

Orbio – Biometrics Made Easy

Helena Kaikkonen	Jianing Xu Wang	Nikita Zubairov	Benjamin Biberstein
University Of Washington	Polytechnic University of Catalonia	Technical University of Munich	ETH Zurich

1 INTRODUCTION

Our web application, titled Orbio, streamlines research studies involving real-time biometric data collected from smartwatches. Powered by CLAIID¹—ETH Zurich's cutting-edge "Closing the Loop on AI and Data Collection" platform, developed at the ADAMMA lab—our solution simplifies watch setup, study management, and the processing and visualization of biometric data. It empowers Principal Investigators (PIs) and users to effortlessly track study progress and visualize data in real time.

2 PROBLEM STATEMENT

Research studies involving biometric data from smartwatches often suffer from fragmented workflows and inefficient management. Principal Investigators (PIs) struggle to ensure consistent data collection, as gaps in data can go unnoticed, compromising research integrity. Existing platforms lack a centralized solution, making it difficult for PIs to monitor and control all aspects of the study in real time.

There is a clear need for an intuitive, easy-to-use platform that simplifies study management, streamlines smartwatch setup, and provides real-time monitoring to ensure continuous and reliable data collection. Additionally, the platform must allow PIs to easily manage and oversee multiple studies simultaneously.

2.1 Usage Scenario

Research studies involving biometric data collection often face challenges in efficiently gathering and managing participant data. Orbio bridges this gap by providing a web interface that connects smartwatches to research studies, enabling automated data collection and visualization.

2.2 Users

- Principal Investigators (PIs) that want to conduct a research study involving biometrics data from smartwatches.
- Users that have a smartwatch and want to visualize their watch's data and/or participate in a research study.

2.3 Current Solutions

Traditional methods for collecting biometric data in research studies often involve:

- Manual data collection during lab visits
- Proprietary hardware/software combinations
- Limited real-time data access
- Complex data management systems

3 APPROACH AND IMPLEMENTATION

3.1 Architecture Overview

The system is built with three main components:

- Web Interface (Frontend)
- API Server (Backend)
- Data Processing Scheduler

3.2 Key Design Choices

Dual User Interface:

- Separate views for PIs and study participants
- Role-based authentication system
- Customized dashboards for each user type
- Intuitive navigation and workflow

Data Visualization:

- Real-time data processing
- Multiple visualization options:

```
const API_CALLS = [
  {
    graph: BASE_URL + "/heartrate/graph",
    download: BASE_URL + "/heartrate/download",
    name: "Heart Rate",
  },
  {
    graph: BASE_URL + "/acceleration/xyz",
    download: BASE_URL + "/acceleration/download",
    name: "Acceleration in XYZ Axes",
  },
  {
    graph: BASE_URL + "/acceleration/vector",
    download: BASE_URL + "/acceleration/download",
    name: "Acceleration Vector Magnitude",
  }
];
```

3.3 Study Management

- Comprehensive study creation interface
- Participant tracking
- Document management (inclusion criteria, informed consent)
- Status tracking system:

```
<Box>
  <Heading size="sm" mb={3}>Study Details</Heading>
  <Stack gap={2}>
    <Text>Participants: {study.num_participants}</Text>
    <Text>Start Date: {new Date(study.start_date).toLocaleDateString()}</Text>
    <Text>End Date: {new Date(study.end_date).toLocaleDateString()}</Text>
    <Text>Duration: {formatDuration(study.duration)}</Text>
  </Stack>
</Box>
```

3.4 Implementation Details

User Authentication:

- JWT-based authentication
- Role-specific routing
- Secure password handling

User On-ramping and Configuration:

- Easy configuration file downloads and simple PDF instructions for users to quickly gain access to biomarker data

Orbio Configuration Instructions

1. [Download Android Studio](#) onto your computer if you don't already have it.

2. Download the configuration files below.

- [Project Files](#)
- [JSON Setup File](#)
- [Java Application File](#)

3. Follow the instructions in the linked PDF:

- [Instruction PDF](#)

Data Processing:

- Handles large volumes of sensor data
- Efficient data storage and retrieval
- Data resampling for performance optimization

Study Management

- Document version control
- Participant progress tracking
- Metric selection and monitoring
- Automated data collection

3.5 Alternative Designs Considered

Data Storage:

- Chosen: PostgreSQL with time-series optimization
- Alternative: MongoDB
 - Pros: Flexible schema, easier scaling
 - Cons: Less efficient for time-series data, complex aggregations

Authentication System:

- Chosen: Custom JWT implementation
- Alternative: OAuth2 with institutional providers
 - Pros: Easier integration with universities
 - Cons: More complex setup, external dependencies

Data Processing

- Chosen: Scheduled batch processing
- Alternative: Real-time processing
 - Pros: Immediate data availability
 - Cons: Higher server load, more complex error handling

4 SYSTEM SHOWCASE

4.1 Principal Investigator Journey

Study Creation and Setup:

```
<Text>
  <strong>Create a Study:</strong> Use the "Create Study" option to set up
  a new research study. You'll need to provide study details, duration, and
  required documentation.
</Text>
```

Participant Management:

- Monitor participant enrolment
- Track data collection progress
- Download participant data
- Manage study documentation

4.2 User Journey

Study Participation:

```
<Text>
  <strong>Join a Study:</strong> Enter the study code provided by the researcher,
  review the study details, and sign the informed consent form.
</Text>
```

Data Collection:

- Automated data collection from smartwatch
- Real-time data visualization
- Study progress tracking

5 USAGE DESCRIPTION

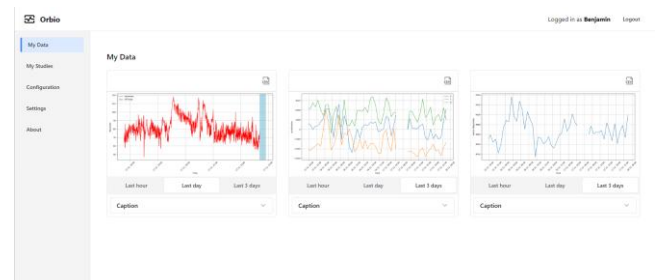
Users of Samsung Galaxy smartwatches can view their own biometric data in graph format and manage studies that they are participating in.

Principal investigators can create studies, manage participants and view each participants' data and their adherence to data collection.

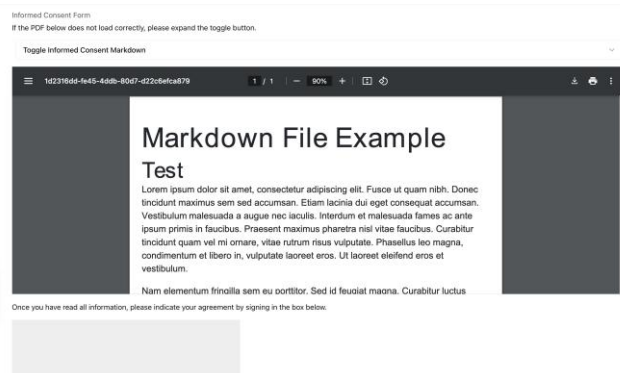
6 INTERFACE AND INTERACTION WORKFLOW

All interaction is done via the web application interface. The home page, shows the login/signup pages, which can be either as a user or as a Principal Investigator (PI).

- During signup as a user, detailed steps to install the software to collect biomarker data from smartwatch are shown. Once the setup is completed, data will be shown in approx. 10 minutes. Users can view their data, join a study via a study code and manage and track their studies, and change their profile data, accessing these views using the navigation bar.

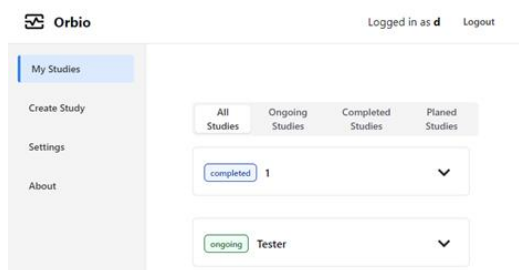


- Additionally, when joining a study, users will view a PDF in-browser of the Informed Consent form provided by the PI. Users can sign in a signature box directly on the website, and Orbio will automatically append this signature and the date to the PDF and store this.



- If logged in as a PI, PI's can directly create studies specifying the parameters desired for them easily, view all their studies (not started, ongoing or completed), and view a specific study's information and its participants when clicking on it, accessing these views using the navigation bar.

Both user and PI can access an "About" page that gives a description of all the functionalities, pages and how to use them. Furthermore, account information can be modified.



7 DISCUSSIONS

7.1 Lessons Learned

Data Volume Management:

- Early performance testing is crucial
- Data resampling strategies need careful consideration
- Balance between data resolution and system performance

User Experience:

- Clear documentation improves user understanding of functions
- Role-specific interfaces enhance usability
- Real-time feedback is essential for user engagement

System Architecture:

- Modular design facilitates maintenance
- Clear separation of concerns improves scalability
- Proper error handling is crucial for reliability

7.2 Limitations and Future Improvements

Current Limitations:

- Fixed data resampling rates
- Limited metric types
- Basic visualization options

- Manual document version control

Proposed Improvements:

- Dynamic data resampling based on visualization needs
- Additional metric support
- Advanced visualization options
- Automated anomaly detection
- Real-time alerts
- Integration with institutional authentication systems
- Enhanced data export capabilities
- Machine learning-based data analysis tools

8 CONCLUSION

Our main use case was accomplished, the interaction of principal investigators and users, and the management of studies and processing and visualization of biomarker data. Due to time constraints, the doctor use case was not implemented. While no major issues arose barring us from completing our main use cases, some minor backend/frontend integration challenges occurred regarding endpoint usage and implementation. Our primary conclusion is that we misjudged the time required to complete this project.

The following improvements remain for future development:

- Doctor View: A dedicated view for sharing biometric data with doctors to aid in diagnosis.
- Data visualizations: more interactive and better-looking graphs could be shown.
- Markdown Editor: Integration of a markdown editor within the "Create Study" page.
- Interactive Tutorial: A post-signup tutorial to guide users through the webapp.

REFERENCES

- [1] "Closing the Loop on AI and Data Collection". <https://claid.ethz.ch>.