IDLab
INTERNET & DATA LAB

UNIVERSITEIT GENT

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Harnessing the power of hybrid AI for designing spatiotemporal behavioral markers for health and their dynamic visualization

Sofie Van Hoecke


Intermittent, subjective self-reporting

Universitair Ziekenhuis Gent

Dienst Neurologie (Dir. Prof. Dr. P. Boon)
Hoofdpijnraadpleging (Prof. Dr. K. Paemeleire)

NAAM: **JAAR:**

DAG

2017 MAAND	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
SEPTEMBER	M 9 X						M 8 X												M 10 X						M 4 X			M 8 X			
HPScore																															
Behandeling																															
OKTOBER			H 9 X	H 8 X				M 10 X	M 9 X			M 9 X						M 8 X					M 10 X								
HPScore																															
Behandeling																															
NOVEMBER						M 8 X	M 9 X		M 8 X					M 8 X		M 8 X				M 8 X	M 8 X		M 8 X				M 6 X		M 7 X	
HPScore																															
Behandeling																															
DECEMBER				M 7 X	M 6 X		M 9 X				M 8 X									M 9 X	M 6 X										
HPScore																															
Behandeling																															
JANUARI							M 6 X			M 7 X		M 7 X			M 9 X			M 9 X				M 8 X	M 7 X			M 8 X			M 6 X	M 8 X
HPScore																															
Behandeling																															
FEBRUARI	M 7 X				M 6 X	M 7 X	H X												M 6 X	M 6 X							M 6 X				
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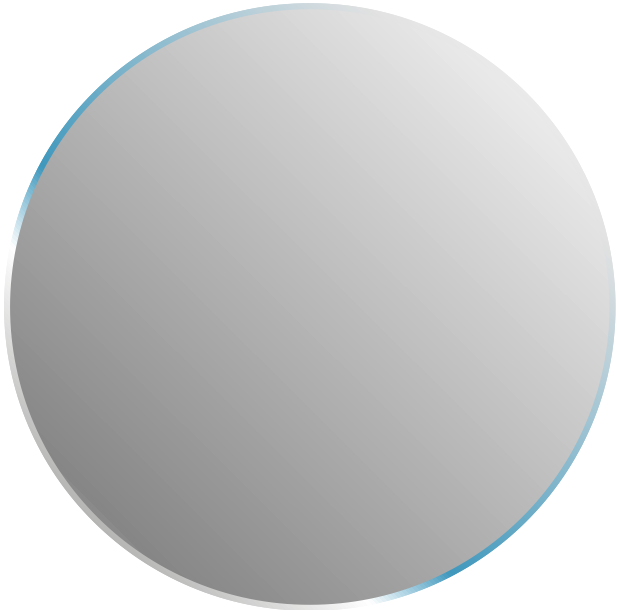
Behandeling																															

We generate data



WEARABLE AND SMARTPHONE SENSORS

Wearable sensors

Empatica E4

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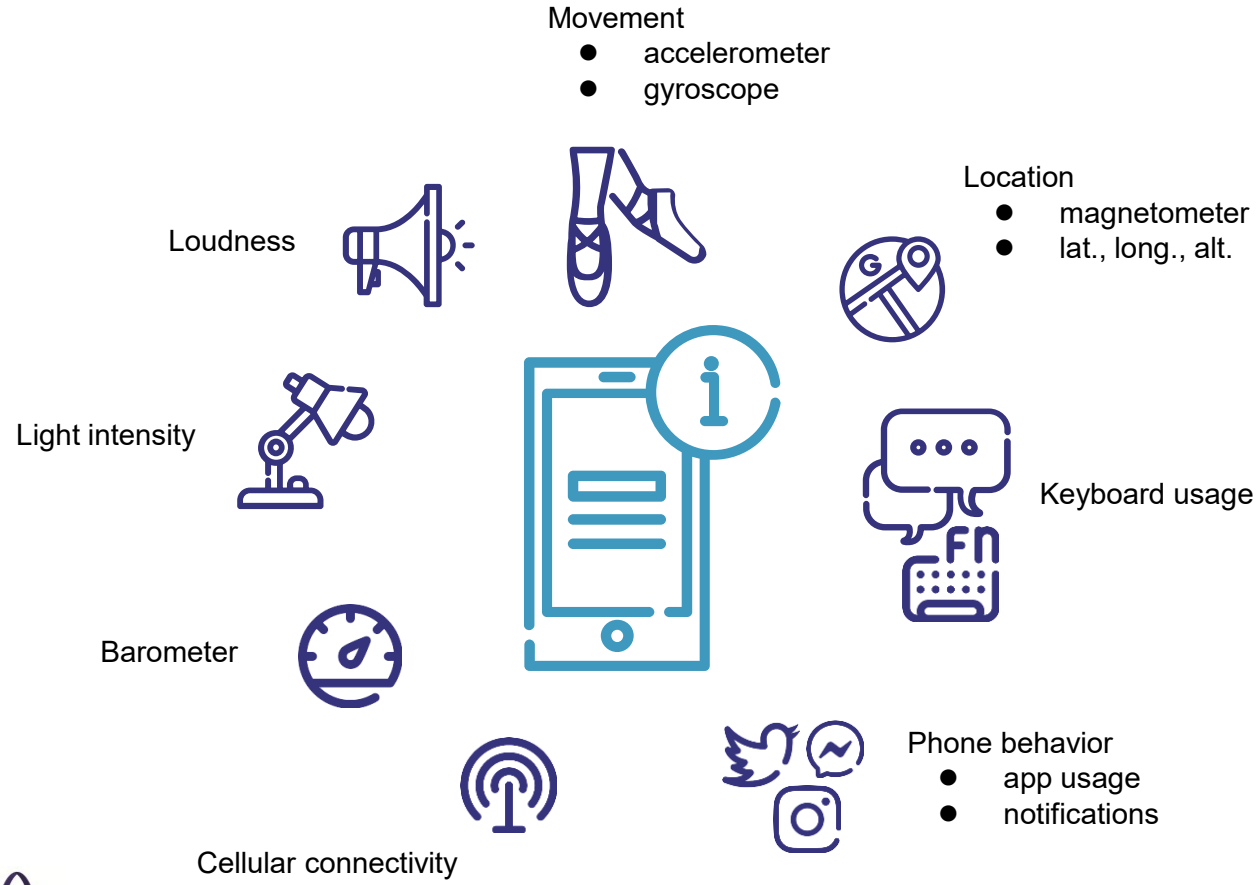
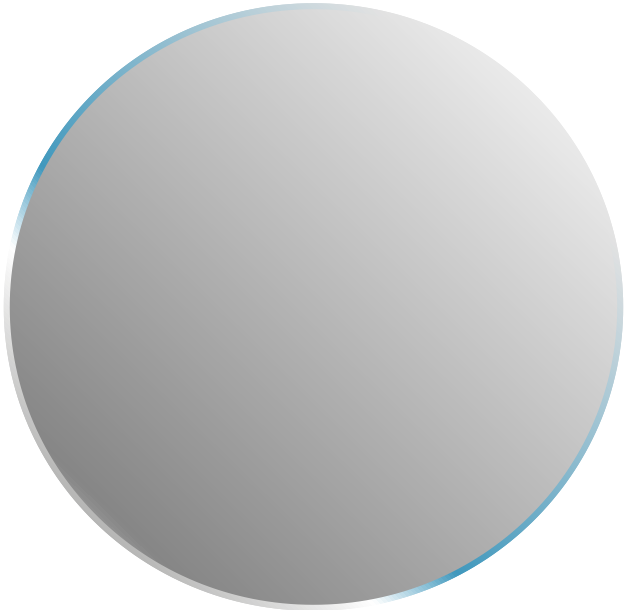
Smartphone (virtual) sensors

