From Pixels to Physiology: Real-Time Algorithm Development for Telemedical Applications

Bachelor/Master project "Information Systems"

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1: Project Overview

Background: Due to the decreasing number of hospitals in Germany, the need for telemedical solutions is growing to ensure comprehensive healthcare coverage. Remote photoplethysmography (rPPG) offers a promising solution.

Project Goal: Implementation of a real-time rPPG algorithm to assess physiological parameters and contribute to the development of innovative telemedical solutions.

Highlights: Work with a large dataset; deep-dive into applied machine learning; close cooperation with the chair team; final prototype suitable for inclusion in a personal portfolio

2: Project Background

The decline in the number of hospitals in Germany – from 2,354 in 1993 to 1,874 in 2023 (Statistisches Bundesamt, 2024) – has led to a growing need for telemedical solutions to maintain comprehensive healthcare coverage. Such solutions are particularly crucial for elderly individuals and people with disabilities, who often face challenges in reaching medical facilities. Among different approaches, remote measurement of vital signs, such as heart rate and oxygen saturation, is emerging as a promising solution. Remote photoplethysmography (rPPG) algorithms enable contactless measurements using standard low-cost RGB cameras. Subtle changes in skin color caused by pulsatile blood flow can be captured through video analysis (Ayat et al., 2024). This solution has the potential to reduce the need for in-person visits, allowing patients to attend medical consultations from home.

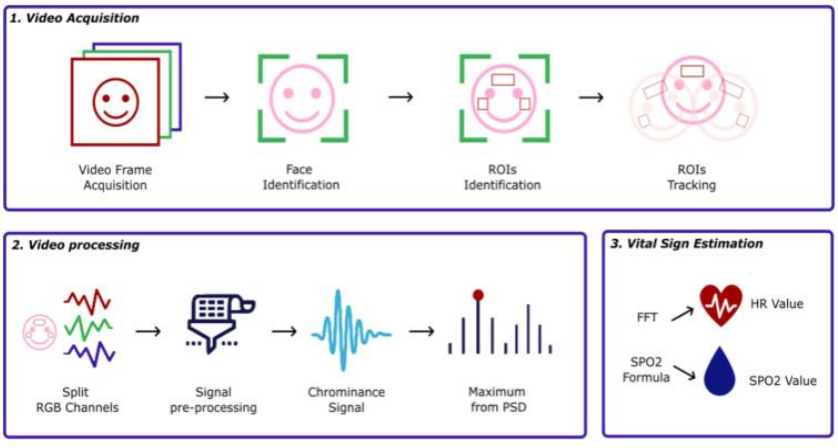

Figure 1 rPPG methodology for physiological parameter estimation by Casalino et al. (2025)

In recent years, numerous datasets and open-source tools have been made publicly available to support the development and evaluation of rPPG algorithms (Demirhan & Ricanek, 2023). However, most available tools focus on post-processed data rather than real-time monitoring

(Casalino et al., 2025), which limits their usability in practical scenarios. First steps toward real-time applications have been introduced by Ayat et al. (2024), Casalino et al. (2025), and Gopi and Dehbozorgi (2024). As illustrated in Figure 1, successful rPPG measurement consists of three main steps: (1) video acquisition, (2) video processing, and (3) vital sign estimation.

3: Project Objective

The overreaching goals of this project are:

- Development of a reliable real-time rPPG framework
- Creation and implementation of the framework
- Exploring applied use cases for real-time rPPG assessment
- Evaluation of the framework

The objective of this Bachelor/Master project is to lay the foundation for a real-time rPPG algorithm using machine learning methods such as face detection and region of interest selection. Currently, available algorithms focus on post-processing, which limits their application in real-life settings. This project addresses this problem and aims to develop and implement a real-time rPPG algorithm. To train this algorithm, students will be given access to the UBFC-Phys dataset containing PPG signals and video data. Following successful training, participating students will collect data from a small sample to validate the algorithm using a mobile measurement device (e.g. an ECG chest strap). For validation, this data will then be compared with the rPPG algorithm data and evaluated against selected performance metrics, such as mean absolute error or root mean square error. Students will be given access to the necessary measurement equipment during the project.

The objectives of this specific project are the following:

- **Development** of a methodological framework to process real-time rPPG data
- **Implementation** of the framework and the algorithm
- **Assessment** of the algorithm's performance metrics to ensure successful training
- **Visualization** of real-time measurements
- **Evaluation** of the algorithm with self-gathered data

Depending on group size, adjustments to the project scope can be made. Adjustments will be announced at the kickoff and/or in subsequent milestone meetings. Each finished artifact has to be properly documented to facilitate understanding and further development by students in follow-up projects.

4: Project Registration and further Information

Bachelor and master students interested in this project may send their application to Cosima v. Uechtritz (cosima.uechtritz@ris.uni-due.de). Please attach to your mail:

- Your current **Transcript of Records**
- A short **letter of motivation**

The deadline for application is **Tuesday, 07.10.2025, 23:59.**

You can apply as a group. To do so, each person in that group has to submit an individual application where all group members are specified.

If the number of applications exceeds our capacities, we will select participants based on their prior knowledge and academic performance.

For successful completion of the project, master students receive 12 ECTS (corresponding to 360 working hours), and bachelor students receive 6 ECTS (corresponding to 180 working hours)

- Master students will invest 18 hours per week into the project.
- Bachelor students will invest 9 hours per week into the project.

5: Project Schedule (Dates are to be announced)

Kickoff	Kickoff with accepted participants Clarify project scope and responsibilities
Milestone 1	Development of a methodological framework
Milestone 2	Implementation of the methodological framework
Milestone 3	Visualization of real-time measurements Evaluation of algorithm performance
Milestone 4	Planning and execution of evaluation study Data collection of minimum n = group size
Milestone 5	Scientific poster presentation
Milestone 6	Submission of project report

6: Grading

The final grade will be calculated based on the sum of the milestones:

- Milestone 1: 15%
- Milestone 2: 20%
- Milestone 3: 10%
- Milestone 4: 15%
- Milestone 5: 20%
- Milestone 6: 20%

7: Sources

- Ayat, Y., Moussati, A. E., Mir, I., & Abdelaziz, E. A. (2024). Low-Cost rPPG Application for Real-Time Heart Rate Monitoring: Robustness Analysis of Signal Processing Technigques. *International Conference on Digital Technologies and Applications*, 301–311.
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- Demirhan, H., & Ricanek, K. (2023, July). A Review of Face Processing for Telehealth: Research Survey of Remote Visual Photoplethysmography (rvPPG). In *2023 Congress in Computer Science, Computer Engineering, & Applied Computing (CSCE)* (pp. 1360-1367). IEEE.
- Gopi, S., & Dehbozorgi, N. (2024). SerenePulse: A Web App Pipeline for Real-time Physiological Monitoring Using rPPG and OpenAI LLMs. In *2024 ASEE Annual Conference & Exposition*.
- Statistisches Bundesamt (Destatis). (2024). *Hospitals: Germany, years, facilities, beds, cases, length of stay*. Retrieved June 15, 2025, from https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Gesundheit/Krankenhaeuser/Tabellen/gd-krankenhaeuser-jahre.html, retrieved 15.06.2025