Integrated Sensors Platform:
Streamlining Quantitative Physiological Data Collection and Analysis

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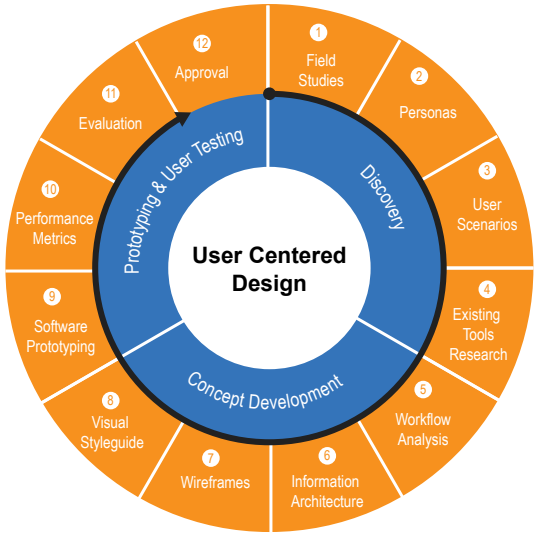
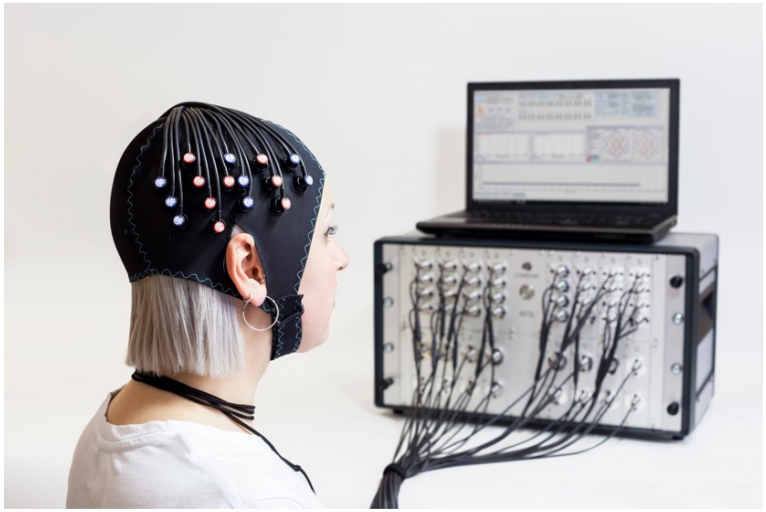
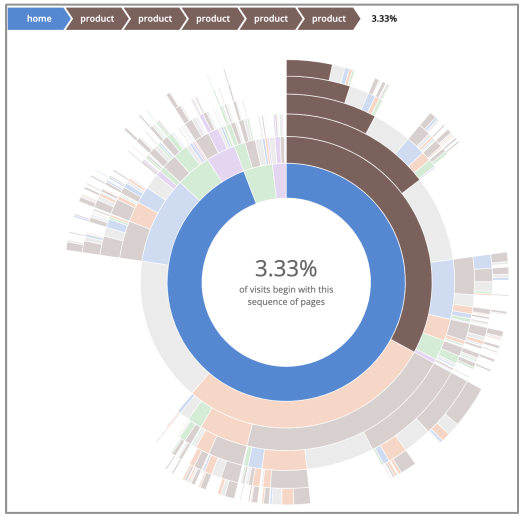
Introduction



User Centered Design to understand users



Neuroergonomics to elicit cognitive state [1]