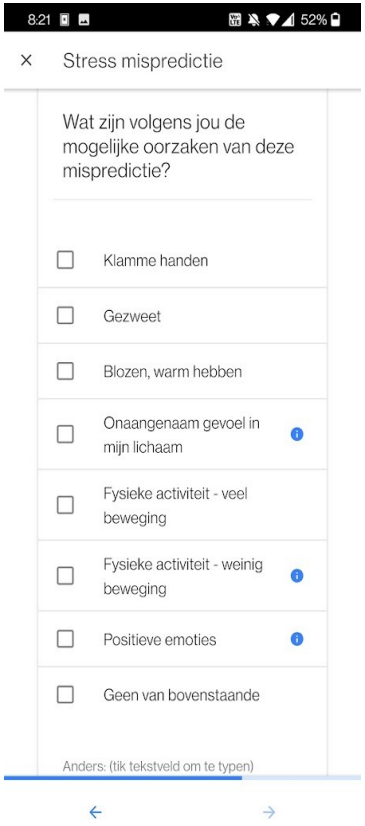


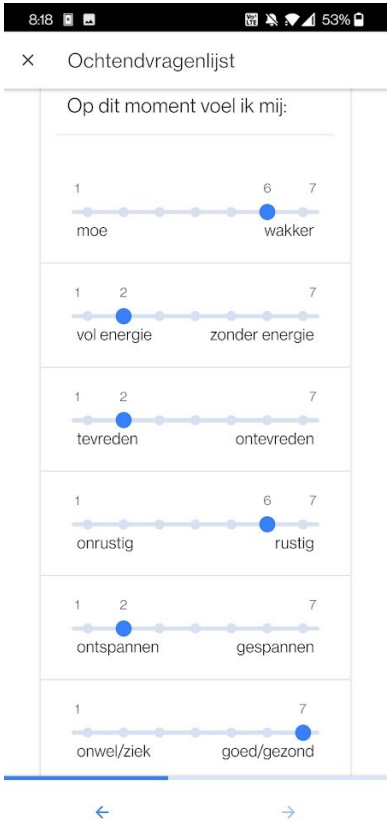
We input data



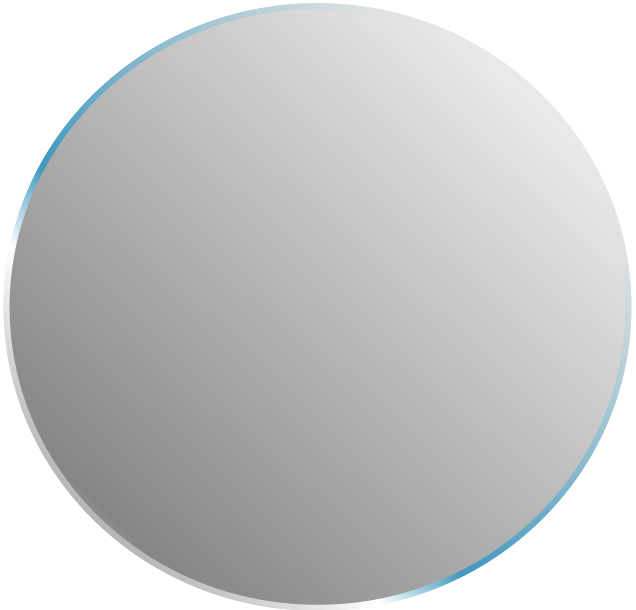
DYNAMIC QUESTIONNAIRES

Dynamic questionnaires



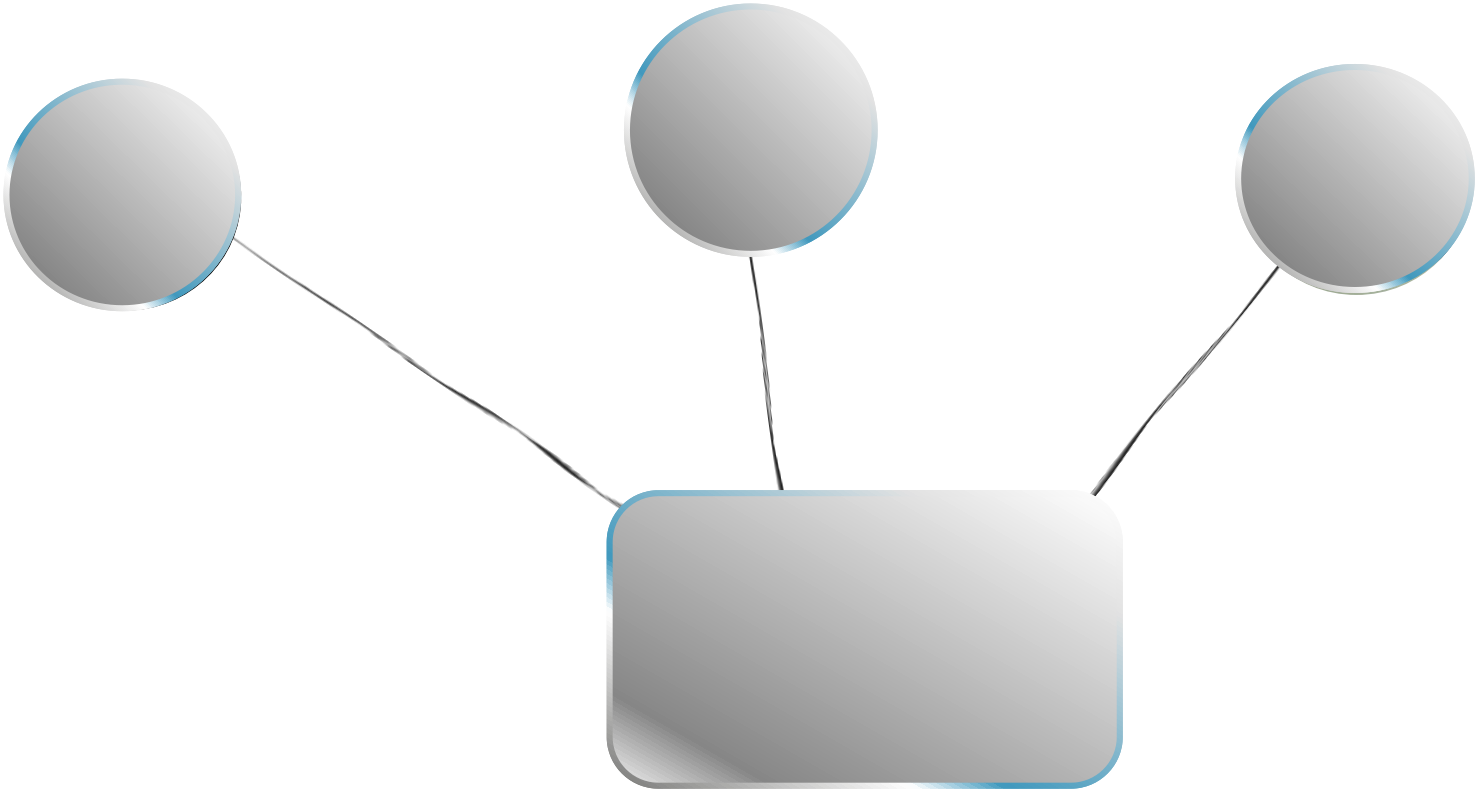


Even if we speak, we generate data



SPEECH

By combining and analysing data, it becomes valuable

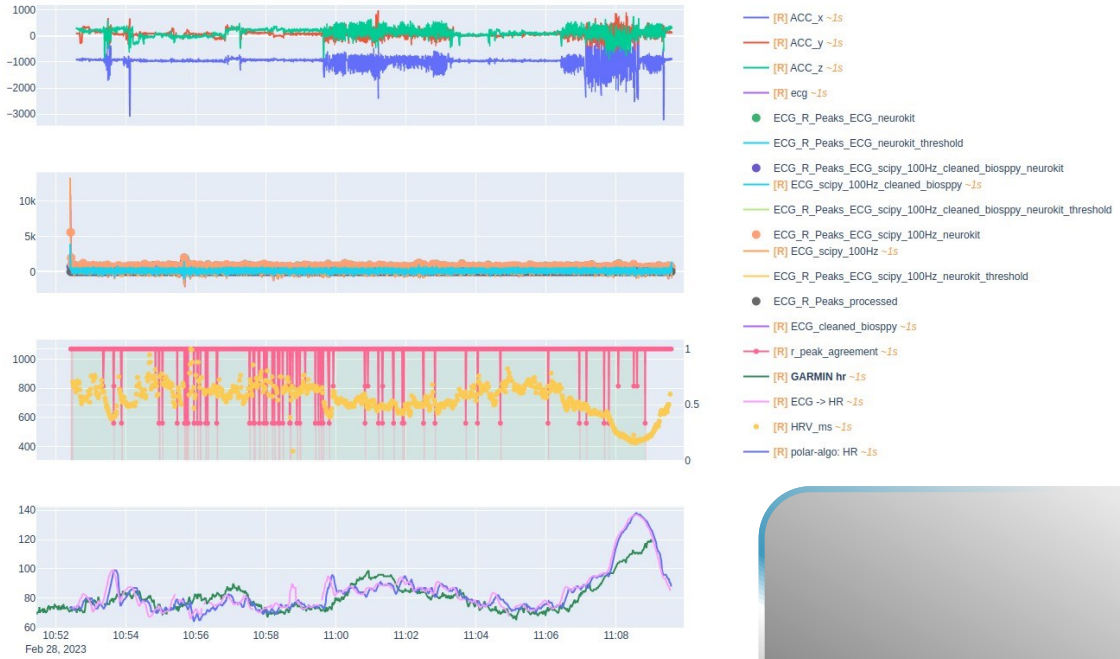


SPATIO-TEMPORAL
BEHAVIORAL MARKERS

By combining and analysing data, it becomes valuable

SPATIO-TEMPORAL BEHAVIORAL MARKERS

By combining and analysing data, it becomes valuable



SPATIO-TEMPORAL BEHAVIORAL MARKERS

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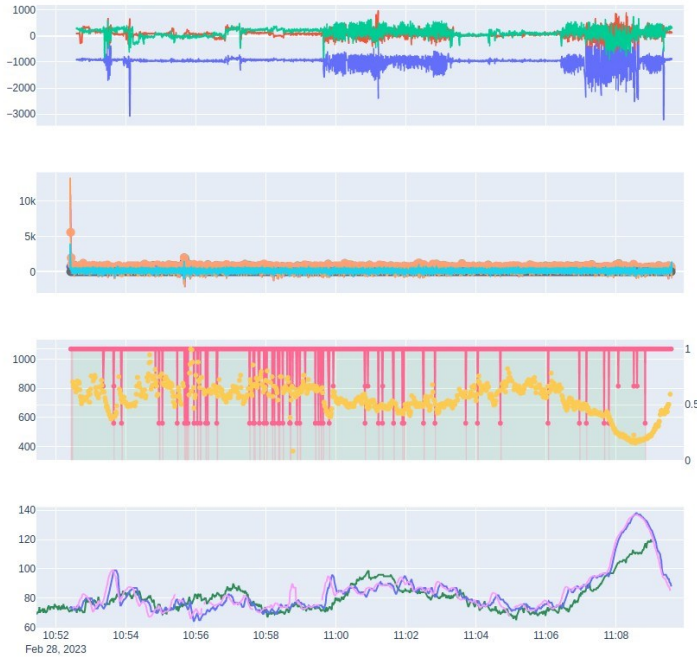
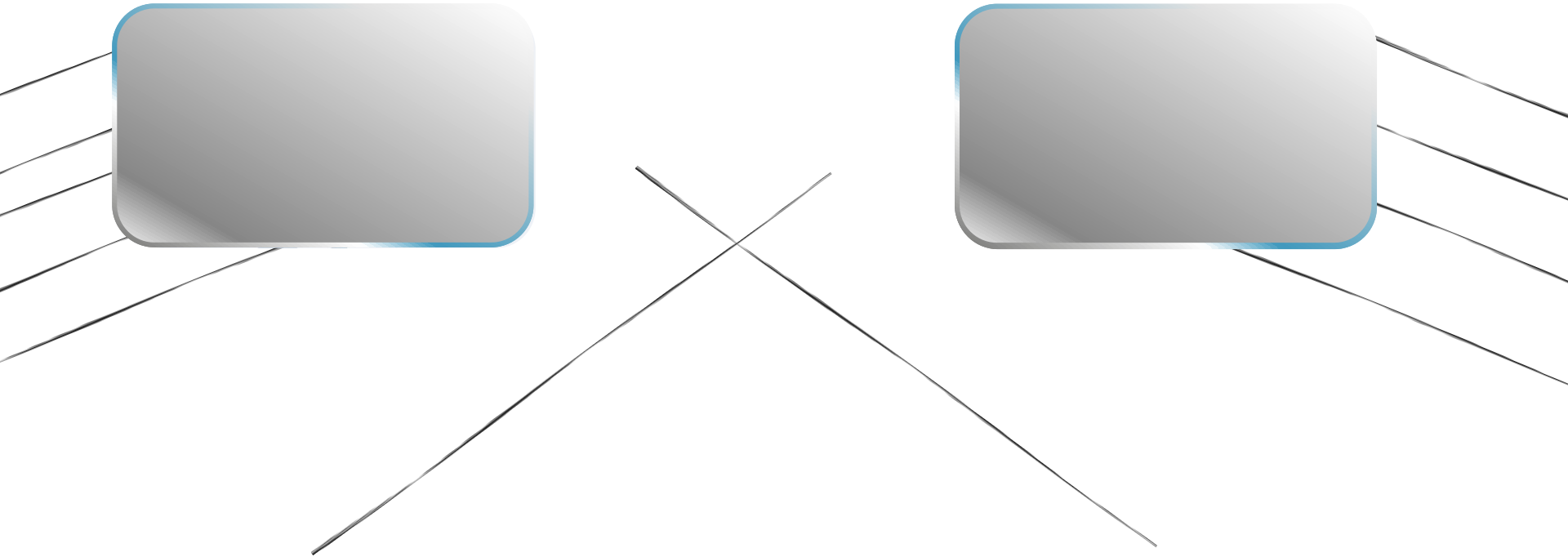
By combining and analysing data, it becomes valuable

