Statistical prediction of hand-load carrying strategy and load level from wearable inertial sensor data

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Objective

To develop and validate a statistical prediction algorithm that uses body-worn inertial sensor data for classifying load carrying strategy and load level in workers.

Motivation

- Work tasks such as carrying heavy hand-loads often and over long durations are known risk factors for low back disorders in workers.
- Work-related overexertion events, dominated by low back disorders and pain, cost the US $13.8 billion each year [1].
- Measuring workers exposures to carrying is an important step towards managing and reducing the prevalence of low back disorders.

Methods

1. Instrumentation

   Inertial sensor (APDM Inc.)
   Sampling freq.: 80 Hz
   R & L Thigh
   R & L Shank

2. Collected data from 10 right-handed males in simulated carrying tasks

3. Algorithmically detect gait events from inertial sensor data [2]

4. Compute predictor variables = 24 Gait parameters for each cycle

5. Implemented Random Forest [3]

6. Predict Carrying Strategy [stage 1]

   2H Side carry

7. Predict Load Level [stage 2]

   2.36 kg
   50% Max Load
   75% Max Load

   75% Max Load

Sample gait trajectory

Model Performance

Based on 10-fold holdout cross-validation repeated 20 times

<table>
<thead>
<tr>
<th>Actual strategy</th>
<th>Predicted strategy</th>
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<tbody>
<tr>
<td>Ref 1H, R, 1H, L 2H side 2H Ant</td>
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Model Interpretation

Top 5 important variables for carrying strategy (top) & loads (bottom)

- Torso-pelvis phase angle, coronal plane
- Coronal ROM at T6
- Pelvis flexion
- Knee flexion ROM
- Torsa-pelvis phase angle, transverse plane

Conclusions

- A two-stage random forest algorithm correctly classified the carrying strategy and load level in 389 out of 478 (81.3%) gait cycles
- Wearable sensor data combined with statistical prediction demonstrate strong potential for measuring workers exposures to physically demanding tasks over time.
- Our goal is to develop low-cost personalized tools for assessing physical workload and injury risk in workers engaged in physical labor.

References


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