

BM Visualization App

Fall 2020

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The University of Texas at Dallas

Multi-scale Integrated Interactive Intelligent Ssensing and Simulation (**MINTS**)



Introductions



Shawhin “Shaw” Talebi
Physics PhD candidate

Enjoys:

- Bread
- Science
- Making slides



Ashen “Ash” Fernando
Physics PhD candidate

Enjoys:

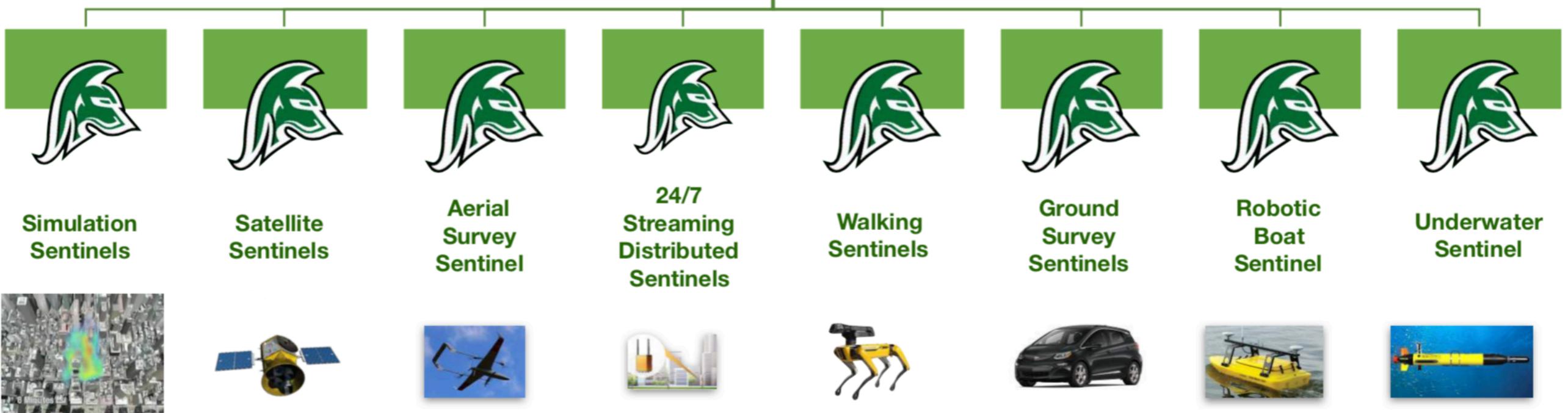
- Video games
- Programming (recently)
- Socialism

Project Background

MINTS Context Engine

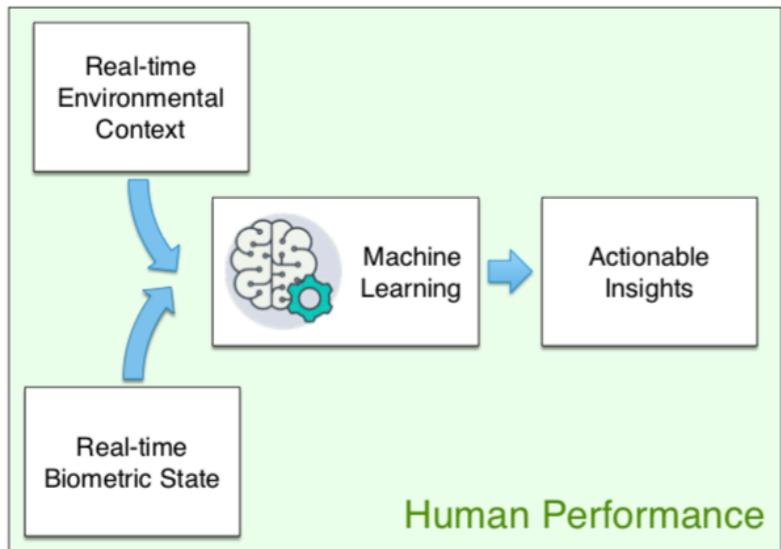
Multi-scale Integrated Interactive Intelligent Sensing and Simulation
CBRN (Chemical Biological Radiological Nuclear) Sentinels For Actionable Insights

MINTS Comprehensive Context Engine



MINTS Context Engine

Multi-scale Integrated Interactive Intelligent Sensing and Simulation
CBRN (Chemical Biological Radiological Nuclear) Sentinels For Actionable Insights