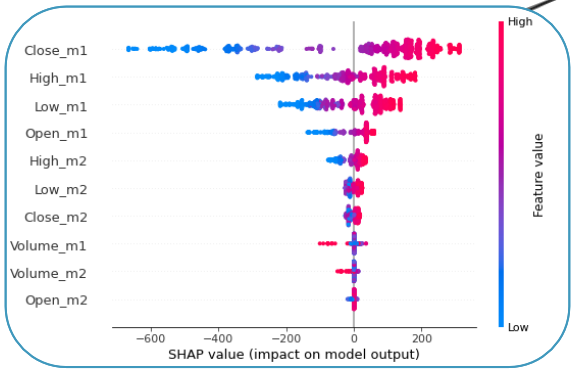


SPATIO-TEMPORAL BEHAVIORAL MARKERS



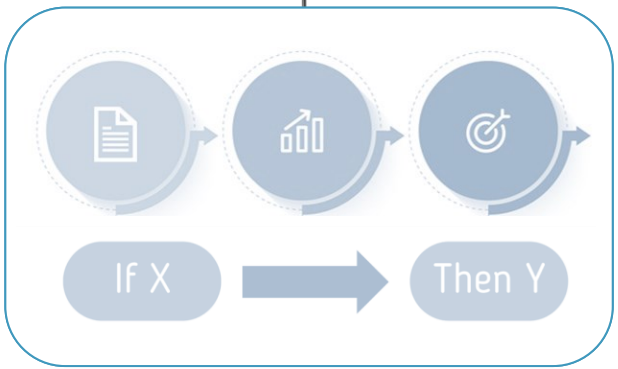
EXPLAINABLE HYBRID AI

MODEL EXPLAINABILITY



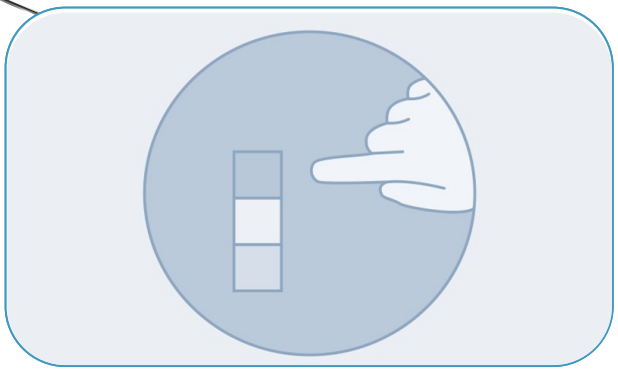
E.g., feature importance

CORRELATION DERIVATION



E.g., migraine triggers

CAUSAL AI



E.g., treatment effect

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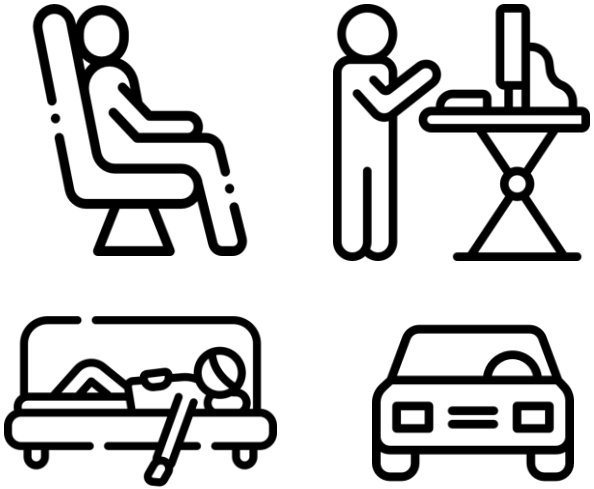
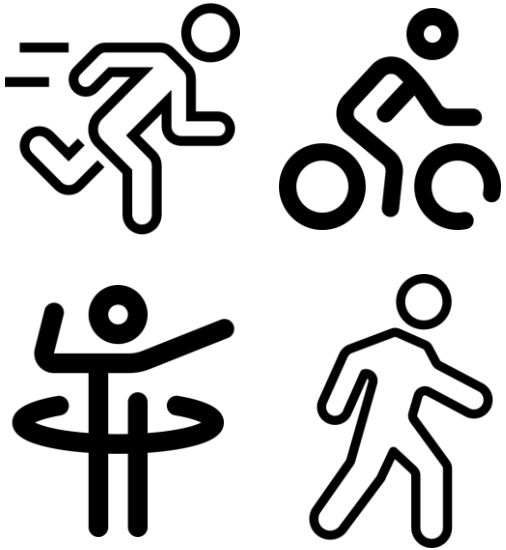
Activity recognition

Sedentary



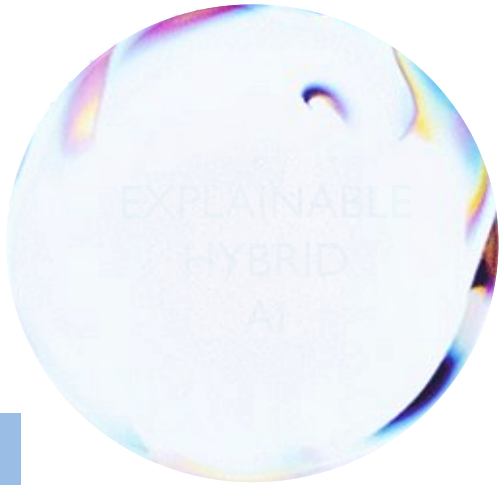
Dynamic



Extra context info:

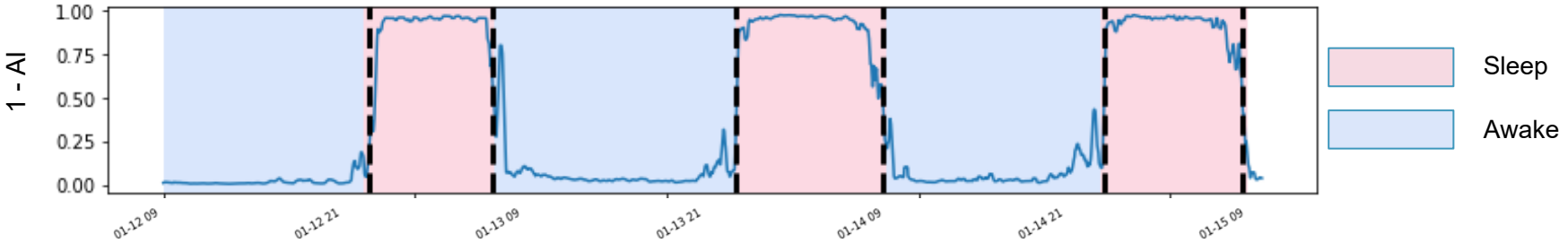
- location & route
- speed & cadence

Sleep detection



Google sleep API

Activity index (AI) + segmentation



Stress detection

Added value of context

Model	Accuracy (std)	Cohen Kappa (std)	Weighted F1 (std)	Compared to Dummy (std)
Baseline (Physio)	40.57 (3.48)	7.80 (1.98)	42.11 (3.08)	6.31 (2.53)
Baseline + Activity	43.09 (0.67)	9.75 (0.09)	44.47 (0.44)	8.68 (0.11)
Baseline + Sleep	42.47 (0.72)	9.51 (0.12)	43.88 (0.59)	8.09 (0.03)
Baseline + Activity + Sleep	**45.52 (2.58)**	**11.19 (1.58)**	**46.03 (2.12)**	**10.23 (2.68)**

Incorporating activity, sleep or both into baseline model improves stress level classification (accuracy increase, but also std dev decrease)

Incorporating both = best model

→ **context matters**

→ **currently further extending towards spatiotemporal context**

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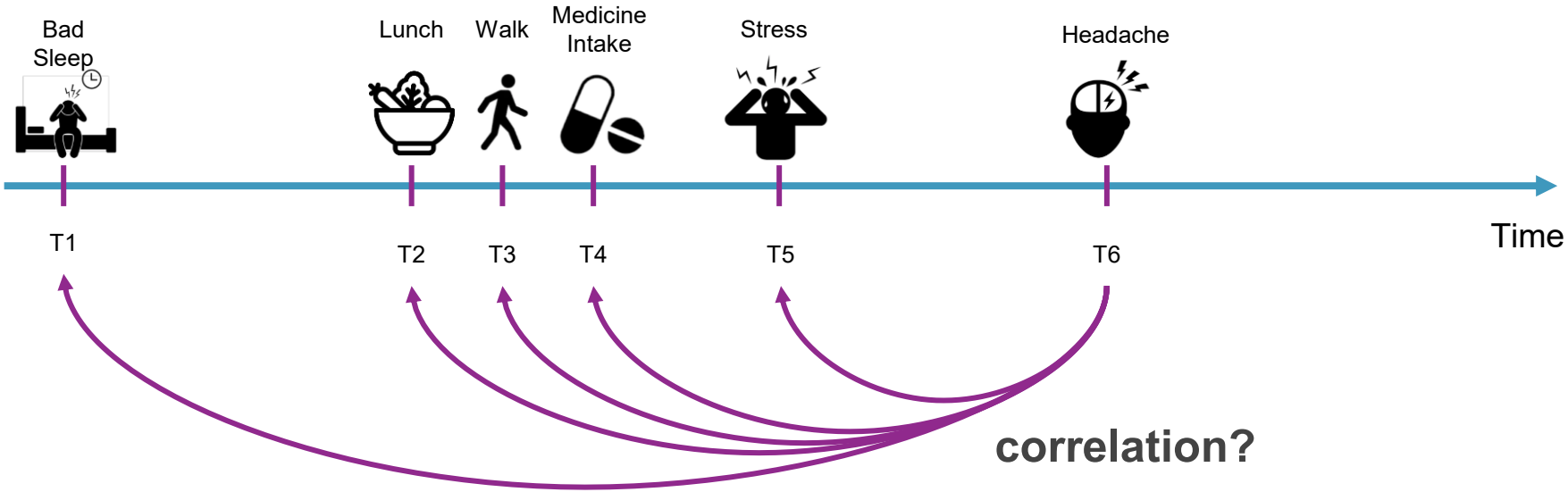
Trigger detection

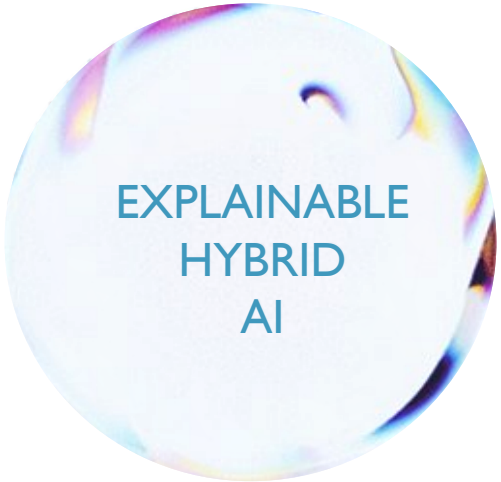
Finding correlations between a headache and previous events



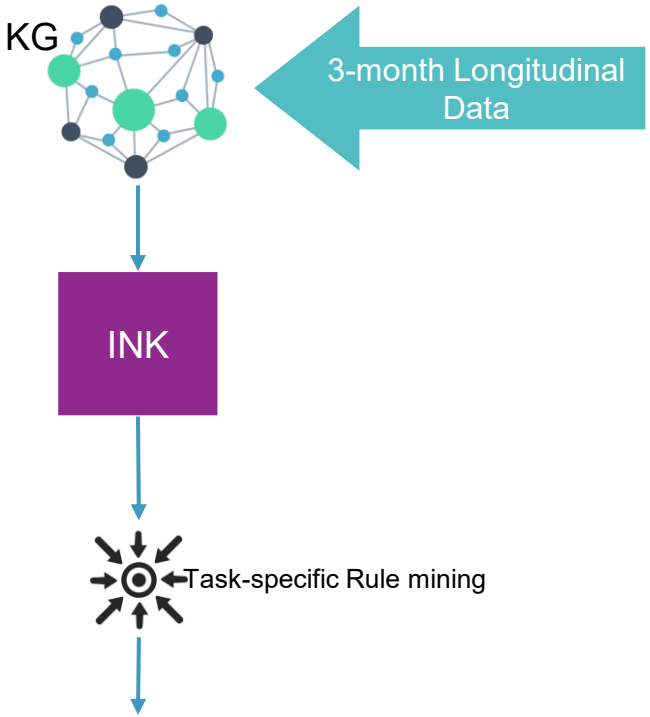
Trigger detection

Time-based Apriori via ML rule mining

Trigger	Proportion
Bad sleep	0.61
Medication	0.61
Current menstruation	0.50
Abnormal sleeping	0.39
Abnormal low stress	0.28
Commuting	0.28
Abnormal high stress	0.22



