laboratory dataset, while the host server must obtain Derived Data from a data stream of 30 samplings every time

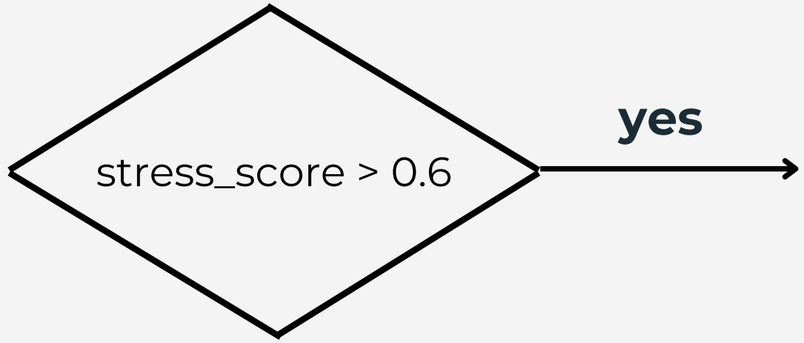


Adaptation:

- The range algorithm was made more flexible, initially training on the first 120 samples and then updating with a moving window of initial and new raw data.
- The rule-based algorithm required 30 additional samples, so we adapted it in the Data Manipulation module by adding a delay and using previous raw data for current derived data

Heatmap Generation

DerivedData object



MoS

moment of stress

Heatmap Generation

realtime

Last Hour Data

hourly routine

firestore

Persistent Data

Test phase

How the app performs at work in an unconstrained environment

Preparation

Devices

- Handheld device: Redmi Note 8 Pro
- Wearable device: Google Pixel Watch 2

TASK

Use the application while traveling in the urban contexts of Pisa and Livorno, both by car and on foot.

IMPRESSION

The user then described his trip, underlining the stress levels perceived during the activities done.

EVALUATION

Qualitative considerations.

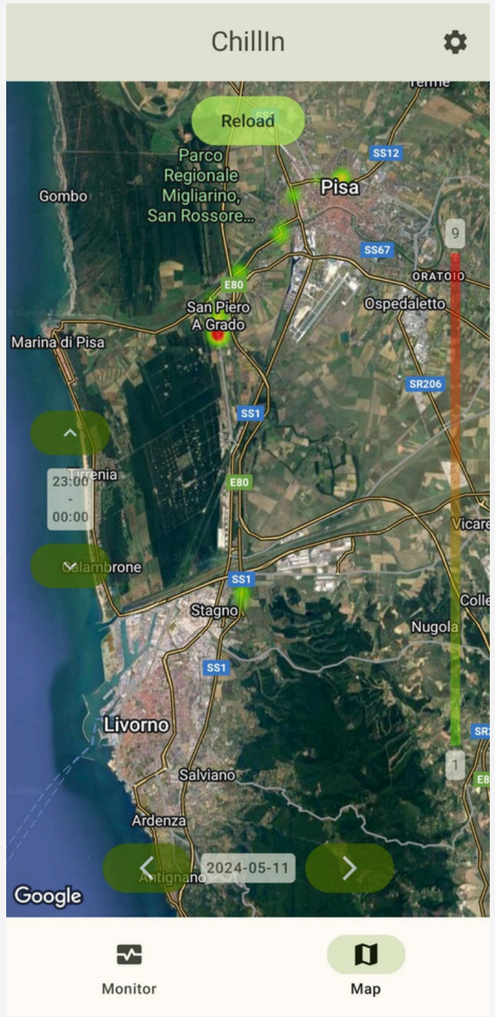
Results

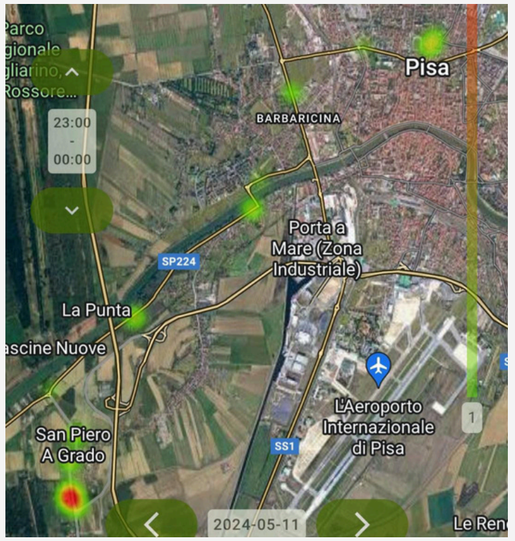
Power consumption

- Detection and fixing of some bugs that caused a rapid decrease in the battery level in the wearable device.
- Decreasing in battery power from 92% to 76% between 12:45 and 15:30

Stress detection

Detection of some stress hotspots during both types of travel, some of which overlapped the user declarations at the end of the task.





Conclusion

Potential applications and possible improvements to reach better app’s quality

Real-time monitoring of user stress level

Understandind user stress triggers

Stress data correlation with geographical location

Sheds lights on stress hotspots within cities

Main features

Public Health

Urban Planning

Community development

Employers wellness

Health self-awareness

Research

Application fields

POWER CONSUMPTION

Caching data sent from the smartphone to the database.

GRACEFUL DEGRADATION

Tolerance to sensor availability, user permissions and internet connectivity issues.

NEW FUNCTIONALITIES

Coldspots tracking for a better evaluation of stress points and a user-dedicated heatmap.

MALICIOUS USER TOLERANCE

Avoid improper data generation, and so issues in heatmap generation.

ALGORITHM ACCURACY

Trying to test new algorithms using different datasets.

INTEROPERABILITY

Currently, data layer implemented limits the availability to Wear OS.

GDPR COMPLIANT

Manage the sensitive data, such as location, according to privacy policy.

References

Kyriakou, K.; Resch, B.; Sagl, G.; Petutschnig, A.; Werner, C.; Niederseer, D.; Liedlgruber, M.; Wilhelm, F.H.; Osborne, T.; Pykett, J. **“Detecting Moments of Stress from Measurements of Wearable Physiological Sensors”**. Sensors 2019, 19, 3805. https://doi.org/10.3390/s1917380

Iqbal, T.; Simpkin, A.J.; Roshan, D.; Glynn, N.; Killilea, J.; Walsh, J.; Molloy, G.; Ganly, S.; Ryman, H.; Coen, E.; et al. **“Stress Monitoring Using Wearable Sensors: A Pilot Study and Stress-Predict Dataset”**. Sensors 2022, 22, 8135. https://doi.org/10.3390/s22218135

THANK YOU!

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