# An ECG-based System for Respiratory Rate Estimation Tested on a Wearable Armband During Daily Life

Jesús Lázaro, Natasa Reljin, Raquel Bailón, Eduardo Gil, Yeonsik Noh, Pablo Laguna, Ki H Chon

University of Zaragoza
Zaragoza, Spain

An approach to estimation of respiratory rate (RR) during daily life by using a wearable armband is presented. This wearable armband provides three electrocardiogram (ECG) channels, and RR can be estimated from them by using ECG derived respiration (EDR) techniques. The armband has been previously reported to successfully monitor RR during lab-controlled restricted-movement conditions. In this study, a first attempt to RR monitoring using the armband during daily life is performed.

Five healthy volunteers wore the armband during 24 hours, with the only instruction of not exercising. In addition, reference ECG signals were simultaneously recorded by a market-available 3-channel Holter monitor. A literature-available EDR technique based on QRS slopes and R-wave angle was used together with a fusion method that combines the information in the different EDR signals based on the shape of their spectra. Furthermore, the output of this fusion technique becomes a "non-estimable rate" in those cases in which none of the spectra has an appropriate shape. These algorithms were used with both armband- and Holter-acquired ECG signals, obtaining RR estimations from both devices. Subsequently, the percentage of armband's accurate RR estimations (differing less than 5% from the Holter estimation) with respect to the total number of Holter's estimations was computed ($R_1$). In addition, the percentage of accurate armband's RR estimations with respect to the total number of armband's estimations was also computed ($R_2$).

Obtained $R_1$ (%) and $R_2$ (%) for the 5 subjects (non-bed / bed time).

| | Subject 1 | Subject 2 | Subject 3 | Subject 4 | Subject 5 |
|---|---|---|---|---|---|
| $R_1$ | 26.59/78.13 | 34.01/63.05 | 50.08/70.12 | 49.11/76.39 | 73.00/88.73 |
| $R_2$ | 60.89/84.42 | 75.31/93.35 | 79.30/81.65 | 87.44/83.29 | 94.57/97.38 |

$R_1$ ranged from 26.59% to 73% during non-bed time, and from 63.05% to 88.73% during bed time. On the other hand, $R_2$ ranged from 60.89% to 94.57% during non-bed time, and from 81.65% to 97.38% during bed time. These results are promising and suggest that the armband may be useful for RR monitoring in some applications. However, an artifact detector specifically focused on detecting those segments which are usable for RR detection needs to be developed.