Automatic Classification of Sport Exercises for Training Support

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Goals in Sports

- muscle size
- body weight
- performance

training
Training Schedule

- **Monday**: Week 1 - 5.6 km/h
- **Wednesday**: 5.6 km/h
- **Friday**: 8.3 km/h

- **Week 2**: Monday - 50 watt, Wednesday - 100 watt, Friday - 100 watt
Feedback

training schedule

coach

feedback

athlete

### Monday
- **Week 1**: 5.6 km/h

### Wednesday
- **Week 1**: 5.6 km/h

### Friday
- **Week 1**: 8.3 km/h

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### Week 2
- **Monday**: 50 watt
- **Wednesday**: 100 watt
- **Friday**: 100 watt
Feedback

- self reports
- sensors
  - physiological
  - motion

[6]
Idea

automatic classification of sport exercises for training support
Pattern Recognition Pipeline

data acquisition → preprocessing → feature extraction → feature selection → classification
Data Acquisition

- Data acquisition
- Preprocessing
- Feature extraction
- Feature selection
- Classification

<table>
<thead>
<tr>
<th>3-D accelerometer</th>
<th>6g</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-D gyroscope</td>
<td>500 deg/s 2000 deg/s</td>
</tr>
<tr>
<td>Sampling rate</td>
<td>200 Hz</td>
</tr>
<tr>
<td>Storage</td>
<td>SD card</td>
</tr>
</tbody>
</table>
Data Acquisition

- **treadmill**
  - 5.6 km/h
  - 8.3 km/h

- **bicycling**
  - 50 watt (70 rev. / min)
  - 100 watt (70 rev. / min)

120 s
Preprocessing

- Data acquisition
- Preprocessing
- Feature extraction
- Feature selection
- Classification

Graph showing vertical acceleration over time. The graph shows two segments of 5 seconds each, with the second segment almost flat. The x-axis represents time in seconds, and the y-axis represents vertical acceleration in g.
Feature Extraction

- Data acquisition
- Preprocessing
- Feature extraction
- Feature selection
- Classification

4 sensors \times 6 \text{ axes} \times 7 \text{ features} = 168

- 5 LPC coefficients
- Spectral centroid
- Bandwidth

LPC: linear predictive coding
Feature Extraction (Spectral Centroid)

Data acquisition → Preprocessing → Feature extraction → Feature selection → Classification

treadmill

5.6 km/h

8.3 km/h

Spectral centroid
Feature Selection

- reduction of number of features
- sequential forward selection
- leave-one-subject-out cross-validation
Classification

data acquisition → preprocessing → feature extraction → feature selection → classification

level 1

feature 1

level 2

5.6 km/h
8.3 km/h
50 watt
100 watt
Classification

- Support Vector Machine (SVM)
  - linear kernel
  - cost parameter: C = 1

- classification rate
  - class dependent mean
  - overall mean
# Classification Rates

## level 1

<table>
<thead>
<tr>
<th>Activity</th>
<th>Class Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>treadmill</td>
<td>97.3 %</td>
</tr>
<tr>
<td>bicycling</td>
<td>99.0 %</td>
</tr>
<tr>
<td>mean</td>
<td>98.2 %</td>
</tr>
</tbody>
</table>

## level 2

<table>
<thead>
<tr>
<th>Speed</th>
<th>Class Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.6 km/h</td>
<td>99.6 %</td>
</tr>
<tr>
<td>8.3 km/h</td>
<td>98.3 %</td>
</tr>
<tr>
<td>mean</td>
<td>99.0 %</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Power</th>
<th>Class Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 watt</td>
<td>60.5 %</td>
</tr>
<tr>
<td>100 watt</td>
<td>61.6 %</td>
</tr>
<tr>
<td>mean</td>
<td>61.1 %</td>
</tr>
</tbody>
</table>
Bicycling

![Graph showing vertical acceleration over time for 50 watt and 100 watt power levels.]

- 50 watt
- 100 watt
Feature Selection: Sensor Placement

Level 1
- Hip
- Wrist
- Ankle
- Chest

Level 2
- Hip
- Wrist
- Chest
- Ankle
Feature Selection: Sensor Type

level 1

level 2

accel

gyro

accel

gyro
Summary

coach \(\xrightarrow{\text{training schedule}}\) athlete

feedback

data acquisition \(\xrightarrow{\text{preprocessing}}\) feature extraction \(\xrightarrow{\text{feature selection}}\) classification

<table>
<thead>
<tr>
<th></th>
<th>treadmill / bicycling</th>
<th>two treadmill levels</th>
<th>two bicycling levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>class rate</td>
<td>98.2 %</td>
<td>99.0 %</td>
<td>61.1 %</td>
</tr>
</tbody>
</table>
Outlook

additional elements
exercises

[8]
sensors

[10]
detail level increasement
number of steps

[9]
quality of exercise execution

[11]
Thank you for your attention!
References