MINTS Comprehensive Context Engine

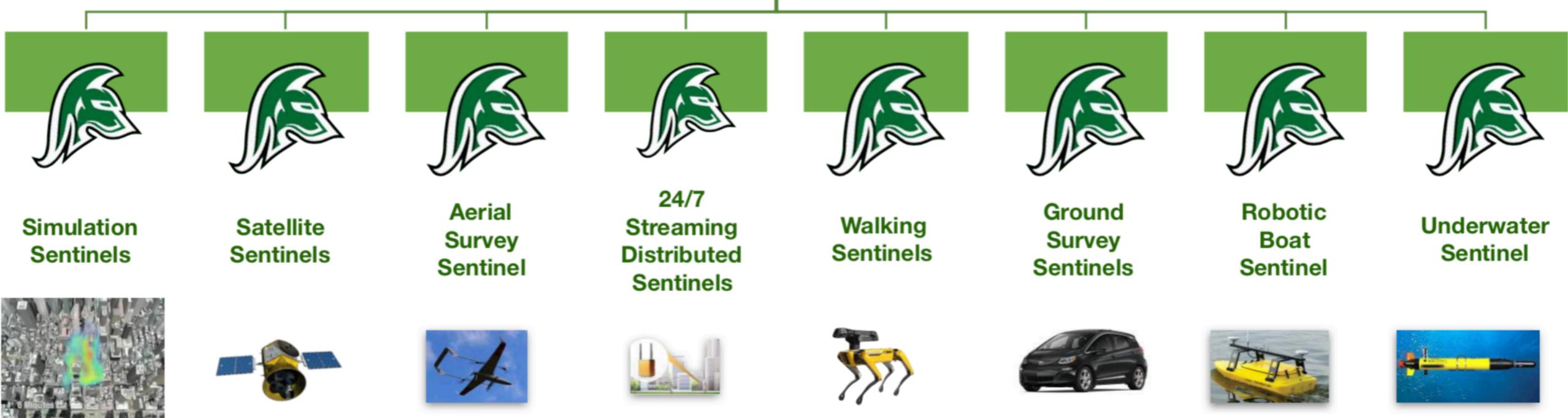


Biometrics Package

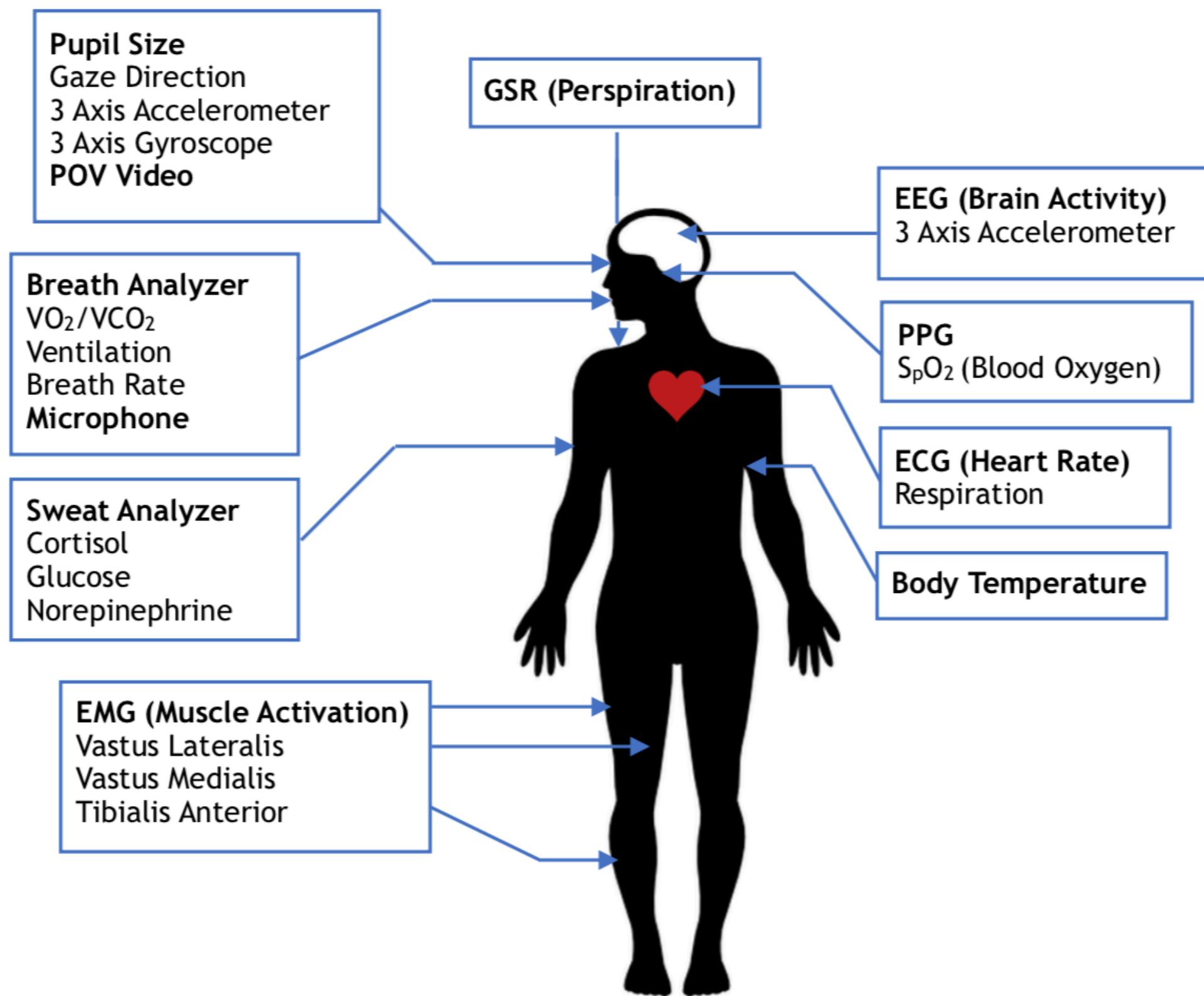


Schematic showing the holistic biometric sensing environment we propose making the human response an integral part of the sensor network. (1) Equivital Black Ghost system, (2) Cognionics 64 electrode EEG cap, and (3) Tobii Pro Glasses 2 for eye tracking.

Eight Sentinel Types



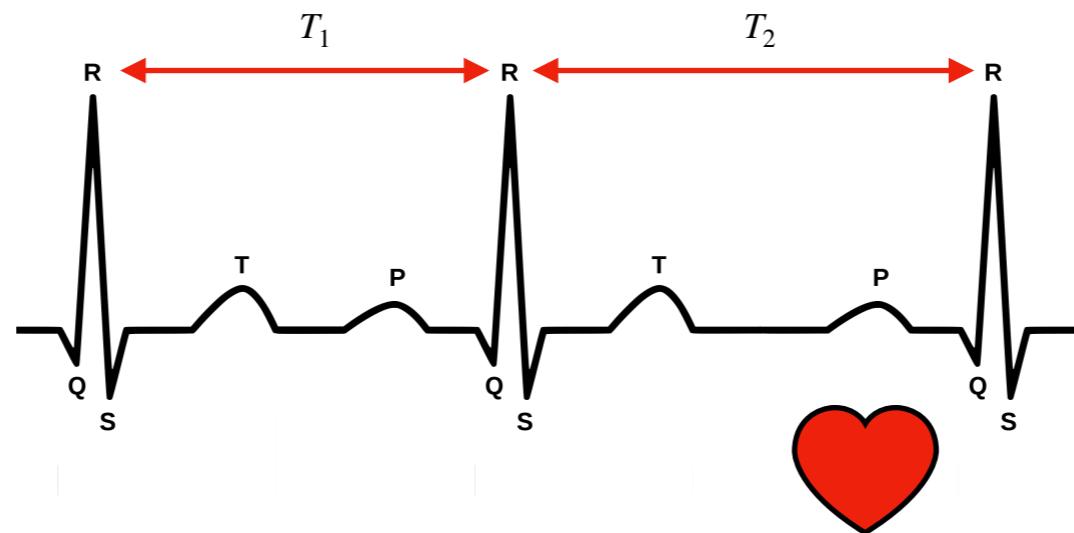
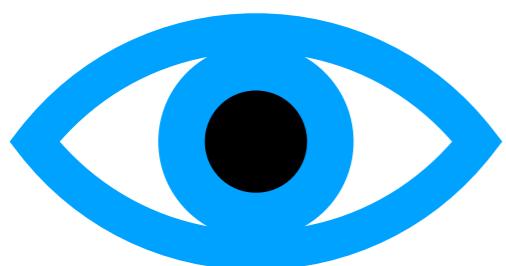
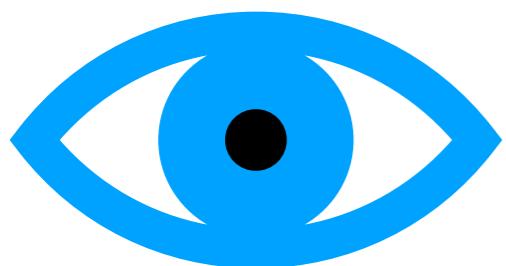
Biometrics



Cognitive Load

The load a task imposes on one's cognitive system

Physiological Measures:



Pupil Diameter

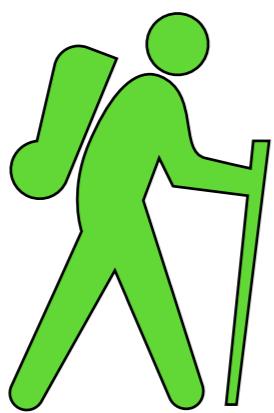
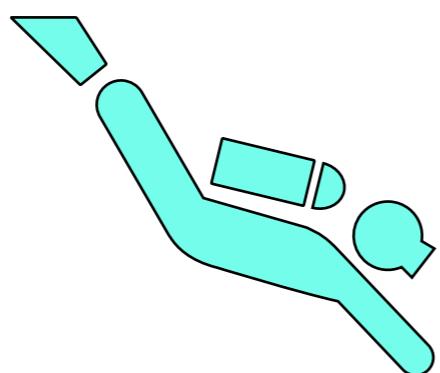
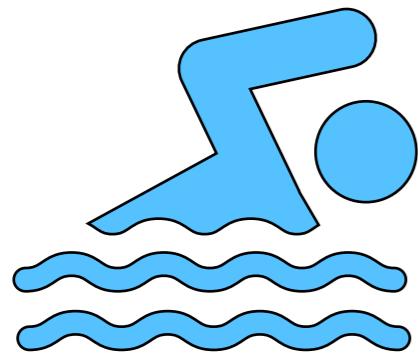
Heart Rate Variability (HRV)

Galvanic Skin Response (GSR)