Semantic rule mining



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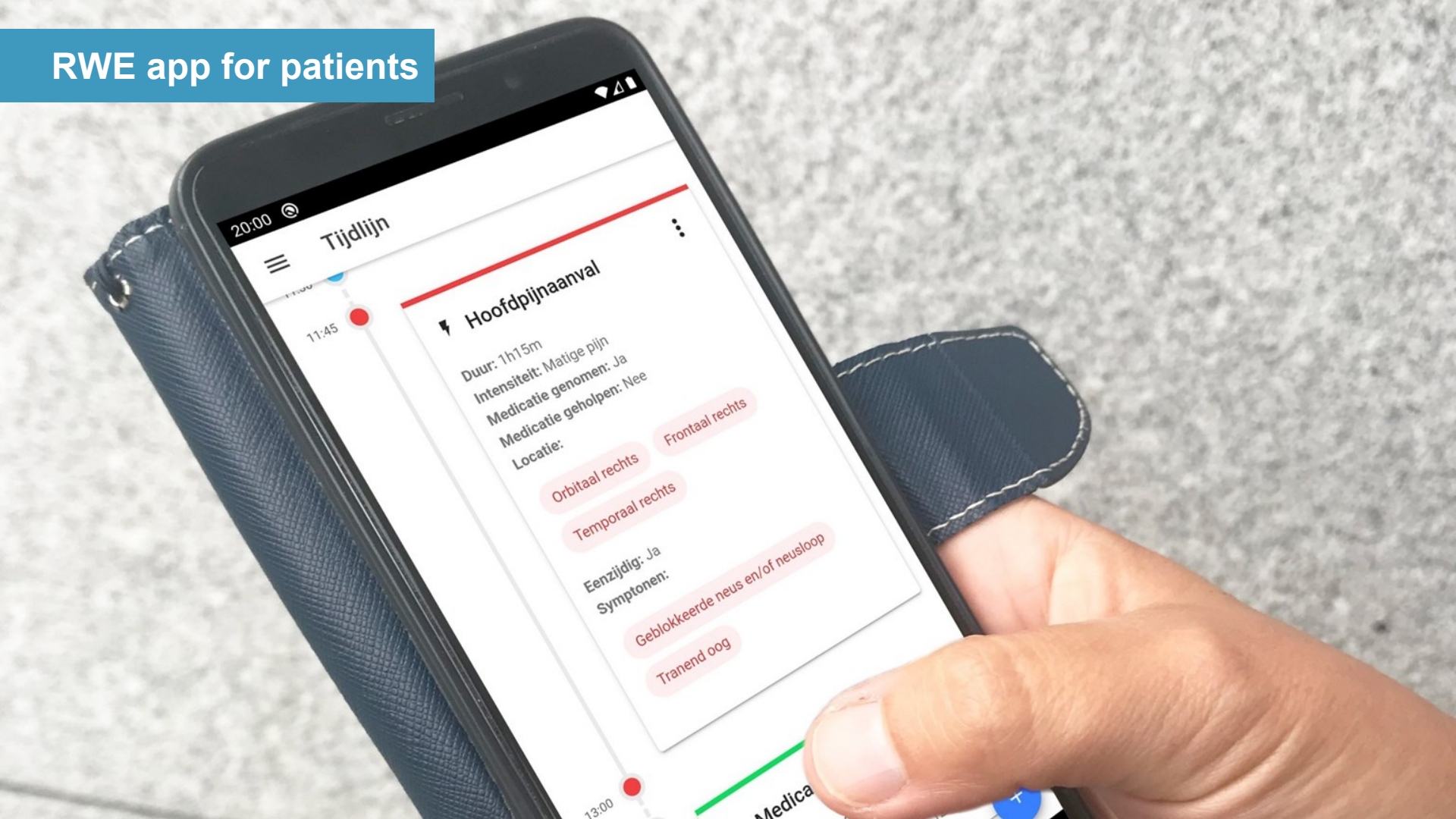
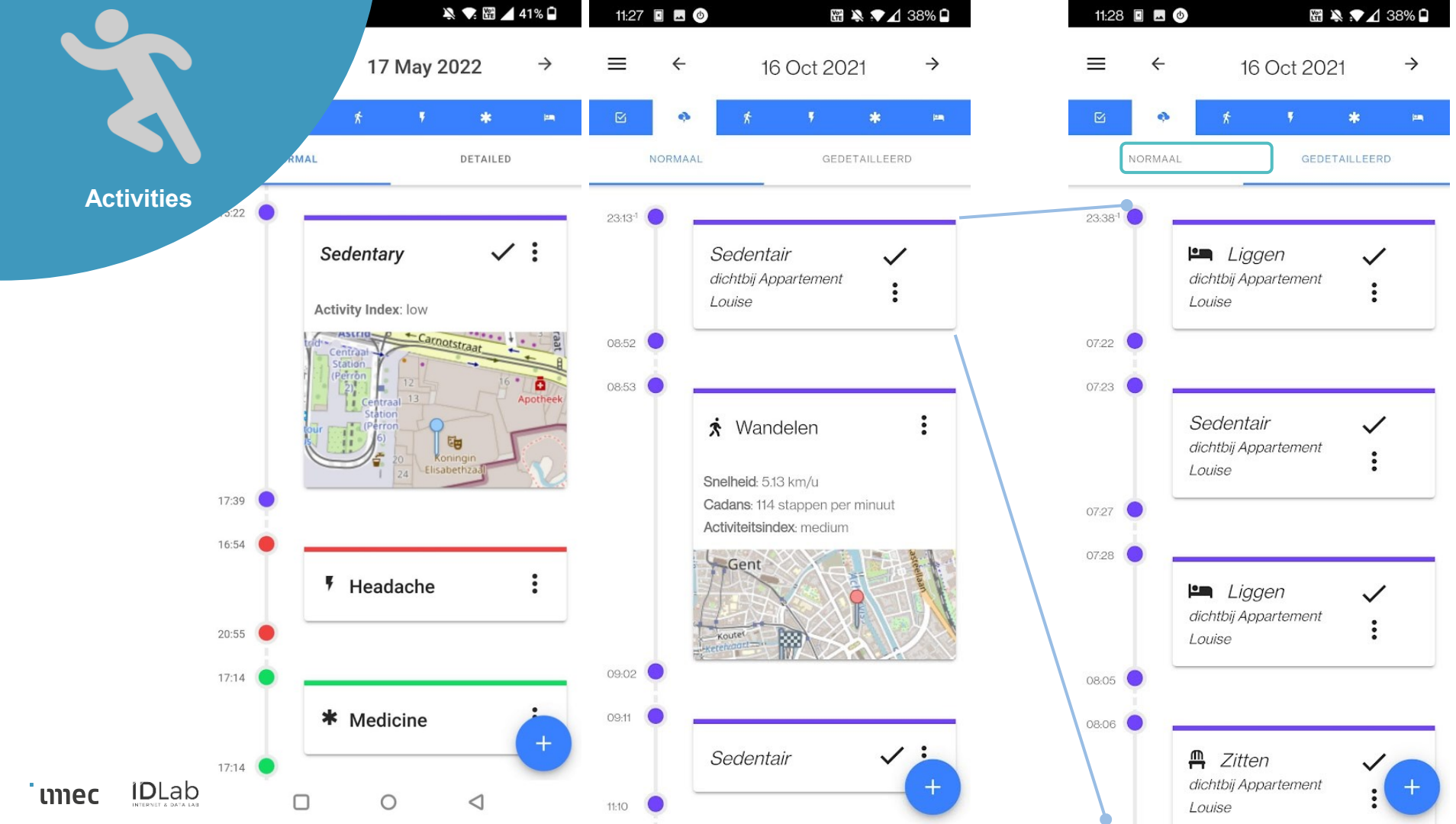
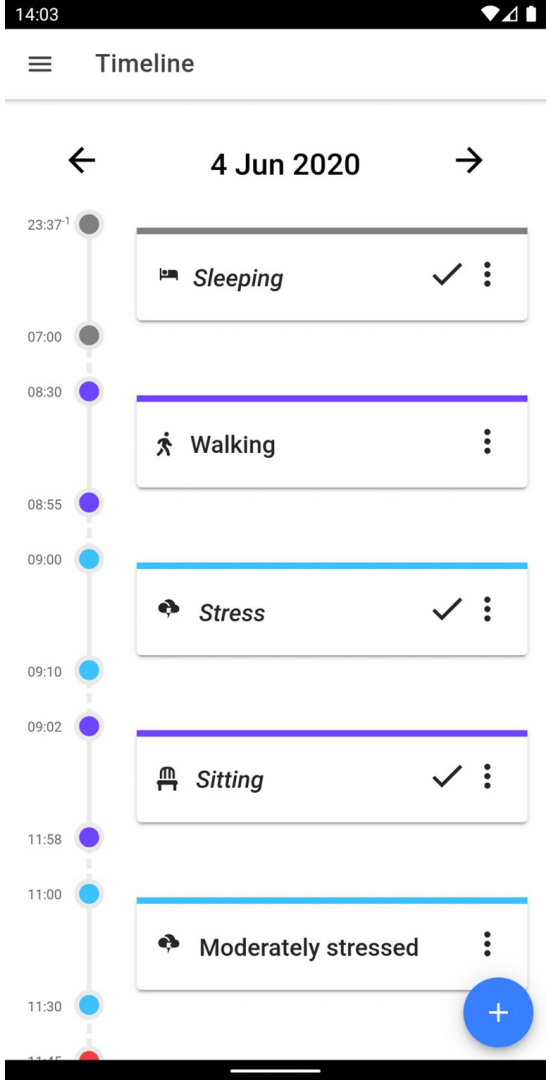
RWE app for patients

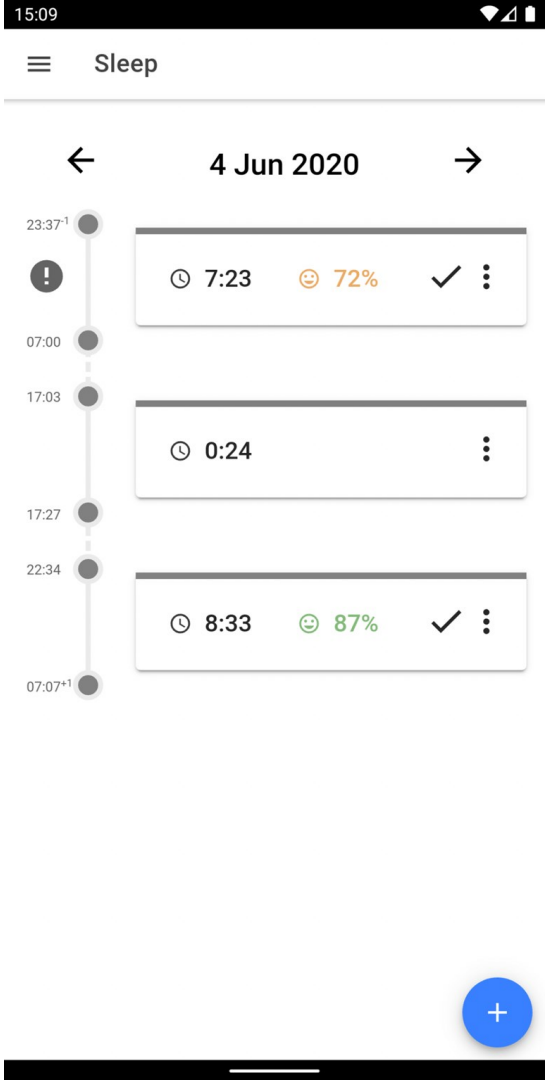


Activities


17 May 2022
RMAL
DETAILED
Sedentary
Activity Index: low
Carnotstraat
Centraal Station (Perron 21)
Centraal Station (Perron 6)
Apotheek
Koningin Elisabethzaal
17:39
16:54
Headache
20:55
17:14
Medicine
17:14
16 Oct 2021
NORMAAL
GEDETAILLEERD
23:13
Sedentair
dichtbij Appartement Louise
08:52
08:53
Wandelen
Snelheid: 5.13 km/u
Cadans: 114 stappen per minuut
Activiteitsindex: medium
Gent
09:02
09:11
Sedentair
11:10
16 Oct 2021
NORMAAL
GEDETAILLEERD
23:38
Liggen
dichtbij Appartement Louise
07:22
07:23
Sedentair
dichtbij Appartement Louise
07:27
07:28
Liggen
dichtbij Appartement Louise
08:05
08:06
Zitten
dichtbij Appartement Louise

