# Vital Signs Assessment for Health Monitoring Using Arm Wearable Multi-Sensor Device

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## Introduction

In highly demanding physical or mental activities e.g., fire fighter, soldiers, drivers or sports athletes, health monitoring is an extremely critical task to prevent collapse and/or avoid serious accidents. Collecting and analysing together vital signs such as heart rate (HR), heart rate variability (HRV), respiratory rate (RR), oxygen saturation (SpO2), core body temperature (CBT) and blood pressure (BP), provide information that allows to: assess a person's state of health, identify the presence of abnormalities or report critical health situations. RUAG AG is interested in a wearable device able to collect vital signs of the soldiers deployed in the field, in order to conduct remote health monitoring for improving military and rescue performance. However, standard positions for collecting vital signs on chest or on the wrist are not suitable because over time or during physical activity they become uncomfortable and other equipment could interfere or collide with the sensors.

## Materials and Methods

A feasibility study for a comfortable and continuous acquisition of physiological signals in different body locations has been performed. The study was conducted to compare chest and arm measurements quality, determine which vital signs could be measured and evaluate the pros/cons of both positions. The comparison procedure involves the simultaneous acquisition of ECG and PPG on both arm and "gold-standard" reference location.
An arm-system prototype has been developed in a previous master's thesis showing positive results in terms of measurements quality and better wearability [1]. The study also serves to assess the reliability of the prototype and to improve its signal acquisition performance. Implementation and validation of algorithms to extract vital signs from measured physiological signals was also part of the feasibility study.

## Results

Arm-ECG showed main differences in the shape and in the QRS complex amplitude which is reduced to ≈10% compared to the chest-ECG. The QRS detection quality for the R-R intervals (RRi) computation was defined as the ratio between corrected and total detections. Errors were due to false or missing QRS detections. The overall detection quality obtained with the arm-ECG at rest, during low-intensity activity and walking, was 98.8%.

An average RRi difference < 1ms between arm and chest-ECG was measured. Arm-PPG results showed that green wavelength is the most suited as is the less affected by motion artefacts in pulse peak/valley detection, allowing reliable RR and BP estimation. A new flexible PCB for arm-ECG was manufactured.

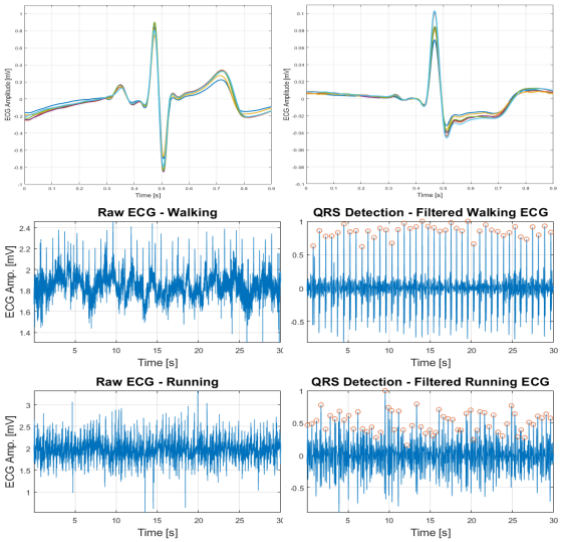


*Fig. 1 Average waveform computed from chest (left) and arm (right) ECG. Raw signals acquired while walking and running with the respective QRS detection on filtered signal.*

## Discussion

With a single wearable ECG-PPG device on the arm, it was possible to extract vital signs needed for health monitoring even during physical activities. For PPG, an algorithm against arm movement artefacts and the optimisation of red and IR lights acquisition would help to extract vital signs in more intense physical activities. ECG recording quality improved with the new flex PCB avoiding the limitations encountered with the first prototype version.

## References

[1] G. Cairoli. Quantifiable fatigue risk assessment using a non-invasive multi-sensor device. Master's thesis, University of Bern, Switzerland, 2022.

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