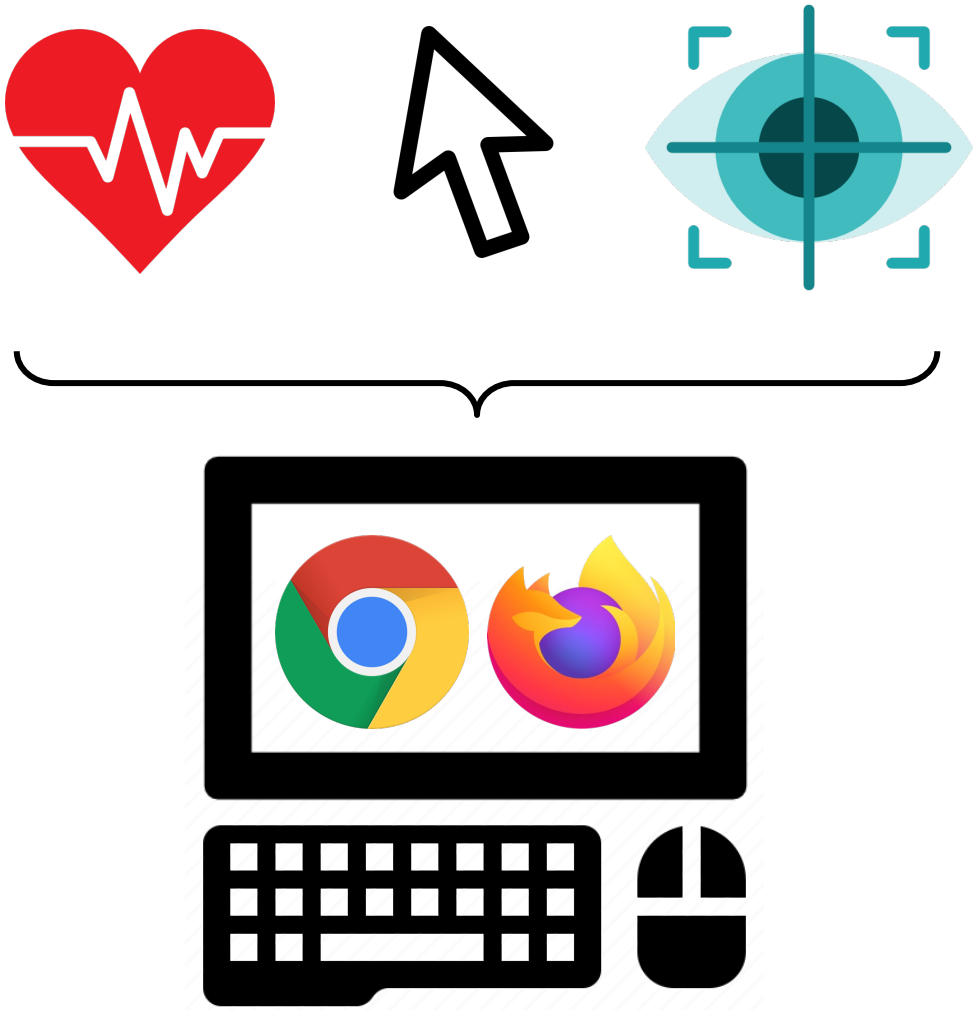
Holistic assessment of design choices impact on complex and nuanced human outcomes

We present a new tool that enables researchers to execute rigorous and quantitative evaluations based on physio-behavioral data

[1] Neuroergonomics: https://doi.org/10.1080/14639220210199753

Integrated Sensors Platform

- Web application to help collect, integrate, and fuse disparate physio-behavioral sensors
- Understand cognitive outcomes and link to the overall performance of the users
- Make it accessible and affordable to human-centered design researchers and practitioners
- Integrate multiple commercial and experimental sensors
- Built-in integration and analysis capabilities



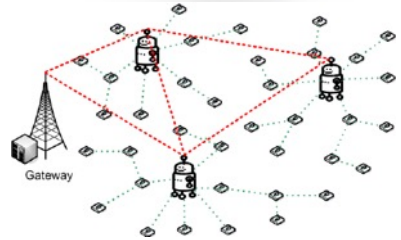
Current State of Sensors














Large number of commercial and academic instrumentation sensors offer a overlap in measures with limited validation in operational relevant tasks

Sensor Considerations

Accuracy
Measurements are within acceptable error range to those obtained with standard/validated devices used in the field

Deployment Restrictions
Local data storage, No voice or image recordings

Maximize

Sensitivity
Provides a sensitive measure of the metric of interest (e.g. workload, fatigue, workflow, etc.)

Integration
Open Source Software enables integration of data collection and analysis across sensors

Invasiveness
Minimal contact, No task interference

Minimize

Cost
Minimize equipment & software costs to enable wider deployment of instrumentation suite

ISP Selected Sensors

Mionix heart rate computer mouse [1]

- Integrated heart rate optical sensor
- Provides a measure of workload
- WebSocket interface

GazePoint GP3 eye tracker [2]