Sleep





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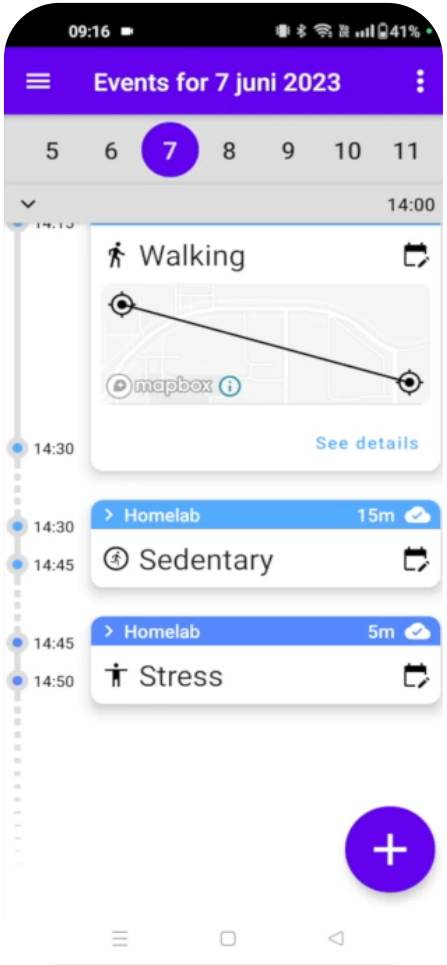
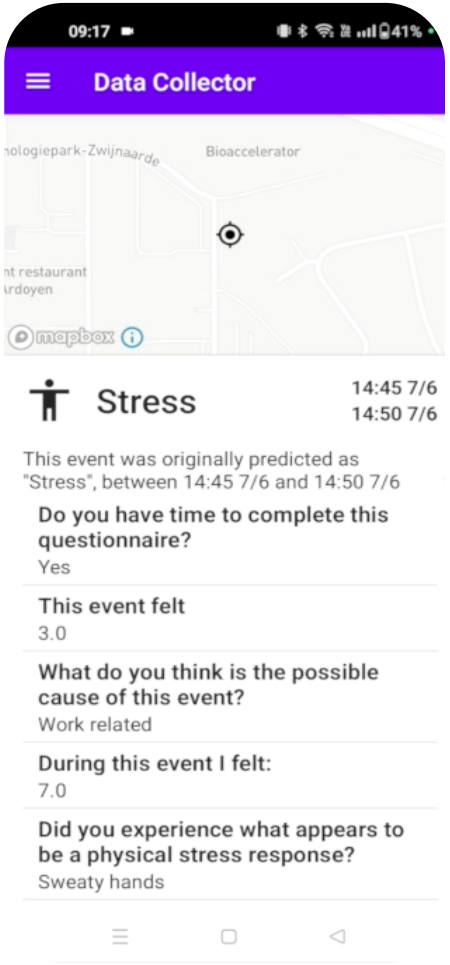
Stress





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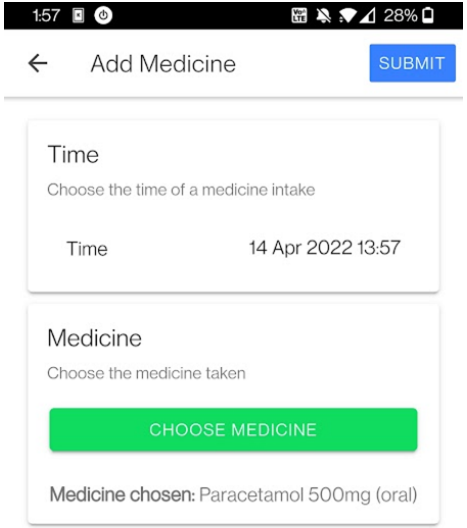
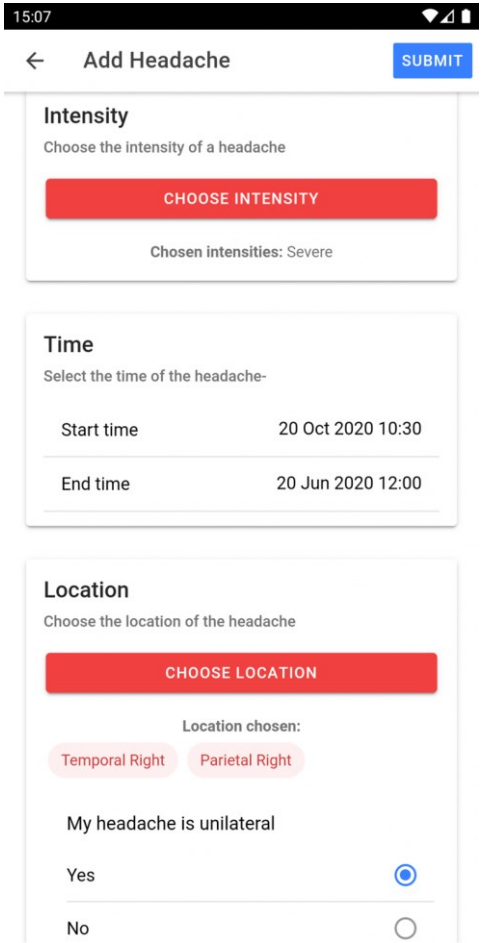
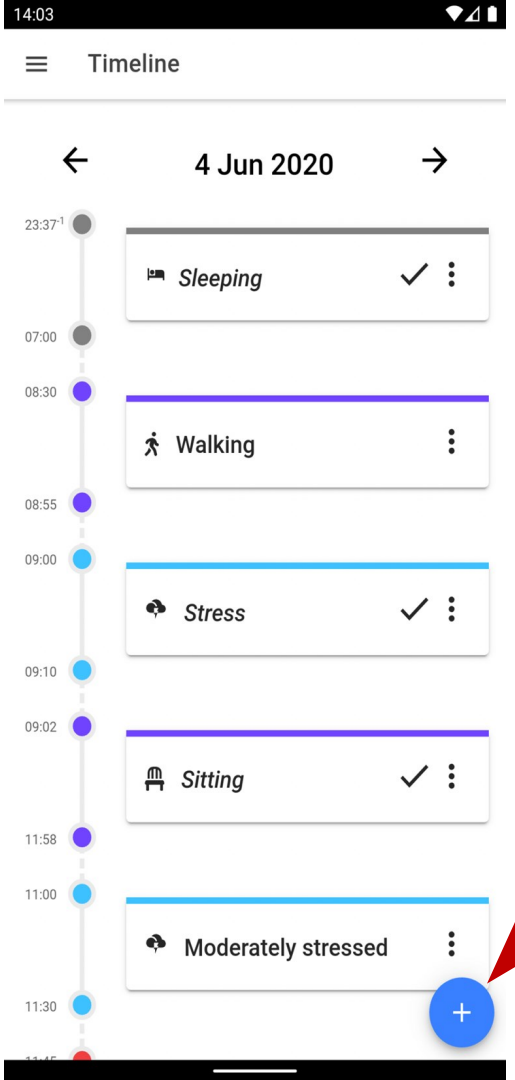
User can add (and label) events







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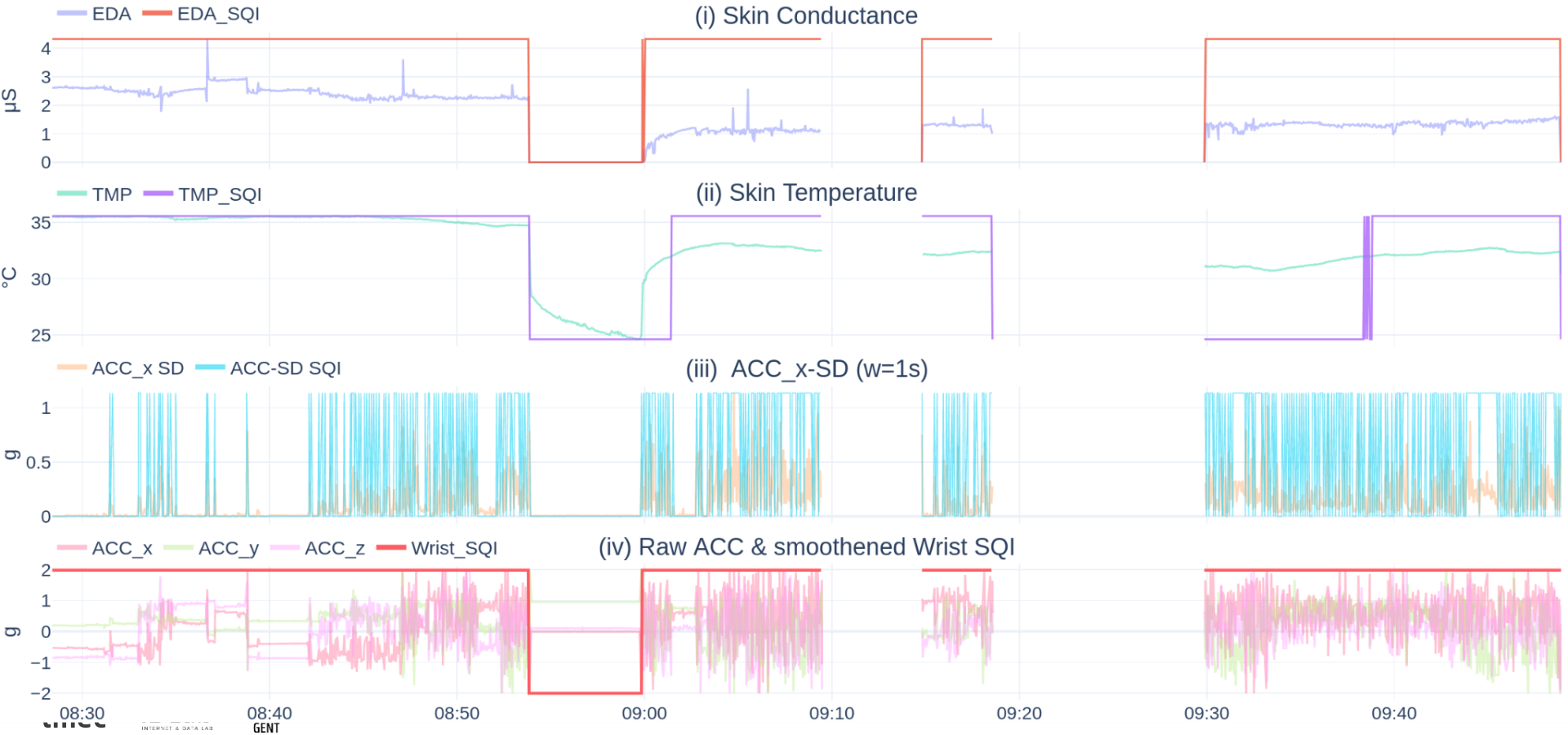
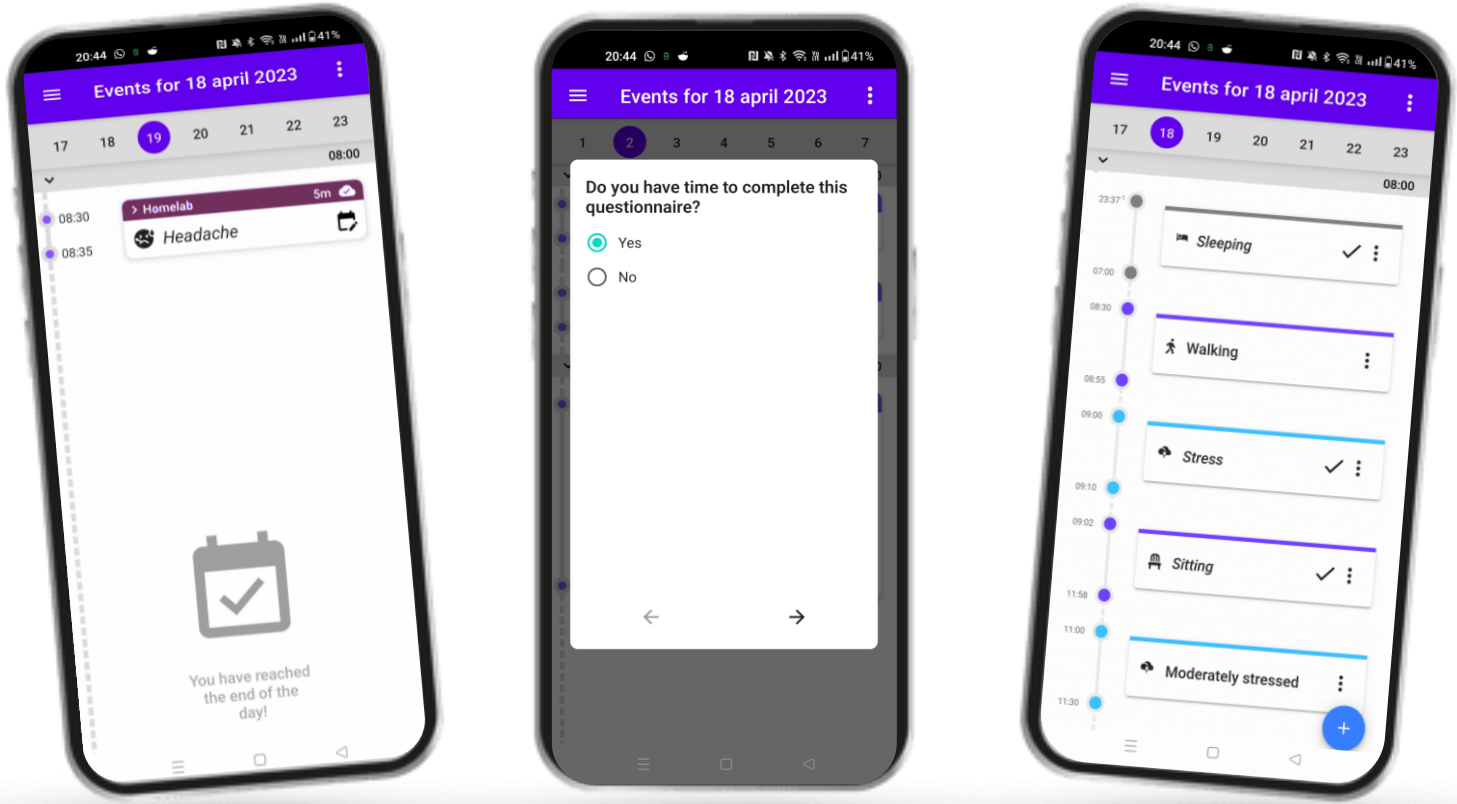
In-house designed labeling dashboard