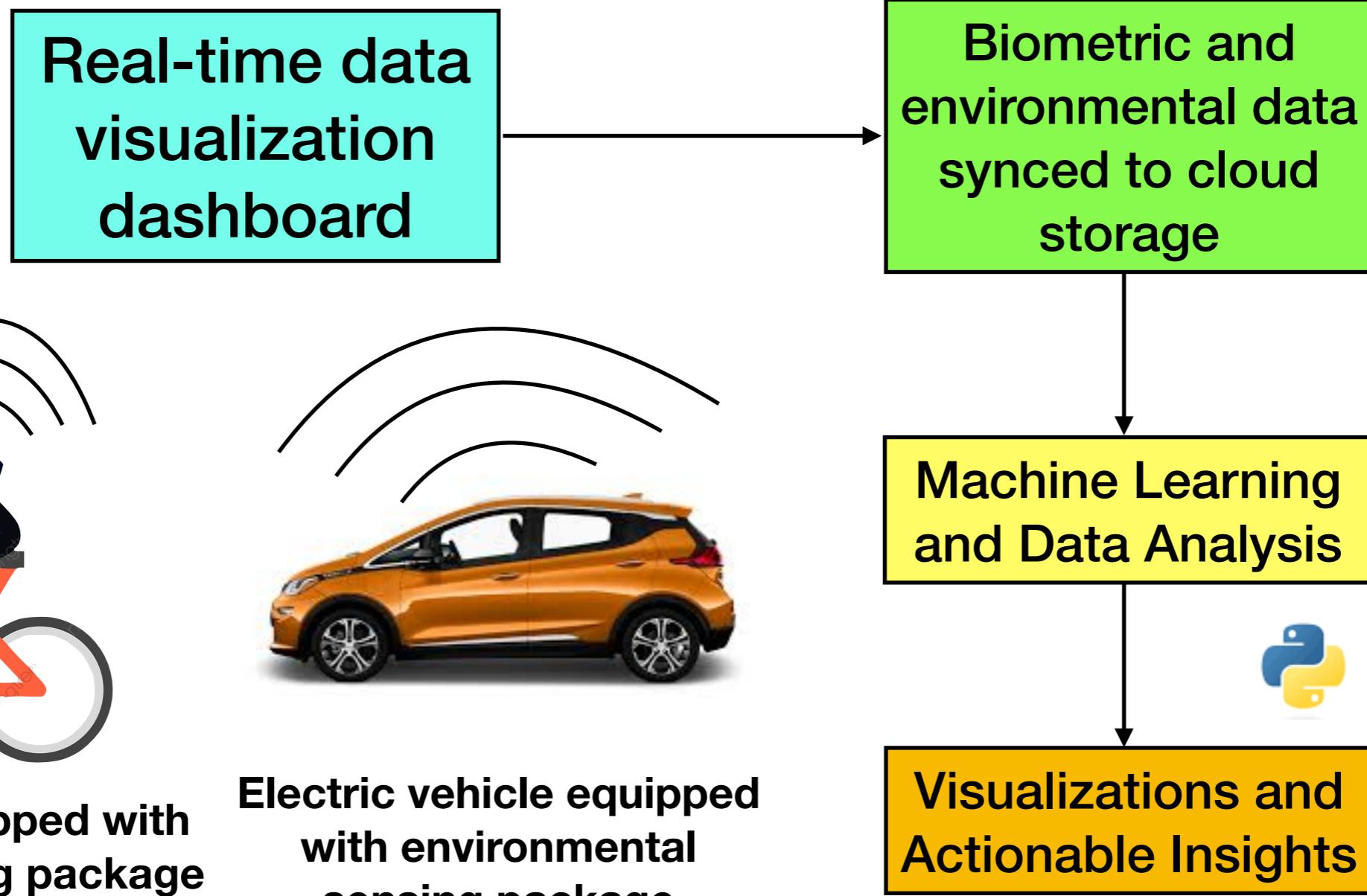


Performance

Achievements in a task



Data Processing Pipeline



MATLAB



Autonomic Nervous System

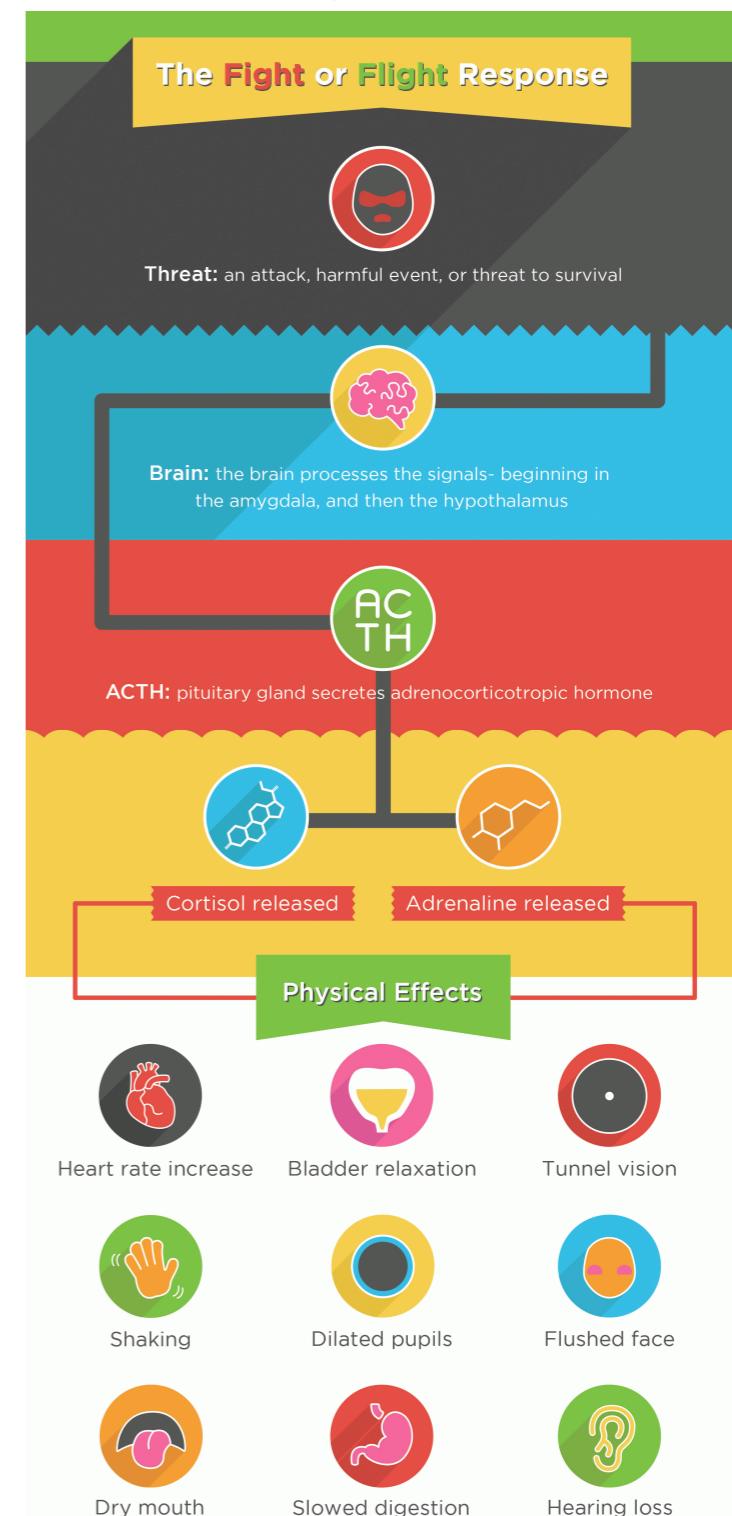
[1]

Human physiological control system that predominantly works unconsciously

Some Autonomic Responses

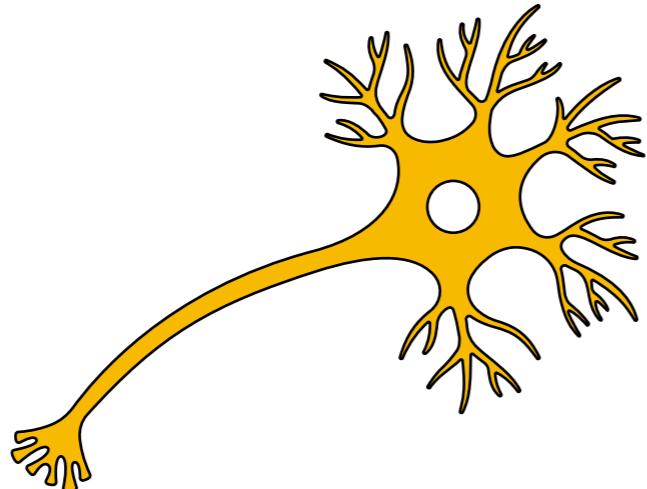
Heart rate
Pupil dilation
Breath rate
Perspiration
Sexual arousal