- Captures gaze position and blinks
- TCP socket interface

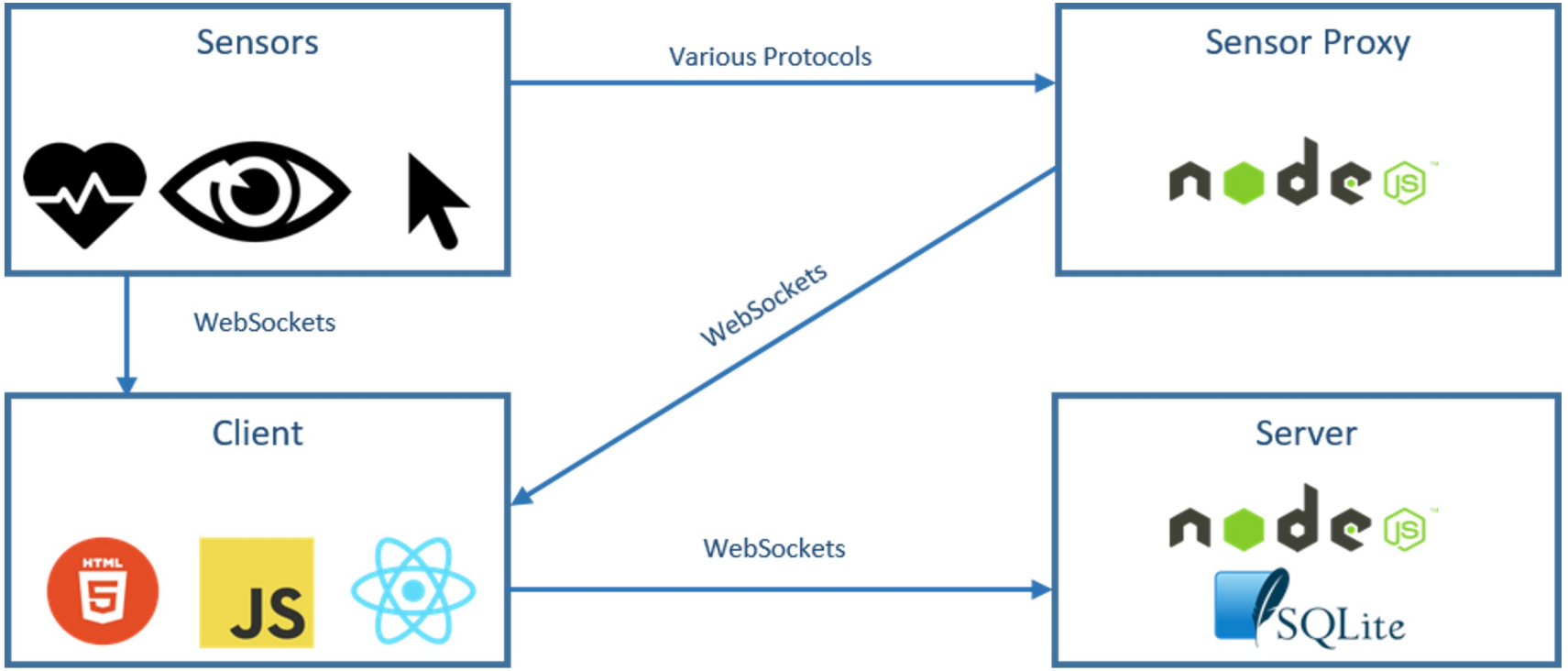
Custom-built software workflow monitor

- Records user actions in the browser
- Captures periodic screenshots
- Written in JavaScript

This demonstrates the advantage of our platform, which combines data collection from commercial and in-house sensors

[1] Mionix Naos QG: https://mionix.net/products/naos-qg
[2] GazePoint GP3: https://www.gazept.com/product/gazepoint-gp3-eye-tracker/

Architecture



Data Configuration Page

Task Information

Session ID

Session ID

Team ID

Team ID

Participant ID

Participant ID

Researcher ID

Researcher ID

Station ID

Station ID

Equipment ID

Equipment ID

Submit

Optional Settings

Database Server

Url

localhost:5000

Mouse

WebSocket Url

localhost:7681

Eyetracker

Proxy WebSocket Url

localhost:5001

Save Every __ Samples

1

Workflow

Screen Capture: Save Every __ Seconds

30

Mouse Move: Save Every __ Samples

1

External Workflow

Proxy WebSocket Url

localhost:5001

Mouse Move: Save Every __ Samples

1

Data Collection Page

Currently not saving data

Session ID: 3
Team ID:
Participant ID:
Researcher:
Station:
Equipment ID:

Begin Saving Remotely ▶

Save Data Locally

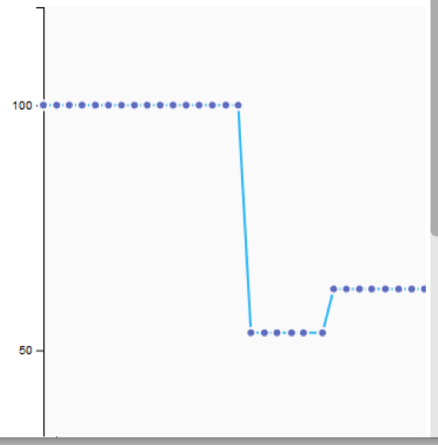
The Heartrate sensor is currently selected.