Automatically detecting wearable non-wear

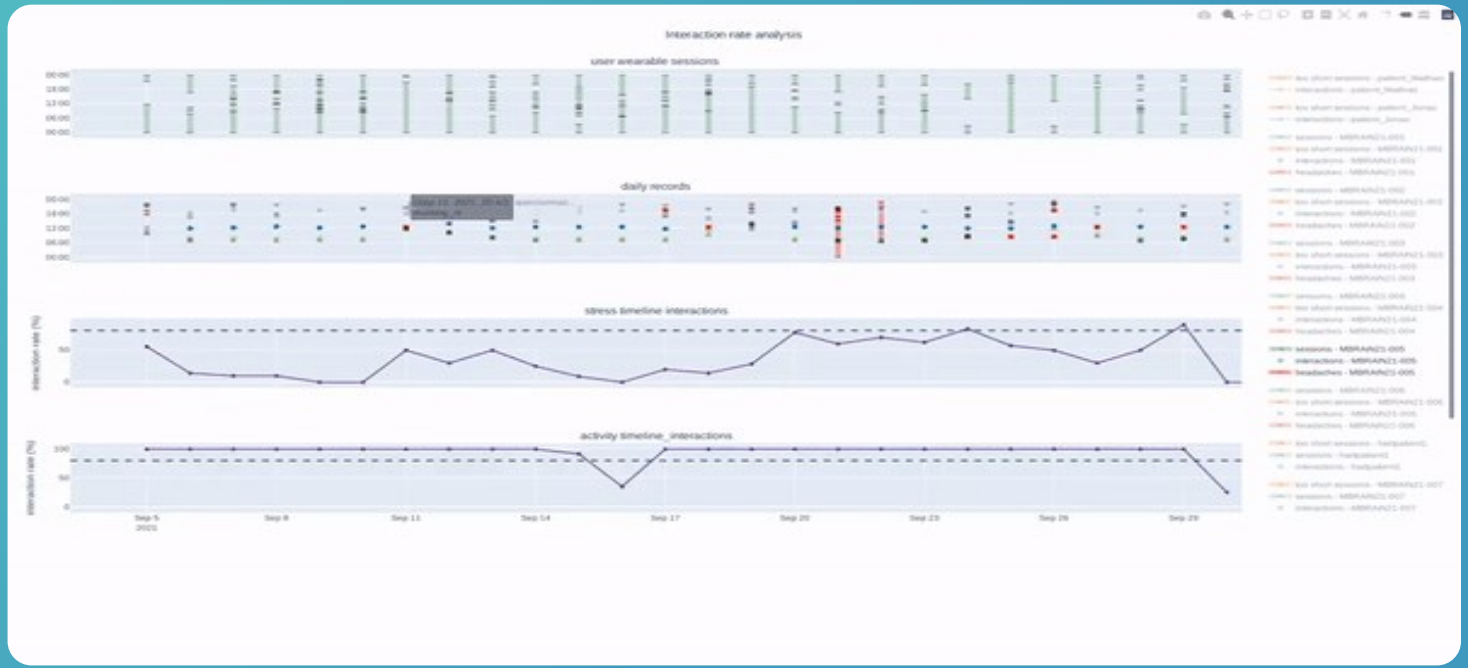


RWE app for patients



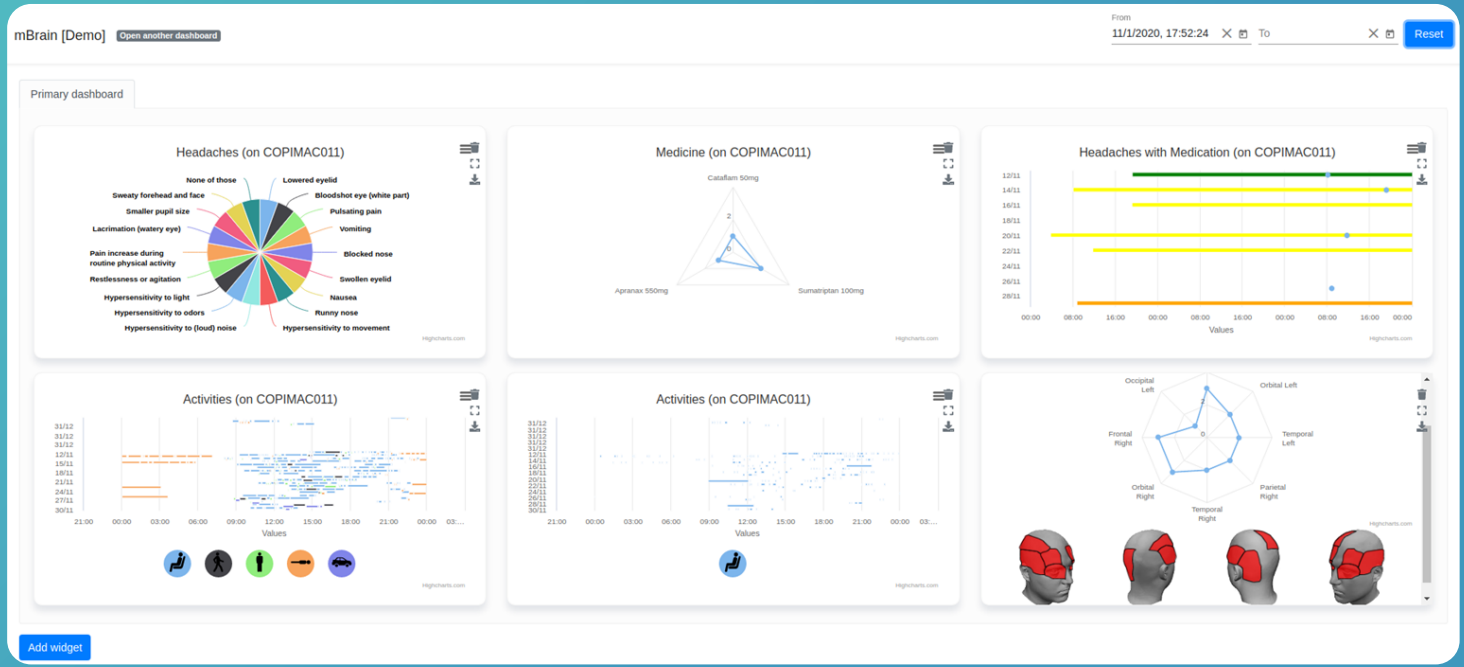
RWE dashboard for clinicians

DYNAMIC CLINICIAN DASHBOARDS



RWE dashboard for clinicians

DYNAMIC CLINICIAN DASHBOARDS



Semantic description of sensors and services

Semantically describing all (virtual) sensors

Body Sensors

- Smartwatch
  - GPS
  - Heart Rate
  - …
- Body Temperature
- GlucoMeter
- …

Environment Sensors

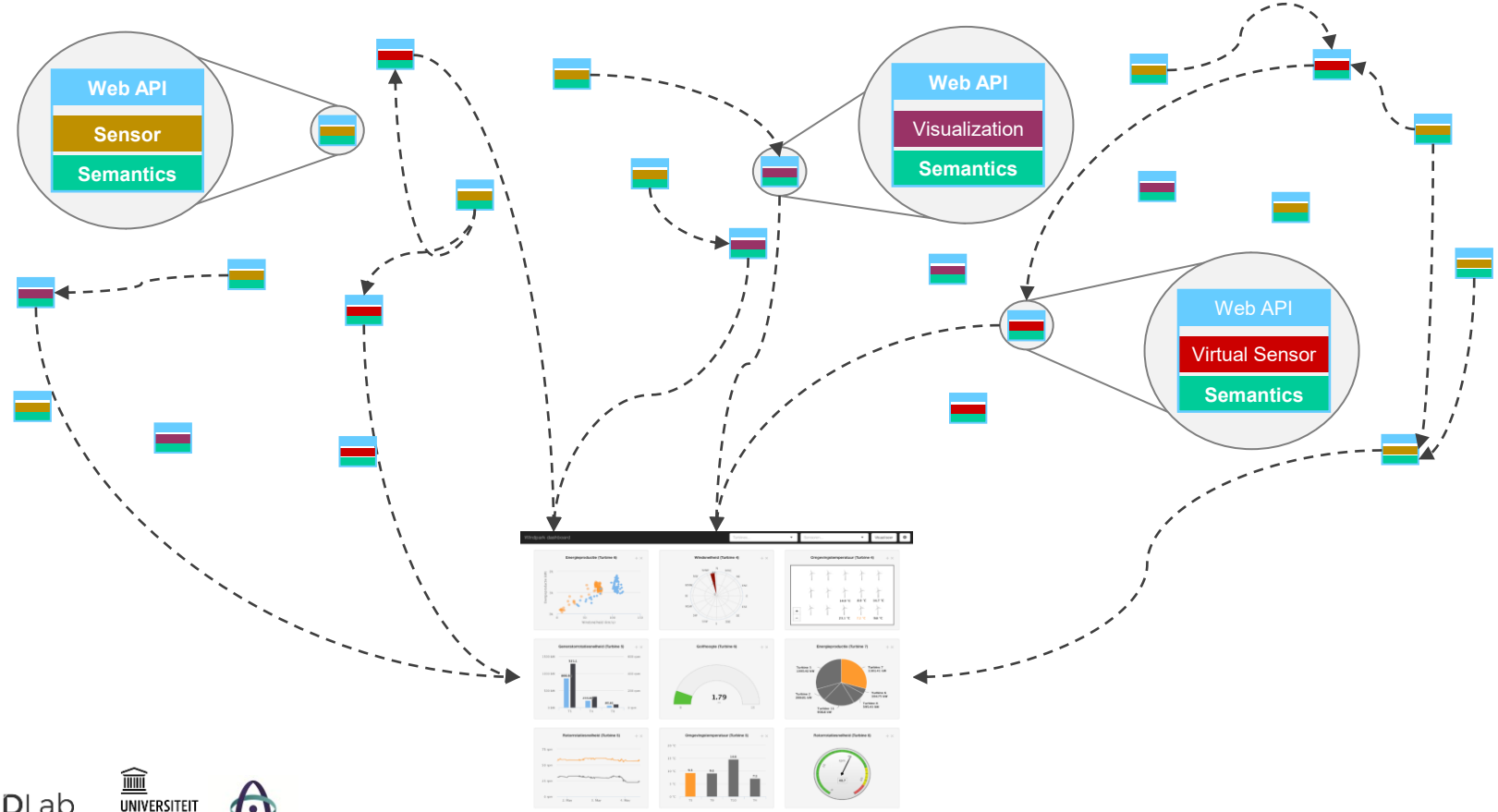
- Presence Detection
- Temperature Sensors
- CO2 Sensors
- …