[2]



Electroencephalography (EEG)

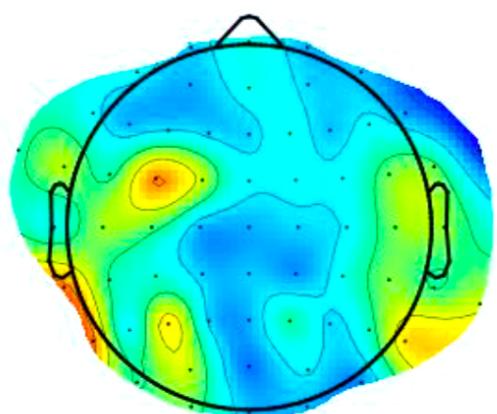
Technique for recording electrical activity from human brain



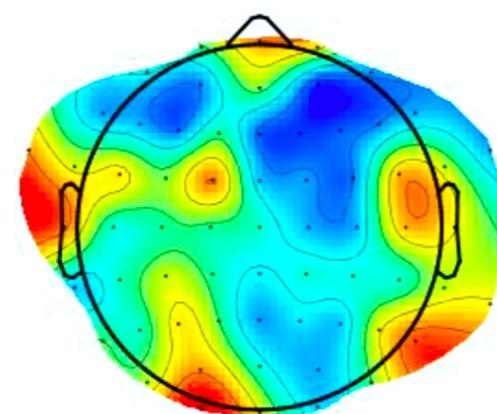
Neuron: basic building block of brain

Activity varies by firing rate

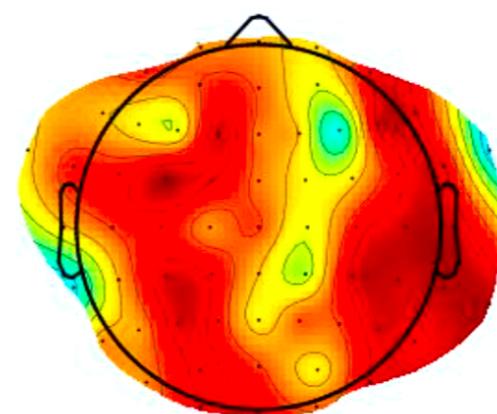
Delta Band (1 - 3 Hz)



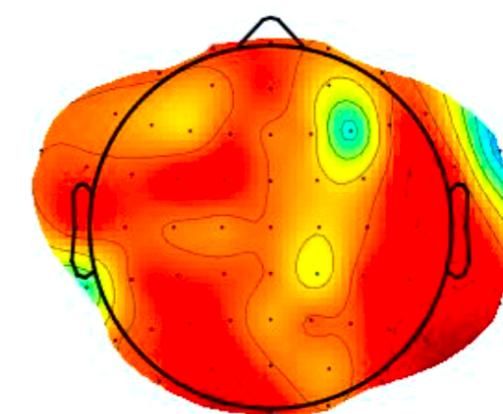
Theta Band (4 - 7 Hz)



Alpha Band (8 - 12 Hz)

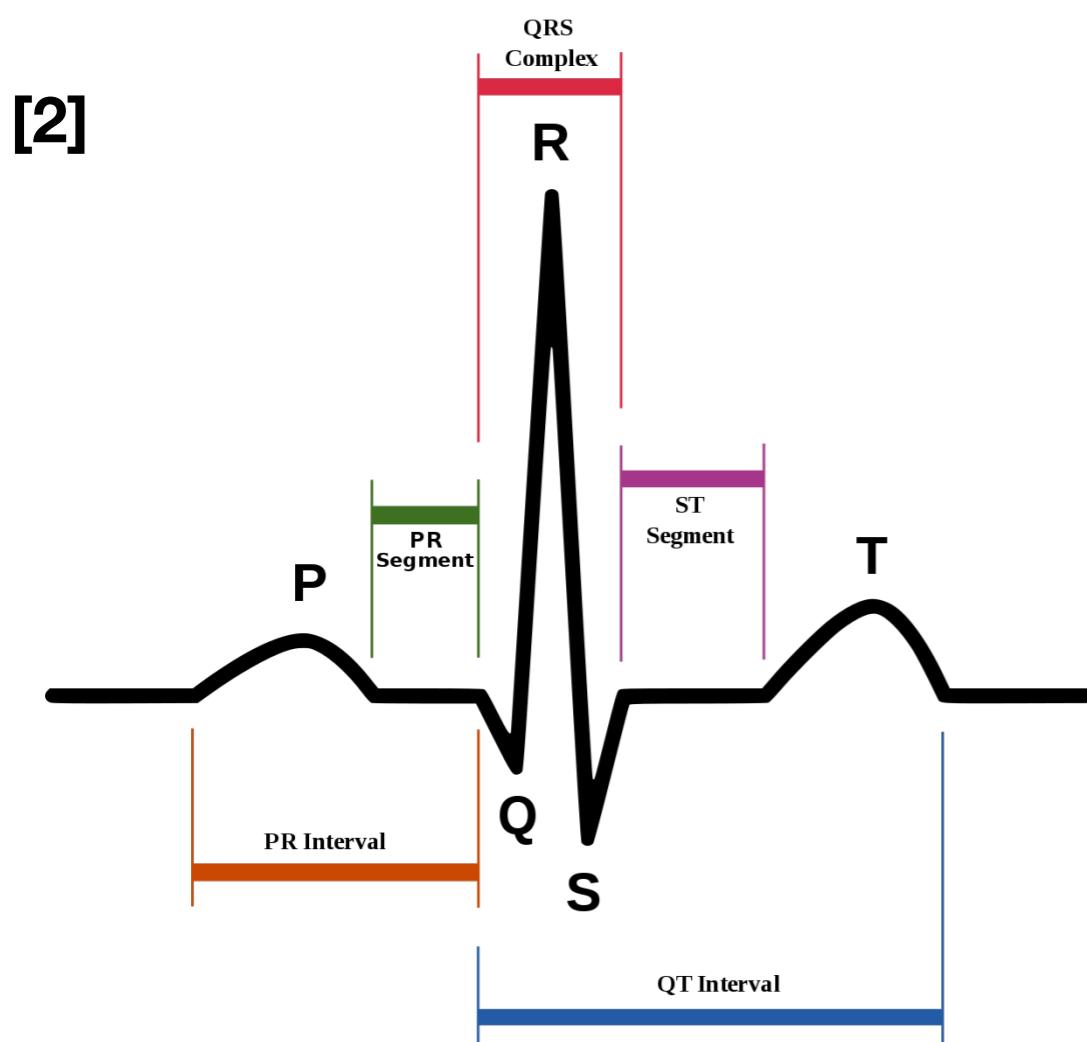


Beta Band (13 - 25 Hz)