Unselect this sensor

Heartrate Status: Active!

Total saved samples: 460

Current Heart Rate: 62.3

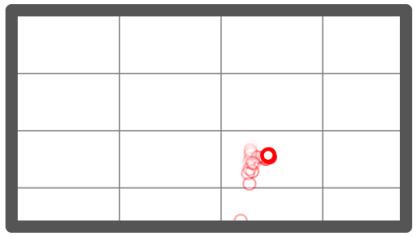


The Eyetracker sensor is currently selected.

Unselect this sensor

Total saved samples: 500

Current X: 0.62
Current Y: 0.61



The Workflow Monitoring sensor is currently selected.

Unselect this sensor

Total saved samples: 60

- {"clientTime":1590002909988,"tool":"ISP","type":"keydown","altKey":null,"clientX":null,"clientY":null,"ctrlKey":null,"keyCode":16,"shiftKey":true,"value":null,"scrollLeft":0,"scrollTop":0,"selector":"#document HTML BODY DIV#root DIV.dashboard DIV#control.box DIV DIV.flush.grid DIV.column DIV.controlButton BUTTON.green"}
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The External Workflow Monitoring sensor is currently selected.

Unselect this sensor

Total saved samples: 240

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- {"type":"onMouseOverSquare","square":"g3"}
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- {"type":"onMouseOverSquare","square":"e3"}
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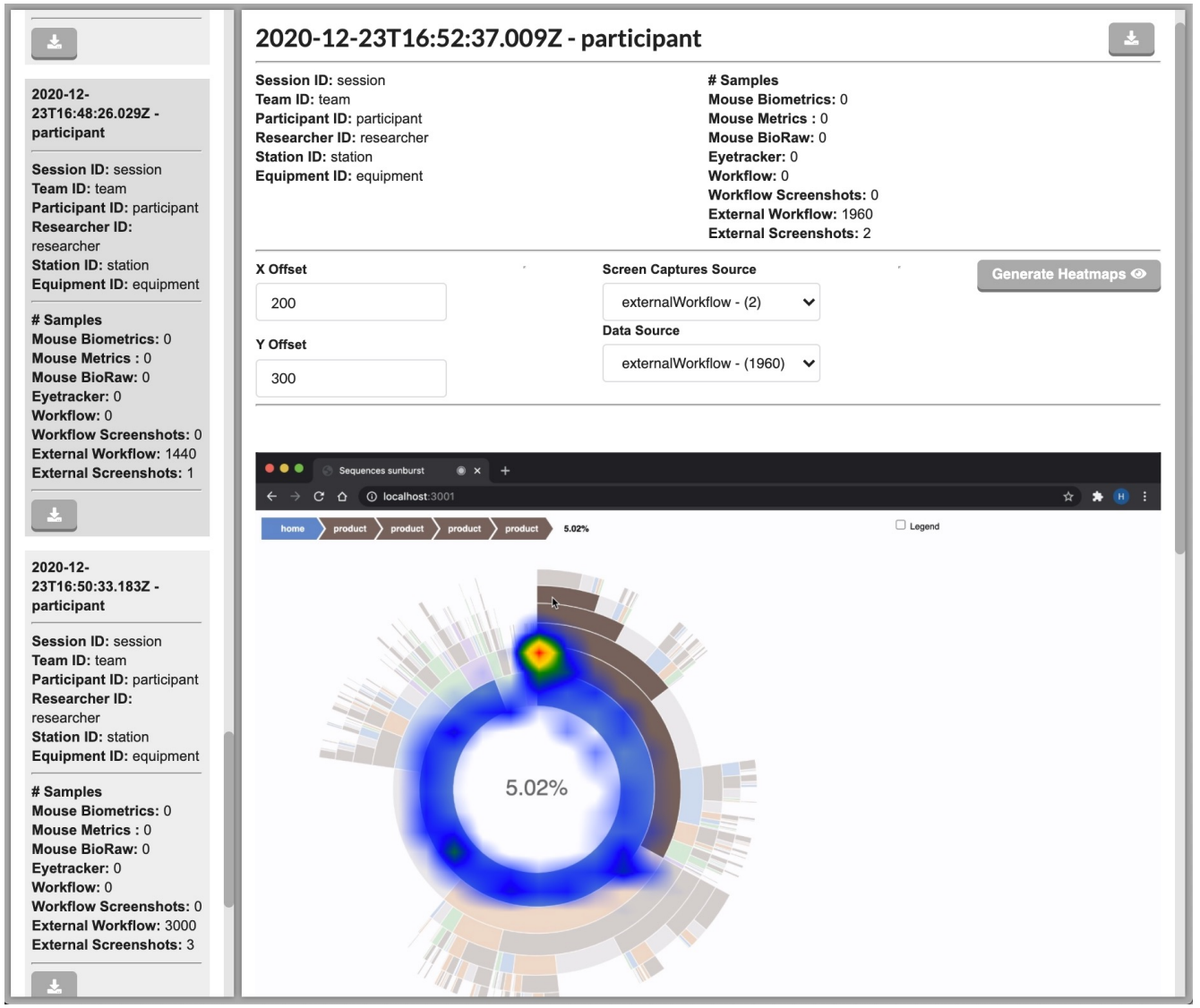
Data Analysis Page