Virtual Sensors

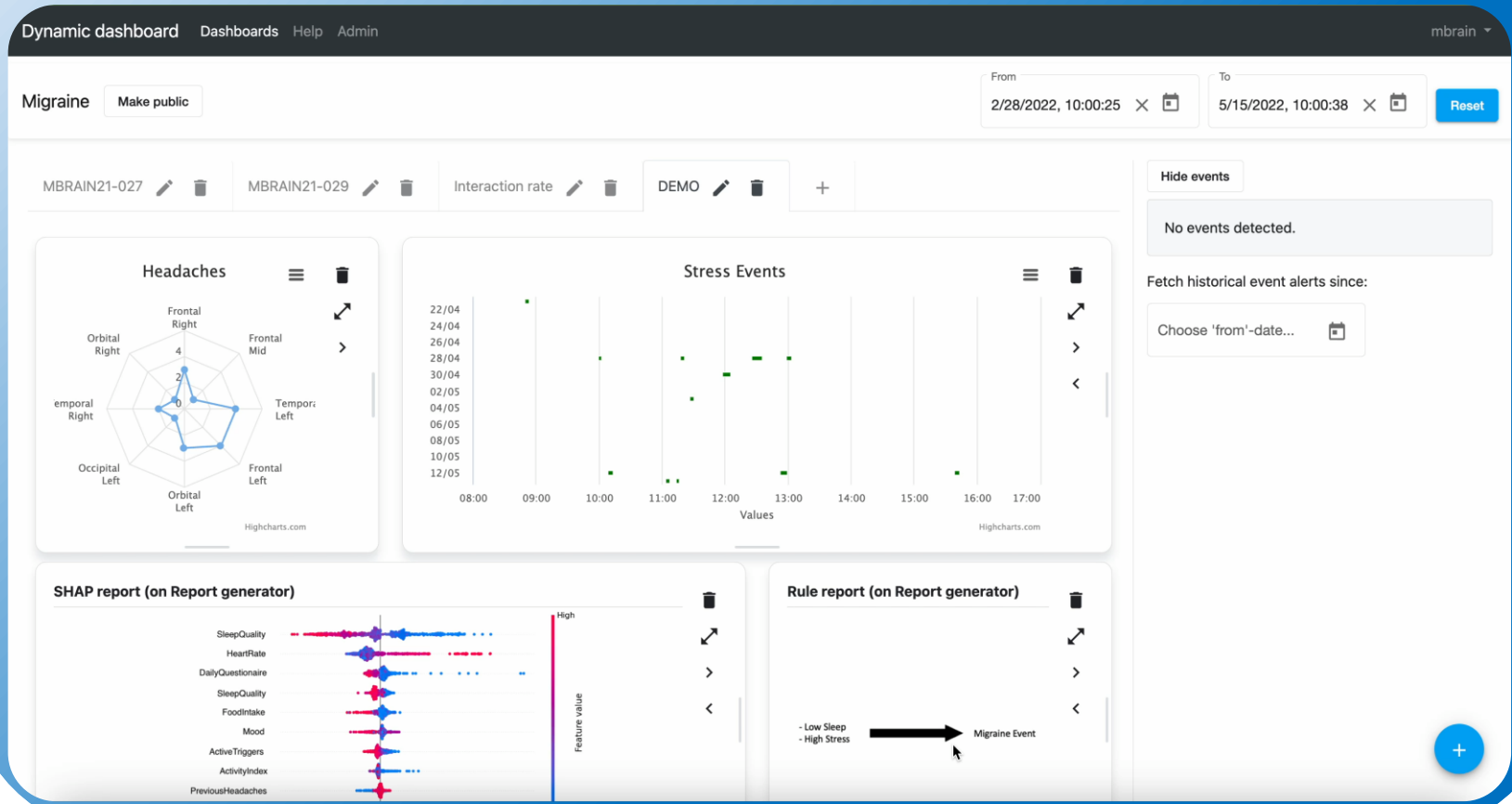
- Human Labeling
  - Migraine Attacks
- Stress Detection
- Activity Recognition
- Sleep Detection
- …

And similar for all visualization widgets…

Semantic description of sensors and services



DYNAMIC CLINICIAN DASHBOARDS



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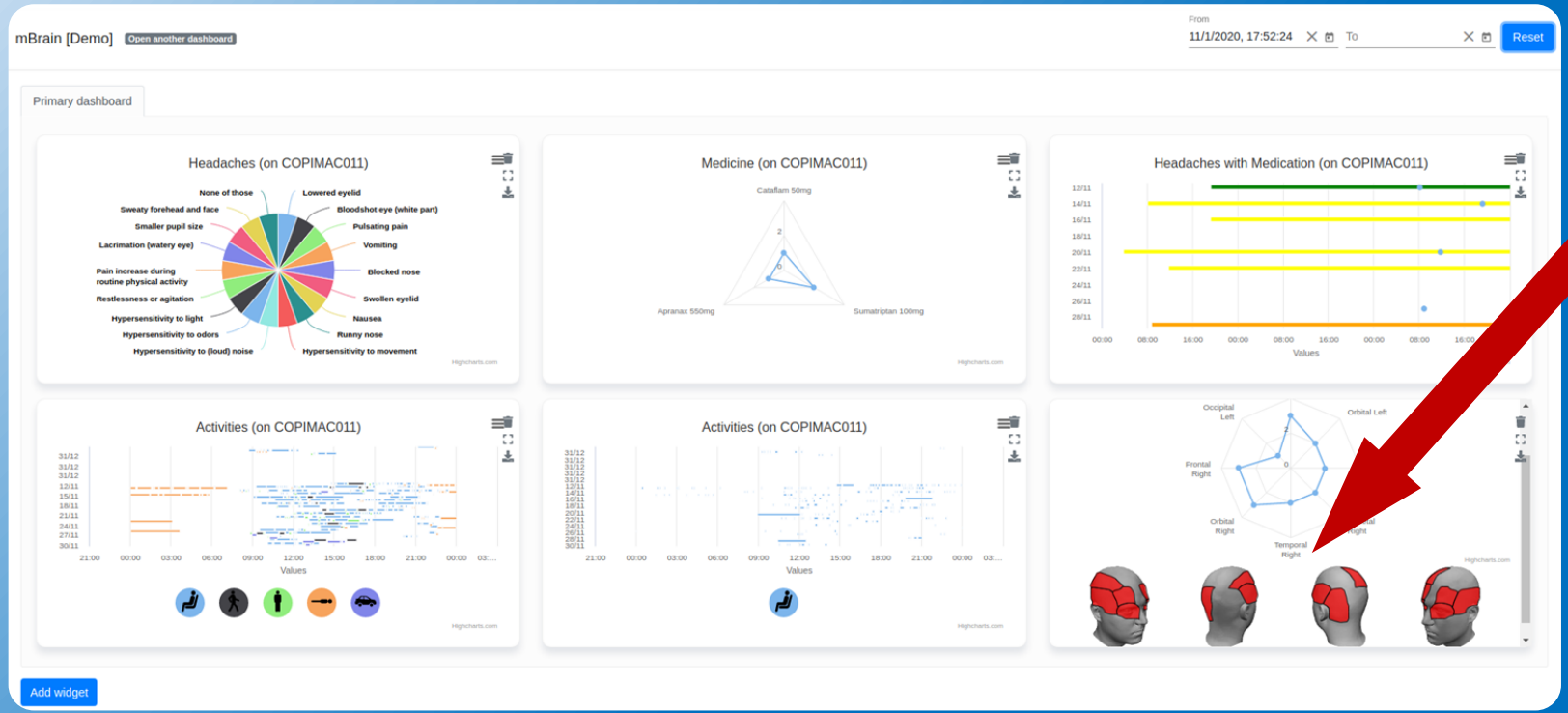
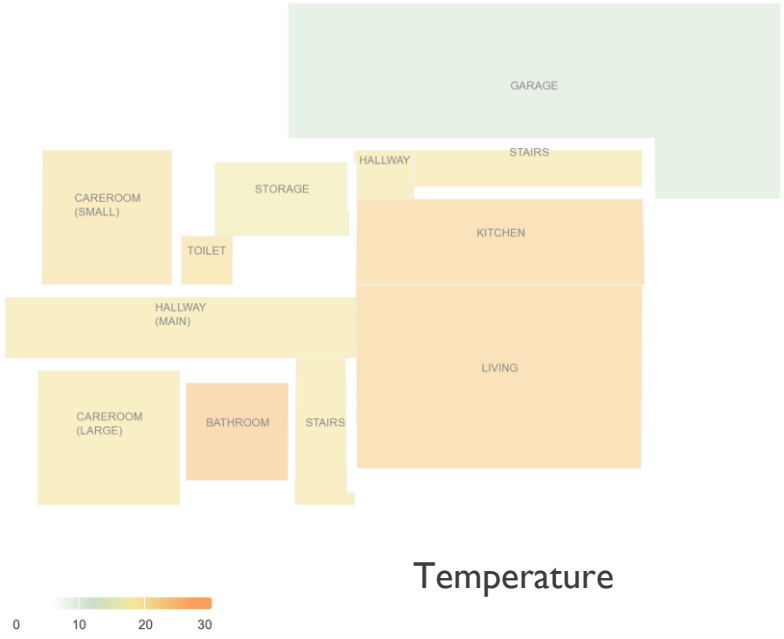
DYNAMIC CLINICIAN DASHBOARDS



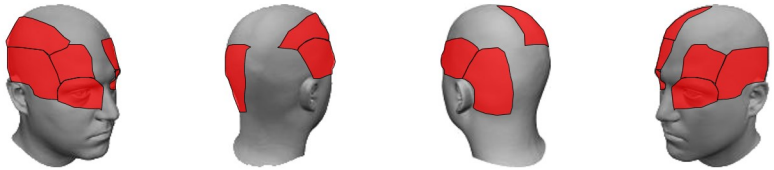
Dynamic spatial visualisation of sensor data

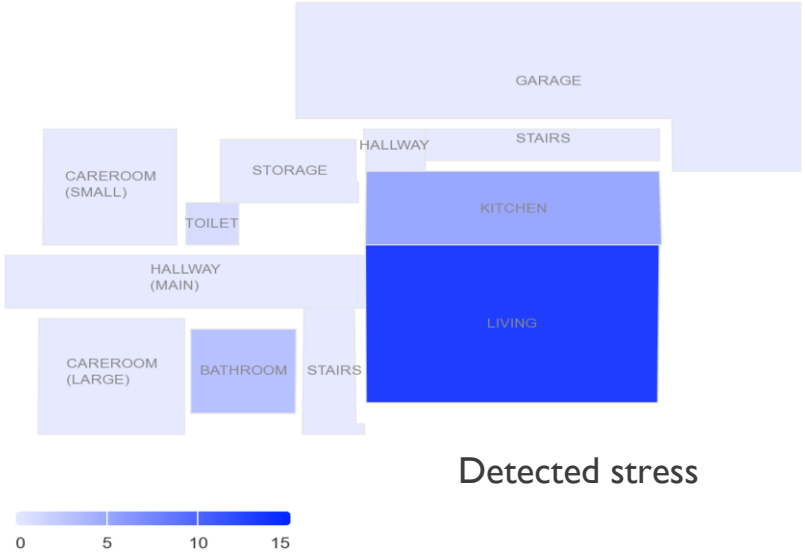
<--> SOTA geospatial only



Temperature

Headache pain





Detected stress

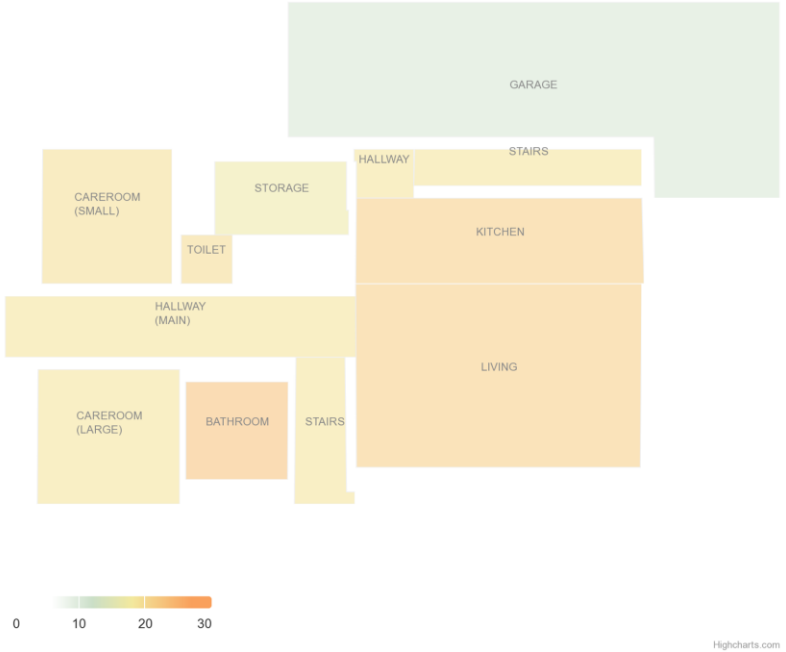
Towards Dynamic Visualization using Semantic Web Technologies

Capturing Domain Knowledge

<*homelab*> a ssn:System, ex:**Building** ;
ssn:hasSubSystem <*groundfloor*> .