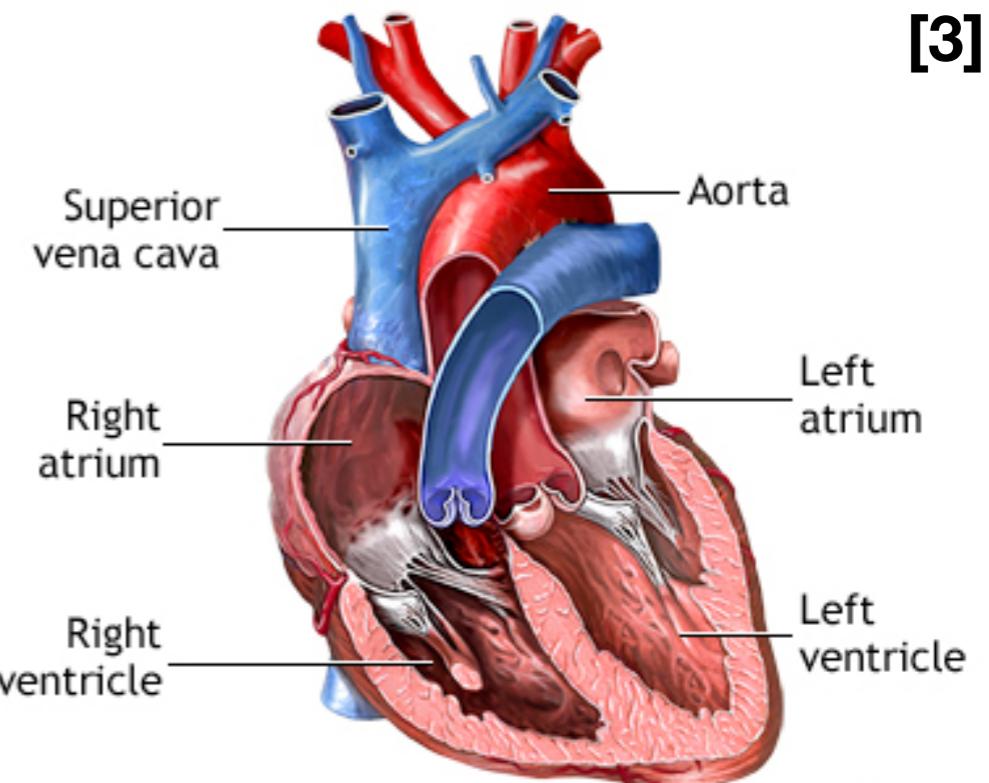


Heart Activity (ECG)

[1] **Electrocardiogram (ECG)** - measures electrical changes associated with the heart using electrodes places on the surface of the skin



[3] **Chambers of the heart**



[1] **P wave** - contraction of the atria
QRS complex - contraction of ventricles
T wave - return of ventricles to rest state

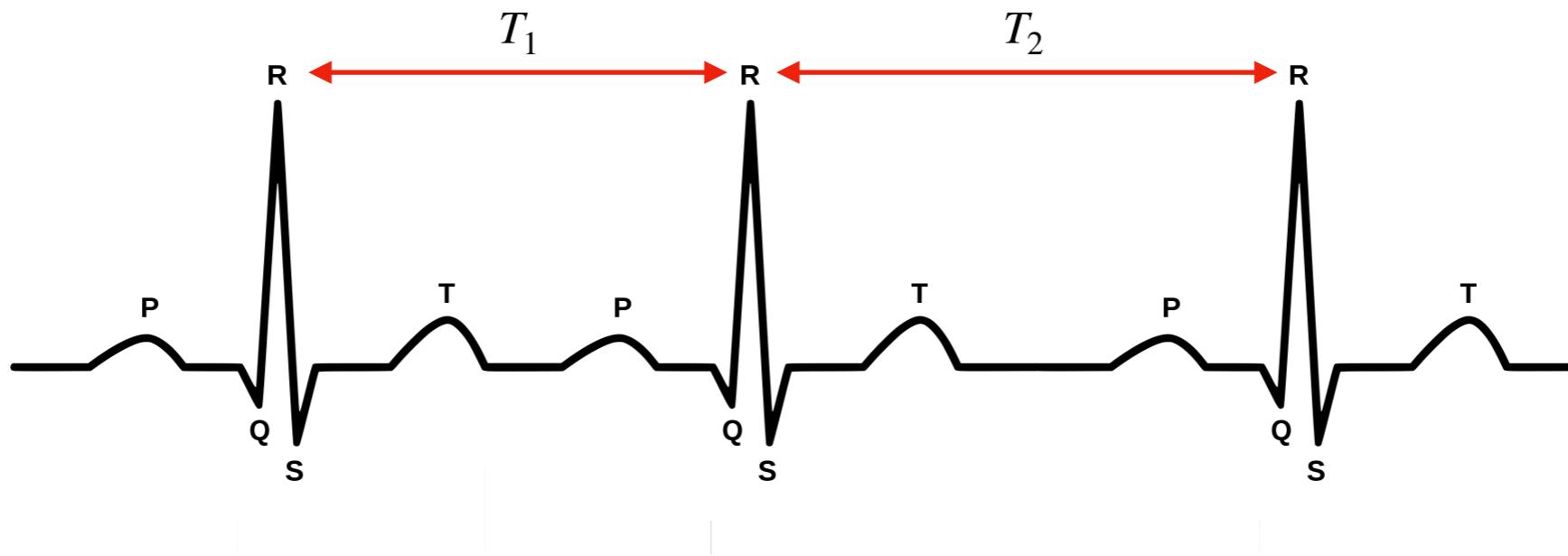
[1] Addison, P.S. (2005). Wavelet transforms and the ecg: A review. *Physiological Measurement*, 26 (5), p. R155

[2] A Survey of Electrocardiogram Data Capturing System using Digital Image Processing: A Review - Scientific Figure on ResearchGate. Available from: https://www.researchgate.net/figure/Typical-Single-Cycle-of-ECG-Signal_fig3_310993108 [accessed 22 Jan, 2020]

[3] <https://medlineplus.gov/ency/imagepages/19612.htm>

Heart Rate Variability (HRV)

Variability in the (time) interval between R waves [1]



Main spectral bands

| | |
|----------------------------------|-------------------|
| Very Low Frequency (VLF) | → 0.003 - 0.04 Hz |
| Low Frequency (LF) | → 0.04 - 0.15 Hz |
| High Frequency (HF) | → 0.15 - 0.4 Hz |
| Ultra Low Frequency (ULF) | → <0.003 Hz |

[2] Power distribution in these bands
identify relative contributions of sympathetic and parasympathetic nervous system to HR modulation

Galvanic Skin Response (GSR)

Measure of skin conductance

- **Sweating**
- **Cognitive Load [1]**
- **Sympathetic NS**
- **Arousal [2]**



[1] Yu Shi, Natalie Ruiz, Ronnie Taib, Eric Choi, and Fang Chen. 2007. Galvanic skin response (GSR) as an index of cognitive load. In CHI '07 Extended Abstracts on Human Factors in Computing Systems (CHI EA '07). Association for Computing Machinery, New York, NY, USA, 2651–2656. DOI:<https://doi.org/10.1145/1240866.1241057>

[2] Bradley MM, Miccoli L, Escrig MA, Lang PJ. The pupil as a measure of emotional arousal and autonomic activation. *Psychophysiology*. 2008;45(4):602-607. doi:10.1111/j.1469-8986.2008.00654.x

Blood Oxygen (SPO₂)

