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Fig1. System composition: Fitbit Surge smartwatch and smartphone.

# SHRAM

## SMART HEART RATE AND ACTIVITY MONITORING

### Motivation and Goals

Living in a society where everybody is busy and lives under stress, heart rate irregularities may occur without noticing, with harmful consequences on health. This project aims to study if it is viable to use a smartwatch for continuous heart rate monitoring, in combination with activity monitoring, to improve current activity related features and detect abnormalities that other way might go unnoticed.

### Project

The possibility of using a smartwatch for heart rate monitoring was evaluated comparing the Fitbit Surge performance against a Zephyr Bioharness 3 chest strap, through a validity test, performing different activities. The application of Heart Rate Variability Techniques and how their patterns are related with the activities being performed was focused. Besides this, another research topic included the study of how the heart rate data and its features can be used to improve activity monitoring analysis, specially the energy expenditure. A model that combines both activity and heart rate data and another model that uses only heart rate data were applied on a dataset and compared, along with the activity based model, with the indirect calorimetry. Finally, a heart rate and activity monitoring system was developed, in which the activity is monitored by the MoverLib and the heart rate is monitored by the Fitbit Surge smartwatch.

This system compares the heart rate value with the activity performed and


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## HR validity test

Eight volunteers (25,6 ± 2,1 aged), including five men and three women, participated in this test, performing different activities: sitting, standing, walking, running and ascending/descending stairs. The evaluated metrics included:

- Accuracy: 100%-mean absolute percentage error
- Reliability: % of samples in which the absolute error is <10 Beats Per Minute (BPM)

## Energy Expenditure study

The dataset used included data from 13 subjects, with an average age of 33,2 ± 9,1 years, wearing a heart rate chest strap monitor and performing a stress test, in which the energy expenditure was measured through indirect calorimetry and an activity based model, which used data provided by the smartphone's accelerometer that was located in the subject's belt.

## Future Work

- Integrate an energy expenditure algorithm that combines activity and heart rate data, provided by the smartwatch
- Explore the stress state detection through activity and heart rate


Fig2. Screenshots of SHRAM application key features. Left: Main page. Middle: Heart rate plot with threshold crossings signalized. Right: Daily Summary.

detects if it is abnormal of not for the physical effort required. It details the heart rate value throughout the day and computes the time spent in each cardiac zone, which is established using the theoretical maximum heart rate. Furthermore, it holds the activity data, including the number of steps, activity performed and also the energy expended.

# Results

The Fitbit Surge smartwatch achieved a reliability score of 75,39% and an accuracy value of 93,80%. Further, these metrics demonstrated a good retest reliability, with Intraclass Correlation Coefficient (ICC) scores of 0,61 and 0,65, respectively. The mean error obtained was 4,21 Beats Per Minute (BPM) and the mean absolute error was 7,22 BPM. The walking and running activities were the ones with lowest reliability and higher data dispersion, although they were also the activities with higher number of samples. The accuracy value was within the values presented in literature but the reliability was lower than the expected. However, in average the heart rate values provided by the chest strap and smartwatch were concordant, reason why it can be considered that the reliability achieved is sufficient to monitor the heart rate in a daily basis.

The energy expenditure model that included both activity and heart rate data achieved a Normalized Root Mean Squared Error (NRMSE) of 19,9%, against a NRMSE of 35,1% achieved by the energy expenditure activity based model that is currently used by the MoverLib. Results are described in Fig3.

| Assessments | Test | Retest |
|---|---|---|
| Accuracy (%) | 94,15 | 93,45 |
| Reliability | 75,83 | 74,94 |
| Mean Error (BPM) | 4,55 | 3,88 |
| Mean Absolute Error (BPM) | 7,43 | 7,01 |

| Energy Expenditure Model | NRMSE | Corr ($r^2$) |
|---|---|---|
| Activity Based | 35,1% | 0,88 |
| Heart Rate Based | 23,5% | 0,90 |
| Combined HR-Activity | 19,9% | 0,92 |

Fig3. Results obtained in validity test and Energy Expenditure study.