<*groundfloor*> a ssn:System, ex:**Floor** ;
ssn:hasSubSystem <*kitchen*> .

<*kitchen*> a ssn:System, ex:**Room** .



Towards Dynamic Visualization using Semantic Web Technologies

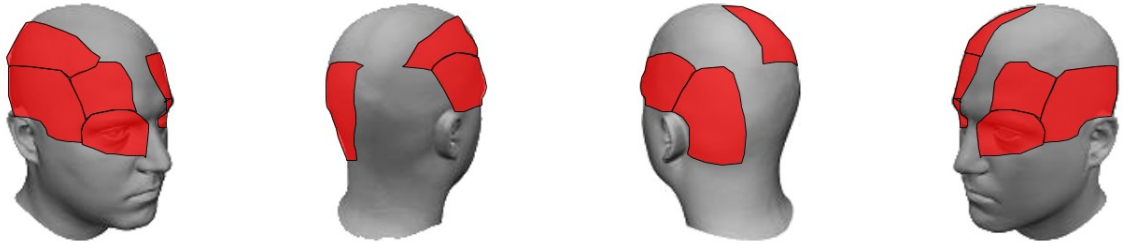
Capturing Domain Knowledge

ex:**Head** rdfs:subClassOf ssn:System ;
ssn:hasSubSystem
ex:**RightFrontalLobe**,

ex:**LeftFrontalLobe**,

ex:**RightOrbitalLobe**,

…



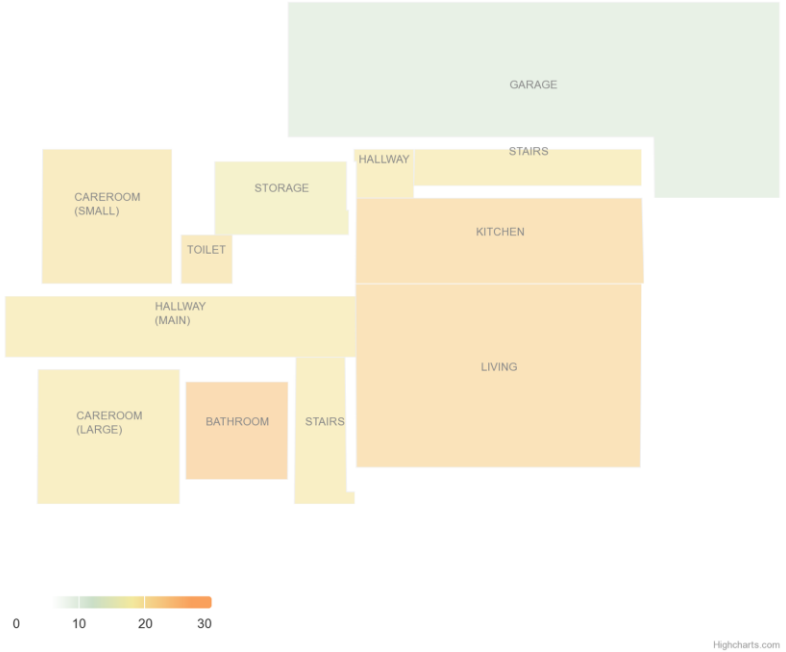
Towards Dynamic Visualization using Semantic Web Technologies

Sensor Mapping

<*kitchen*> a ssn:System, ex:**Room** ;
    ssn:hasSubSystem <*dht11.19243*> .

<*dht11.19243*> a ssn:**Sensor** ;
    sosa:observes <*dht11.19243.humidity*> ;
    sosa:observes <*dht11.19243.temp*> .

<*dht11.19243.temp*> a sosa:ObservableProperty .



Towards Dynamic Visualization using Semantic Web Technologies

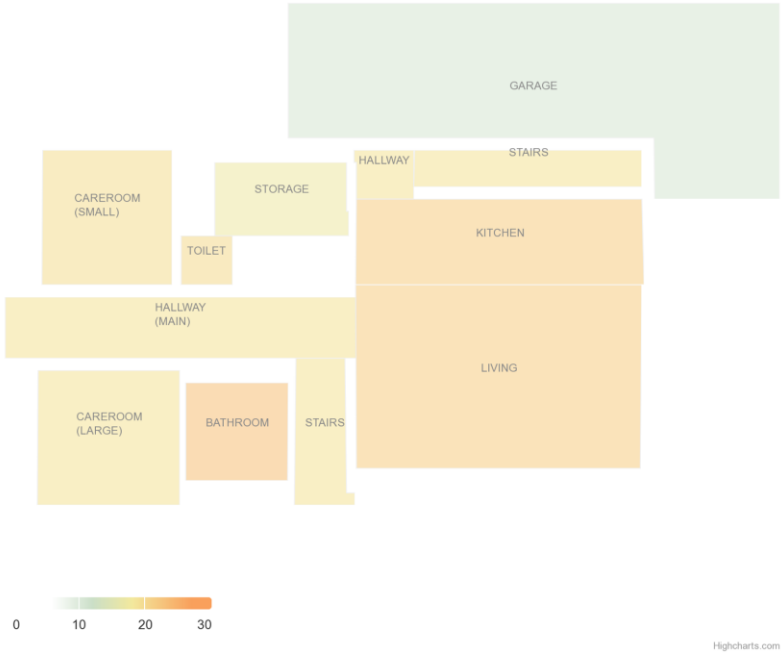
Visualization Mapping

Ontology

<*groundfloor.floorplan*> a dashb:Visualization ;
dashb:hasComponent [
dashb:visualizedSystem <*kitchen*>
]

GeoJSON

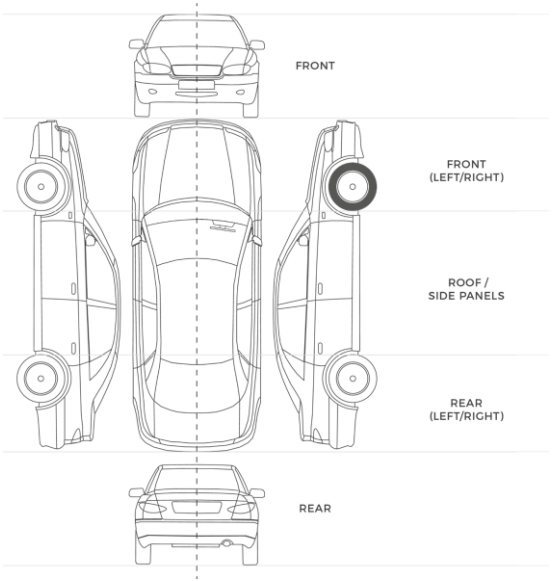
```
{
    "type": "FeatureCollection",
    "name": "groundfloor.floorplan",
    "features": [
        {
            "type": "Feature",
            "properties": { "id": 6, "name": "kitchen", "floor": 0 },
            "geometry": { "type": "MultiPolygon", "coordinates": [] }
        }
    ]
}
```



Spatio-Temporal Visualizations beyond Healthcare

Examples

Manufacturing and Industrial IoT



Air quality / Building Management

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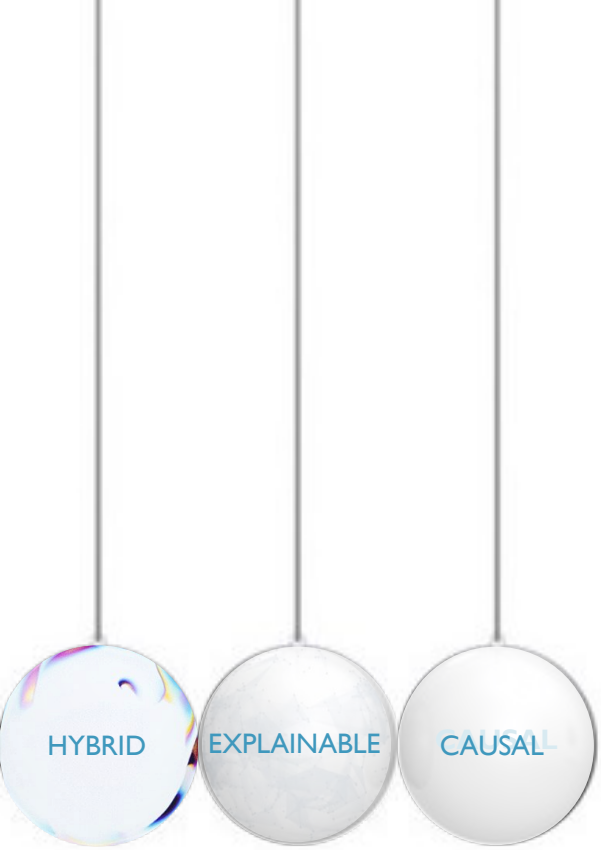
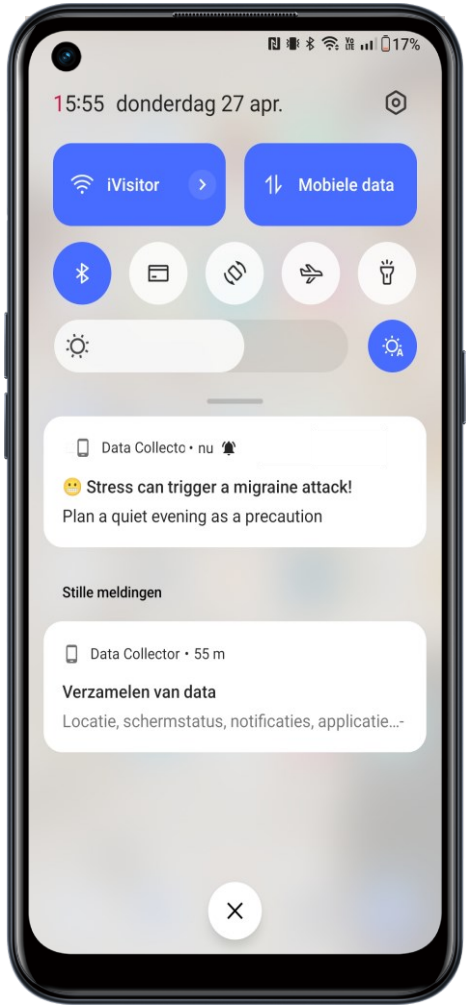
Framework with monitoring app, behavioral markers and dashboards for continuous, objective health monitoring

Make clinicians sharper and visualize what they couldn't see before

Empowering clinicians, pharma, coaches, …





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Empowering clinicians, pharma, coaches, …

Also empowering patients, care providers, …






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Designing AI-driven spatiotemporal behavioral markers and collecting RWE to improve our health and quality of life

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Questions?

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