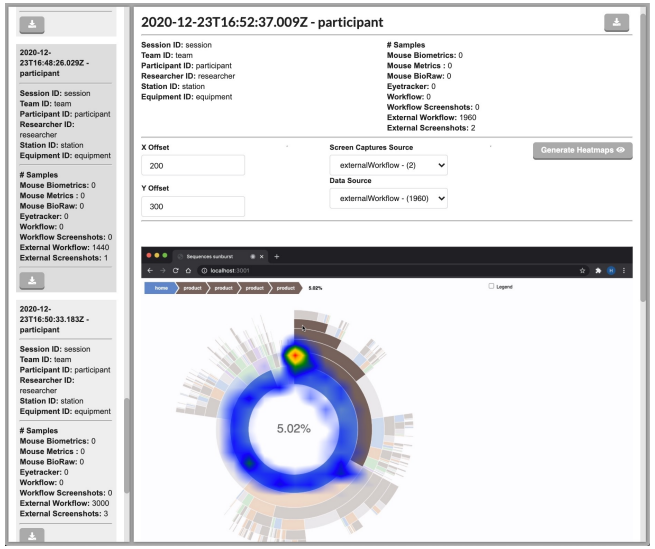
Applications of ISP

1. Data Collection

Conduct a study with ISP to collect data on participants performing computer tasks

2. Data Analysis

Analyze data to evaluate workload, fatigue, user workflow, or tool usage



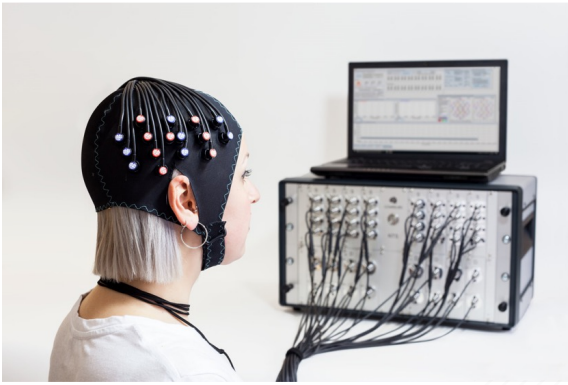
3. Recommendations

Make quantitative-based recommendations to improve operator training or tool design

We aim to enable physio-behavioral monitoring in human-centered evaluations research

Future Work

- **Expand the number and types of sensors**
  - **Proximity sensor to measure collaboration**
  - **Chat monitoring to measure communication**
  - **fNIRS to improve the capture of cognitive load**
  - **Remote sensors, such as eye tracking via webcams**
- **Expand the automatic analysis capability to provide workload and task performance information**
- **Validate that the Server is robust and that data collection is comprehensive**
- **Open Source ISP**



GitHub

Integrated Sensor Platform – Conclusion

- Developed ISP to streamline quantitative physiological data collection and analysis
- Multiple human-based sensors to link factors such as stress, workflow, etc., to the overall performance of the operators
- Currently integrates
  - Heart rate monitor built into a computer mouse
  - Low-cost eye tracker
  - Internally developed software workflow sensor
- Prototyped initial analysis visualizations
- Reduce barriers to to capturing quantitative measures of performance