Proportion of oxygen in blood

Normal: 95-100%
Hypoxic: < 94%



PPG/HR/S_pO₂ Sensor

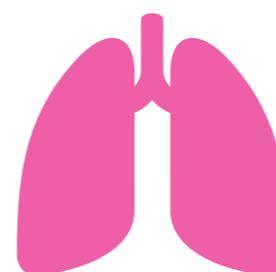
Environmental Condition

Elevation



Physiological Effect

Hypoxia



**Reduction of
cognitive function**



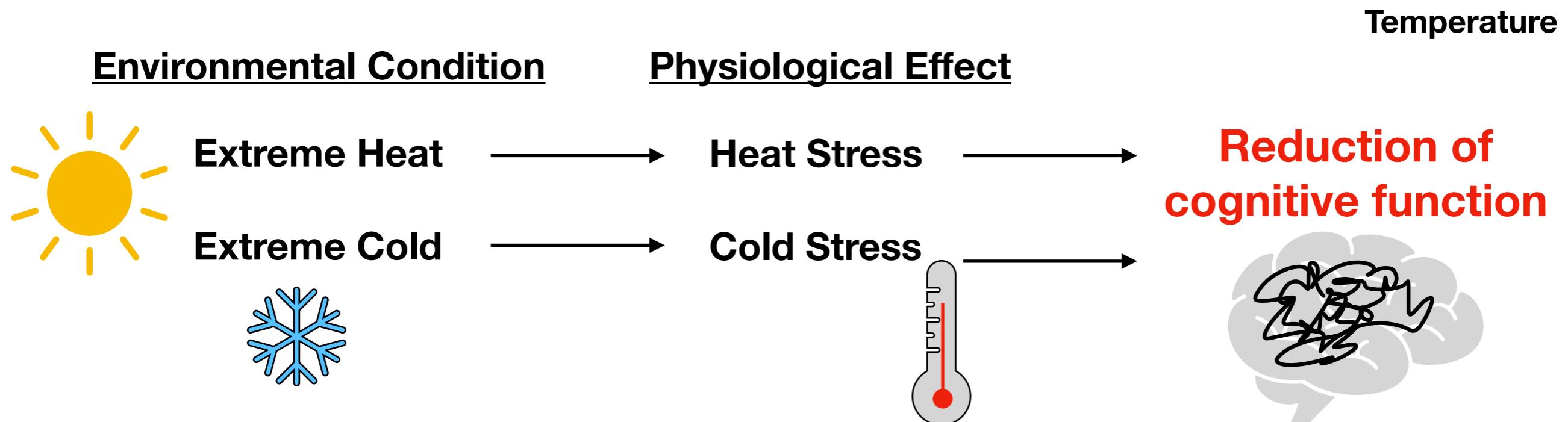
Body Temperature

Amount of heat energy at a body part

Normal: 97-99°F (36.1-37.2°C)
Fever: > 99°F (38°C)



Temperature





Sensors



EEG Mobile-128



ECG



GSR



PPG/HR/S_pO₂ Sensor



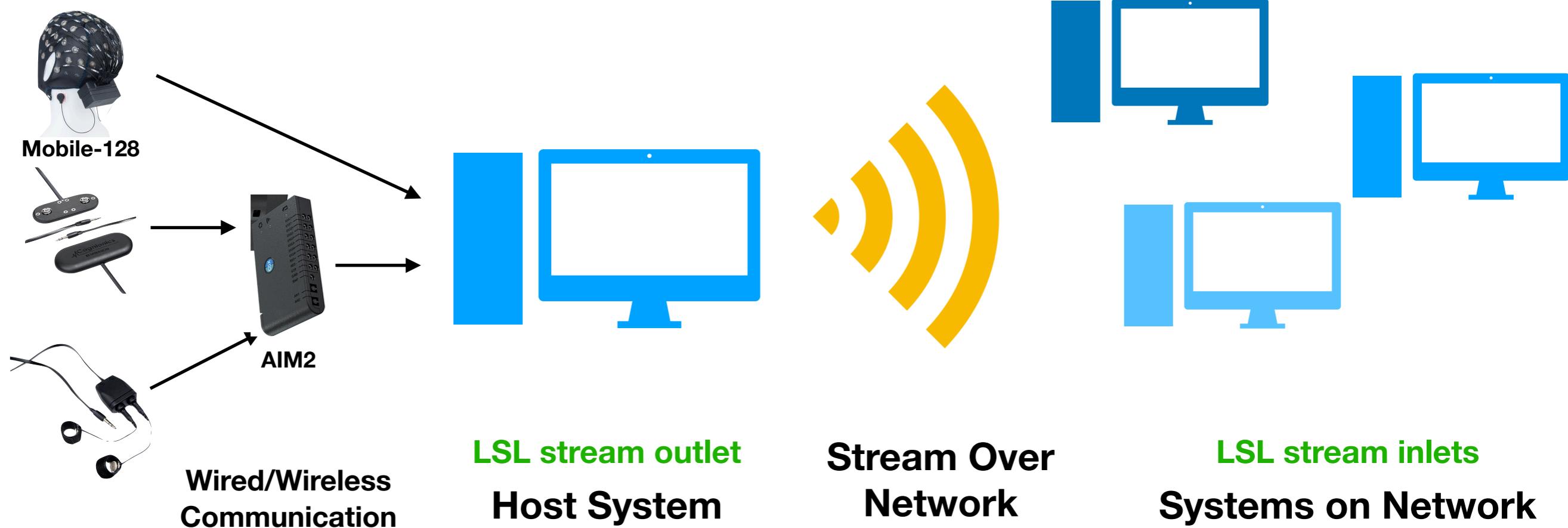
Temperature

Lab Streaming Layer

[1]

A system for the unified collection of measurement time series in research experiments that handles both the **networking**, **time-synchronization**, **(near-) real-time access**

Data Pipeline:



Past Iterations

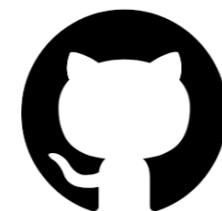
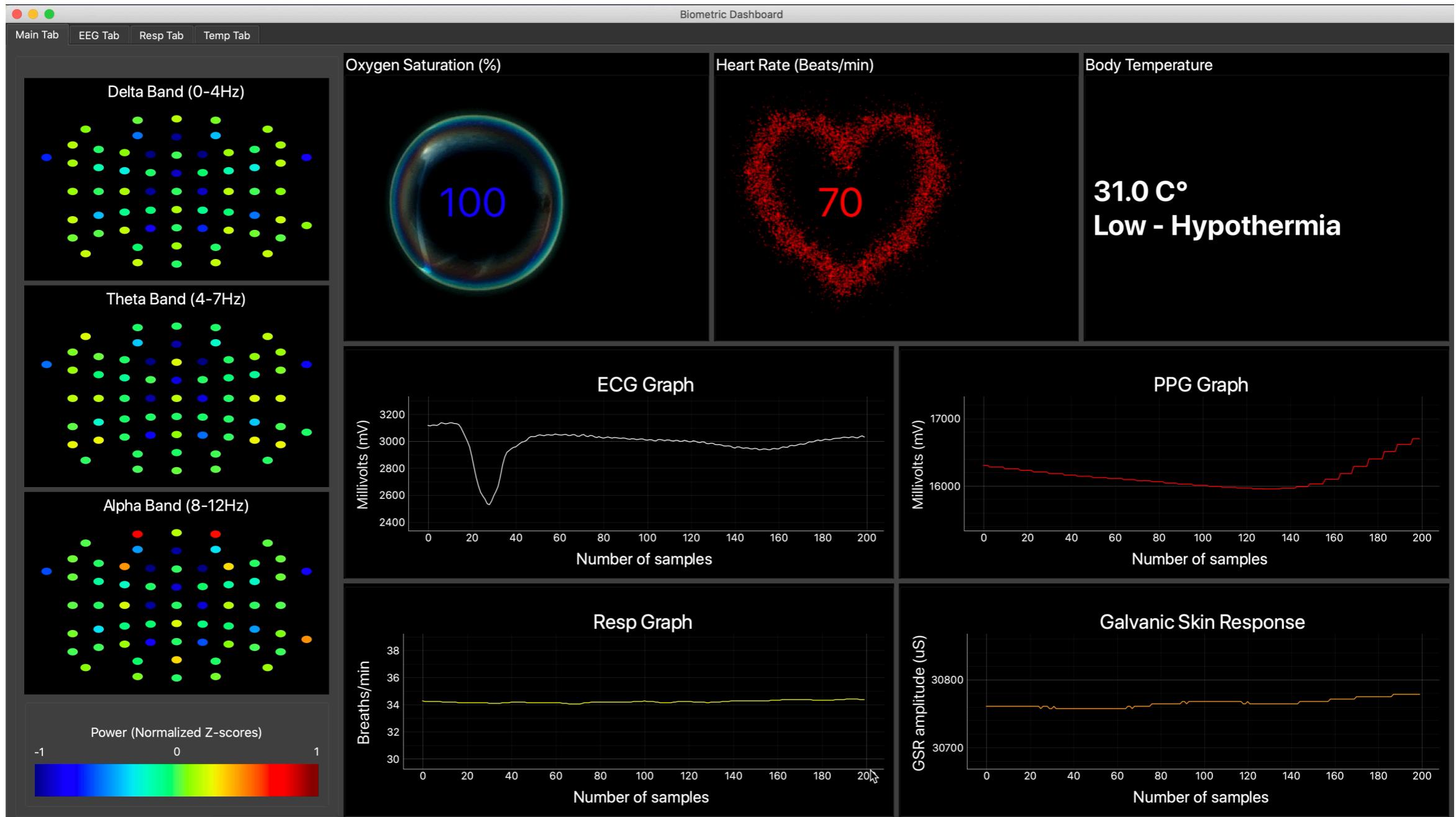
Fall 2019

