Prediction of Physical Exertion Using Wearable Heart Rate and Movement Sensors

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Motivation

- Intensity quantification is an important aspect of weight training to adjust training routines and prevent injuries
- Training intensity can be measured objectively (e.g., running speed) or subjectively (e.g., ratings of perceived exertion (RPE))
- For RPEs, commonly the Borg scale is used which is in the interval [6, 20], with 6=no exertion, 20=highly exhausted
- Goal: estimate RPE values using multi-modal sensor fusion on the fly during training

Study Setup

- 16 subjects performed the squat exercise on the FlyWheel according to the protocol (see fig. 1)
- Subjects were attached to a belt that is connected to the wheel, by spinning the wheel inertia is created (see fig. 1)
- Used multiple sensors: 6 inertial measurement units (full-body setup), electrocardiography to obtain heart-rate variability parameters (HRV), and RGB+D cameras (RGB images, 3D point clouds and skeleton tracking)

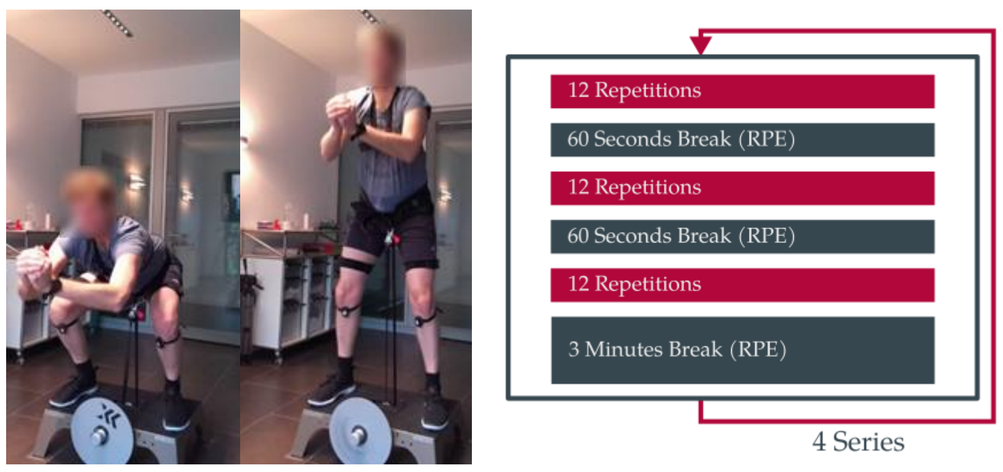

Figure 1: Setup overivew. Left: Subject performing exercises on The FlyWheel platform. Right: The study protocol.

Methods

- Calculated handcrafted features from the preprocessed multimodal sensor data
- Used sliding window approach with different overlaps and window sizes
- Trained conventional machine learning models to predict RPE values: Support Vector Regression (SVR), Random Forest (RF), Gradient Boosting Regression Trees (GBRT)

Results

- Best performing model: Gradient Boosting Regression Trees
- MAPE=7.71%, R^2=0.48, Pearson correlation=85%
- Figure 2 shows predictions of model for individual windows and aggregated over sets (mean +- std)

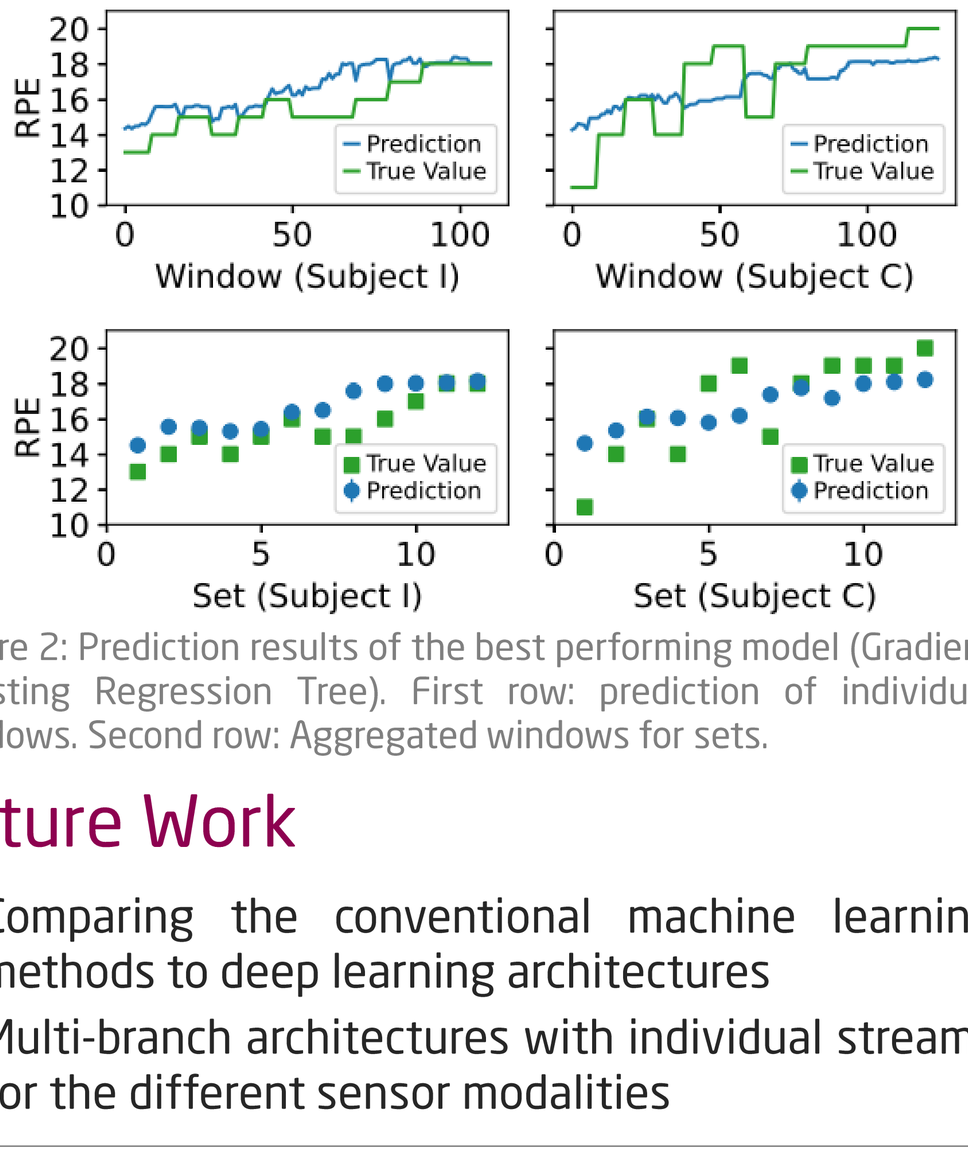

Figure 2: Prediction results of the best performing model (Gradient Boosting Regression Tree). First row: prediction of individual windows. Second row: Aggregated windows for sets.

Future Work

- Comparing the conventional machine learning methods to deep learning architectures
- Multi-branch architectures with individual streams for the different sensor modalities

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