

CSI 6900 Proposal

Programming an embedded smartwatch platform for collecting
physiological signals

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Introduction

Wearable technology has made significant strides in the healthcare field, offering new ways to monitor vital health metrics continuously. Smartwatches, equipped with sensors such as Photoplethysmography (PPG), are now capable of tracking vital signs like heart rate and other physiological signals, providing early indicators of potential health concerns. Monitoring physiological signals, such as oxygen levels in the blood and heart rate, can help detect respiratory and circulatory issues, offering valuable insight for both everyday health tracking and clinical applications [5].

PPG-based smartwatches have shown considerable promise in detecting conditions such as sleep apnea and respiratory disorder [2]. This project builds on these capabilities by developing an embedded smartwatch platform that collects physiological signal data in real-time. The data collected will be analyzed in conjunction with breathing patterns to provide a more comprehensive view of the user's health.

A novel aspect of our project is the use of physiological signal data, combined with breathing signals obtained by a radar platform, to identify individuals. As biometric technologies continue to evolve, physiological traits like heart rate and other vital signs are being explored as unique identifiers, offering a secure and non-invasive method for person identification. By using the continuous and personalized data collected from a smartwatch, it is possible to develop algorithms that can differentiate individuals based on their unique physiological signatures, which can open up possibilities for applications in security and user authentication.

Project Scope and Objectives

This project aims to develop an embedded smartwatch platform that collects and analyzes physiological signal data in real-time. My role involves programming and integrating the Health Sensor Platform 3.0 (MAREFDES104) as a core component of this smartwatch. This platform, equipped with sensors such as Photoplethysmography (PPG), will collect physiological data, which is crucial for monitoring a user's respiratory and cardiovascular health.

The collected physiological signal data will be analyzed in conjunction with breathing patterns gathered through a radar-based platform in collaboration with another project. This combined analysis has the potential to serve not only as a health monitoring tool but also for biometric identification, leveraging unique physiological patterns such as heart rate and other key signals. This aspect of biometric identification can enhance security applications, including user authentication and identity verification while maintaining a non-invasive approach.

Data privacy is paramount in this project. No data will be collected from any user without their explicit consent and registration for the project. The focus on both health tracking and privacy ensures that the smartwatch platform will meet ethical standards in data handling and user privacy.

The major learning objectives of this project are outlined as follows:

- Gaining expertise in embedded programming by working with the Health Sensor Platform 3.0 (MAREFDES104);
- Utilizing and configuring an accelerometer to improve data collection and analysis;
- Collecting and processing physiological signal data from real-life, real-time scenarios;
- Exploring advanced methods for analyzing physiological signal data in conjunction with breathing signals, aiming for person identification applications.

Workplan

Date Range	Task
09-09 ~ 09-16	Review & Method Research
09-17 ~ 09-24	Familiarization with the Health Sensor Platform 3.0
09-25 ~ 10-10	Begin embedded programming for data collection; initial code implementation for reading physiological signals.
10-11 ~ 10-18	Further, refine the code for stable data collection; implement data logging functionality and test on multiple subjects.
10-19 ~ 10-26	Begin testing the embedded smartwatch platform in real-world environments, collecting continuous physiological signals and breathing data.
10-27 ~ 11-04	Continue debugging and optimizing the embedded code.
11-05 ~ 11-20	Develop methods for integrating radar-based breathing signals with physiological signal data; start building algorithms for combined data analysis.
11-21 ~ 11-28	Analyze the collected data to assess identification accuracy; refine algorithms for improved biometric recognition.

11-29 ~ 12-14	Finalize project report; document the findings, challenges, and potential future improvements. Prepare for project presentation.
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Evaluation Criteria & Marking Scheme

This project will be evaluated based on the following key deliverables:

1. **Embedded Smartwatch Platform Development:**

- Successful programming and integration of the Health Sensor Platform 3.0 (MAREFDES104) for physiological signal data collection.
 - Implementation of real-time physiological data collection with stable performance and data logging functionality.
- (40%)

2. **Data Processing & Integration:**

- Development and implementation of methods for integrating physiological signal data with breathing signals from the radar platform.
 - Proper synchronization of the data and initial tests for person identification.
- (20%)

3. **Biometric Identification:**

- Designing and implementing algorithms for biometric identification based on physiological and breathing patterns.
 - Testing the accuracy of identification algorithms and refining them for improved performance.
- (20%)

4. **Final Report and Presentation:**

- A comprehensive report documenting the methodology, system development, data analysis, challenges faced, and final outcomes.
 - A formal presentation of the project, including results and potential future improvements.
- (20%)

References

- [1] Montenegro, M., 2022. Design, development and testing of a smart ring to monitor pulse rate and oxygen saturation.
- [2] Yibing Chen, Weifang Wang, Yutao Guo, Hui Zhang, Yundai Chen & Lixin Xie (2021) A Single-Center Validation of the Accuracy of a Photoplethysmography-Based Smartwatch for Screening Obstructive Sleep Apnea, *Nature and Science of Sleep*, , 1533-1544, DOI: 10.2147/NSS.S323286.
- [3] Jiang Y, Spies C, Magin J, Bhosai SJ, Snyder L, Dunn J (2023) Investigating the accuracy of blood oxygen saturation measurements in common consumer smartwatches. *PLOS Digit Health* 2(7): e0000296. <https://doi.org/10.1371/journal.pdig.0000296>.
- [4] Bin K, De Pretto L, Sanchez F, Battistella L, Digital Platform to Continuously Monitor Patients Using a Smartwatch: Preliminary Report, *JMIR Form Res* 2022;6(9):e40468, URL: <https://formative.jmir.org/2022/9/e40468>, DOI: 10.2196/40468.
- [5] Fu, Y. and Liu, J., 2015. System design for wearable blood oxygen saturation and pulse measurement device. *Procedia manufacturing*, 3, pp.1187-1194.