Backend computation contributions for EEG Foundation of project



https://github.com/amnaaaaali/UTDMINTS_BiometricDataApp

Spring 2020



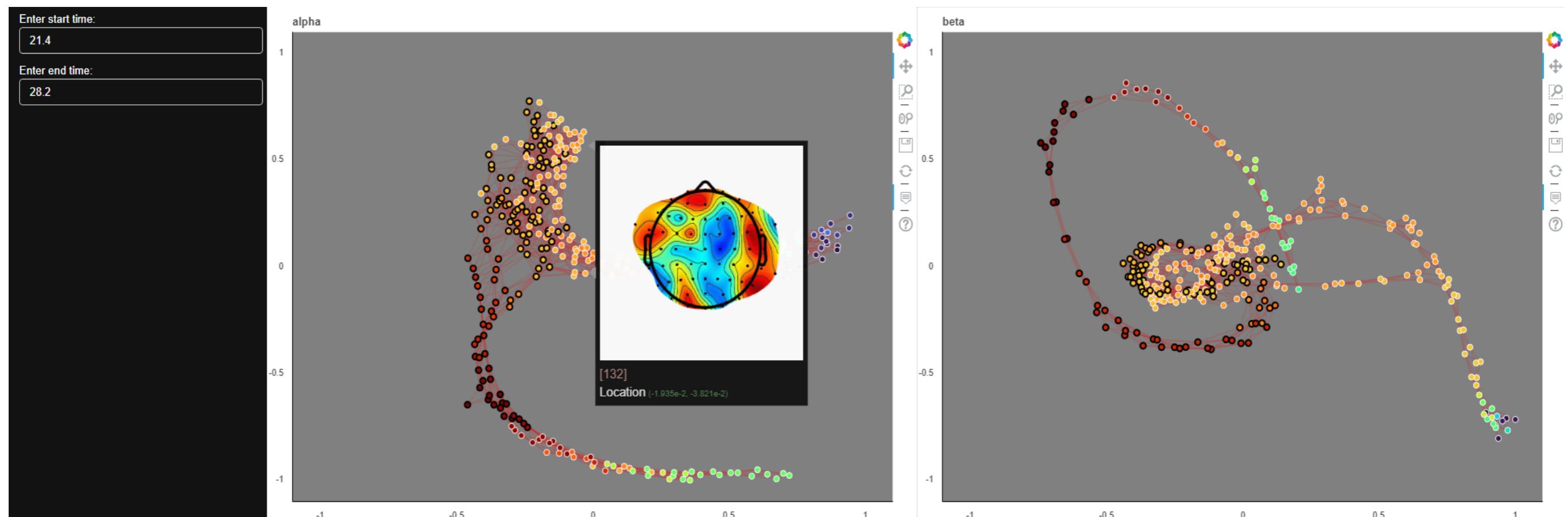
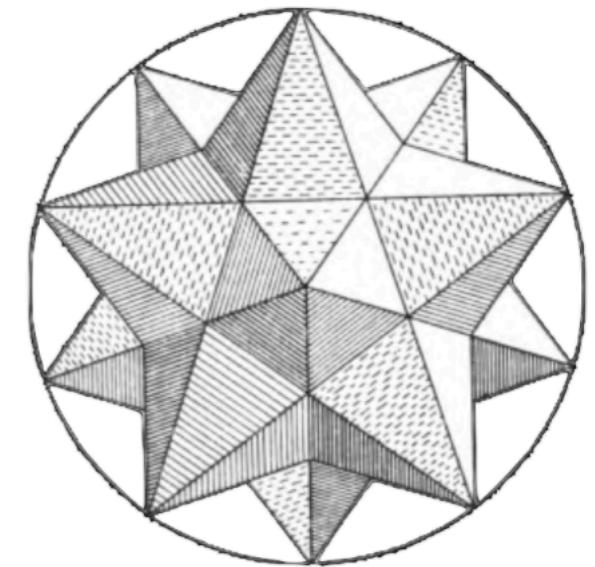
<https://github.com/mi3nts/biometricDashboard2>

https://bikram9-9.github.io/biometrics_dashboard/

Post-Collection Dashboards



TDA (Mapper)



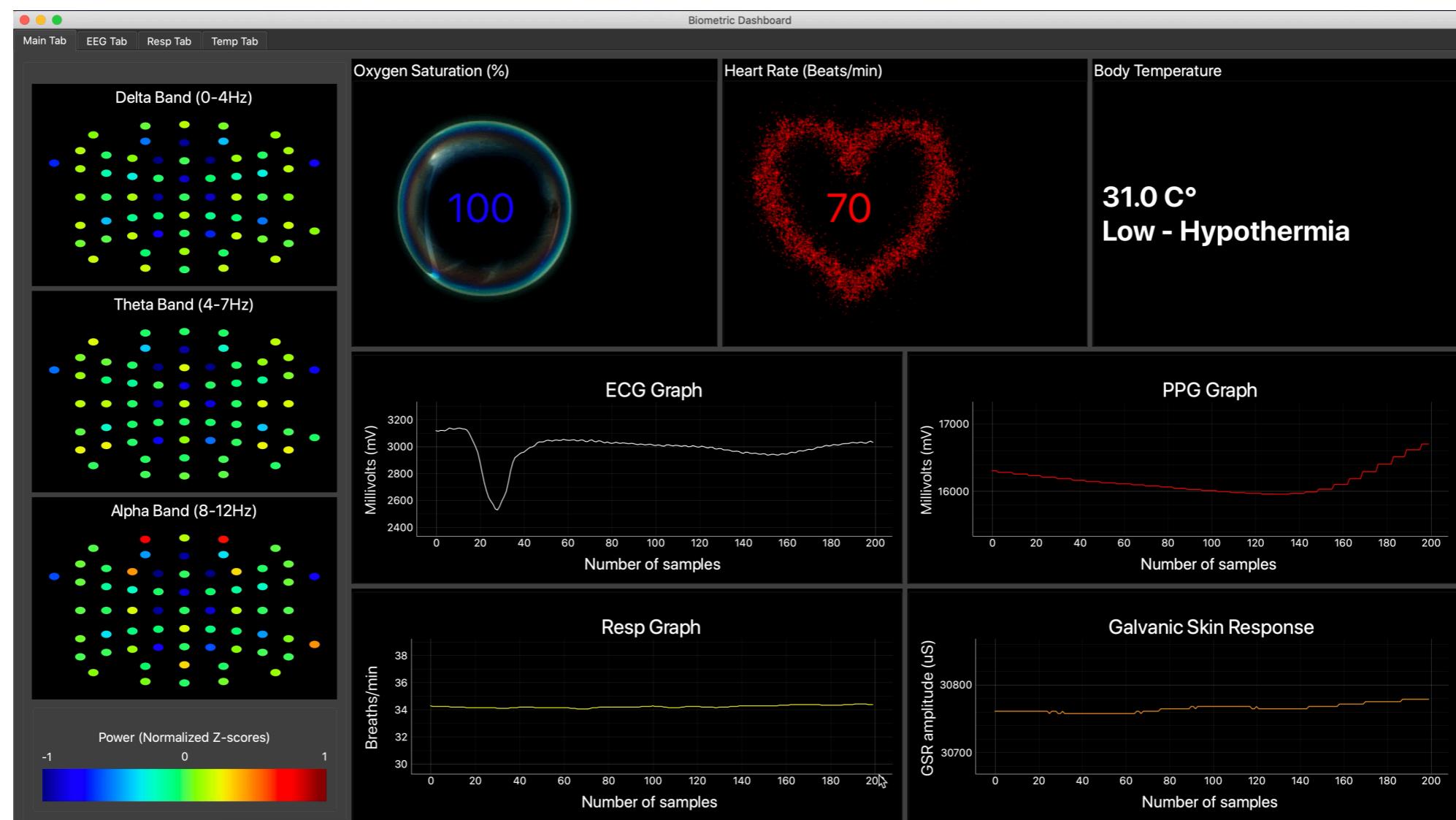
What's Next?

Option 1

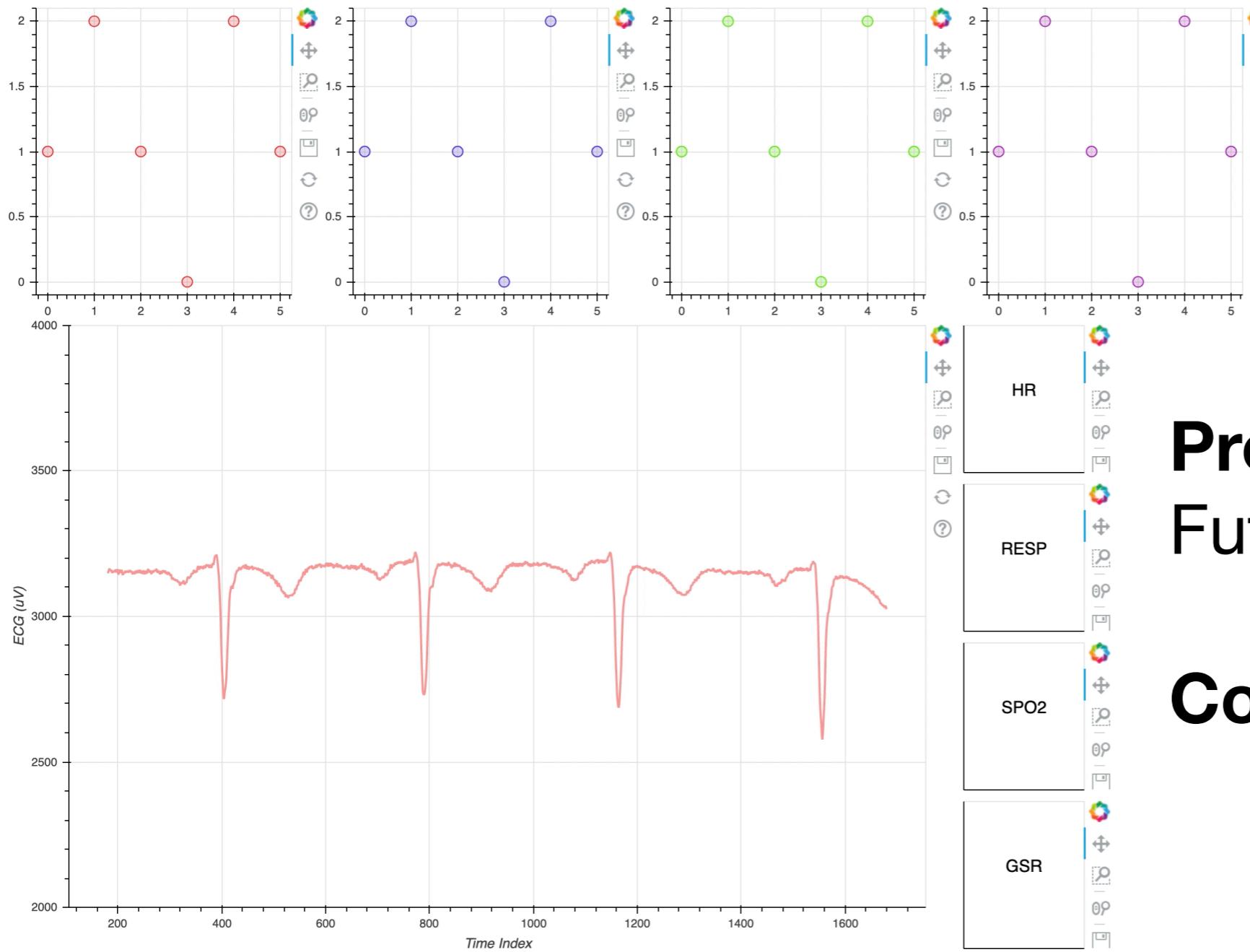


Pros: Build upon existing app. Familiarity

Cons: Less usability



Option 2



Pros: Flexibility
Future augmentation

Cons: Less familiarity

Discussion

Goals

9/18 - Acclimation with project logistics and tools

10/16 - Clear idea of final visual products. Ideally, have first draft

11/13 - Final product and website

Expectations

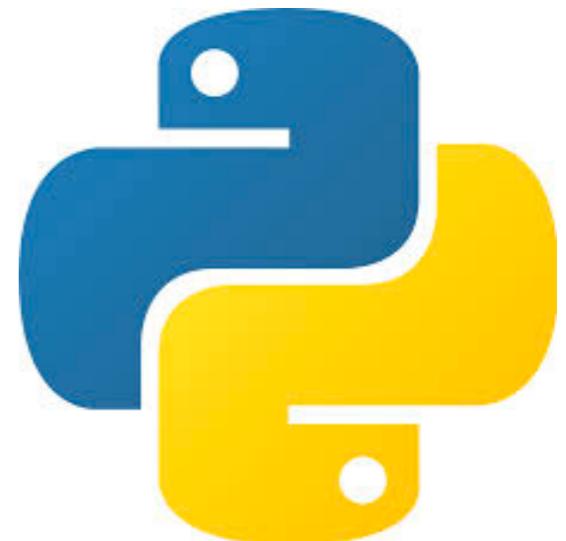
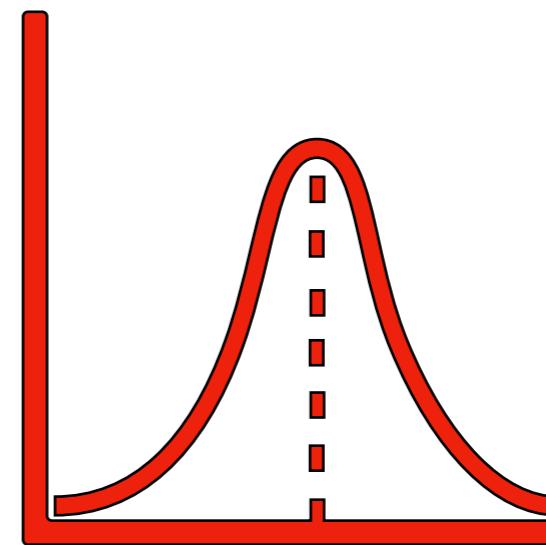
Collaboration

Team goals above individual goals

Be solution oriented

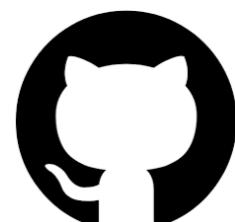
What you can expect

- 1. Steep learning curve**
- 2. 6 hours a week on deliverables**
- 3. Present deliverables and explain topics at team meetings**
- 4. Heavy Python use**
- 5. We are all learning**



Logistics

- **Weekly meetings**
- **Weekly deliverables**
- **Present deliverables at meetings (2-4 slides)**
 - Suggested format:
 - Objectives/deliverables
 - How did it go? Outcomes
 - Demo
 - What's next?
 - Upload PDF to GitHub (ideally) before each meeting
- **Ad hoc meeting times**
 - Ash: **Tu Th** 1-4PM
 - Shawhin: **M** 3:30PM - 7PM, **F** 1PM - 4PM
- **General**
 - GitHub: all code, slides, and documentation goes here
 - Teams: meetings and group discussion
 - Email: meeting recaps and deliverables assigned
 - Text: message: immediate communication



General Tips

Learning

- Hard to learn everything from scratch
- Read through examples and comment each line
- Hack examples for deliverables

Producing

- Comment code as you write it
- Document as you go

Grades

Criteria from UTDesign:

- Overall outcome
- Weekly meetings
- Technical contribution
- Project

Questions?

