Classification of Daily Life Activities by Decision Level Fusion of Inertial Sensor Data

Dominik Schuldhaus, Heike Leutheuser, Bjoern M. Eskofier
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Digital Sports Group
Pattern Recognition Lab, University of Erlangen-Nuremberg, Germany

Universitätsklinikum Erlangen

ASTRUM IT

adidas

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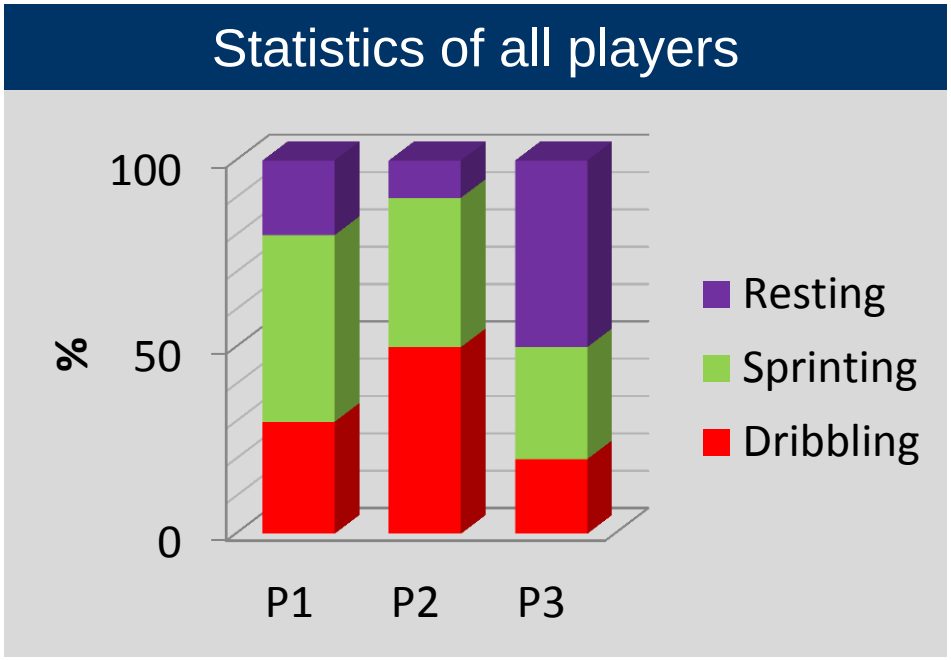
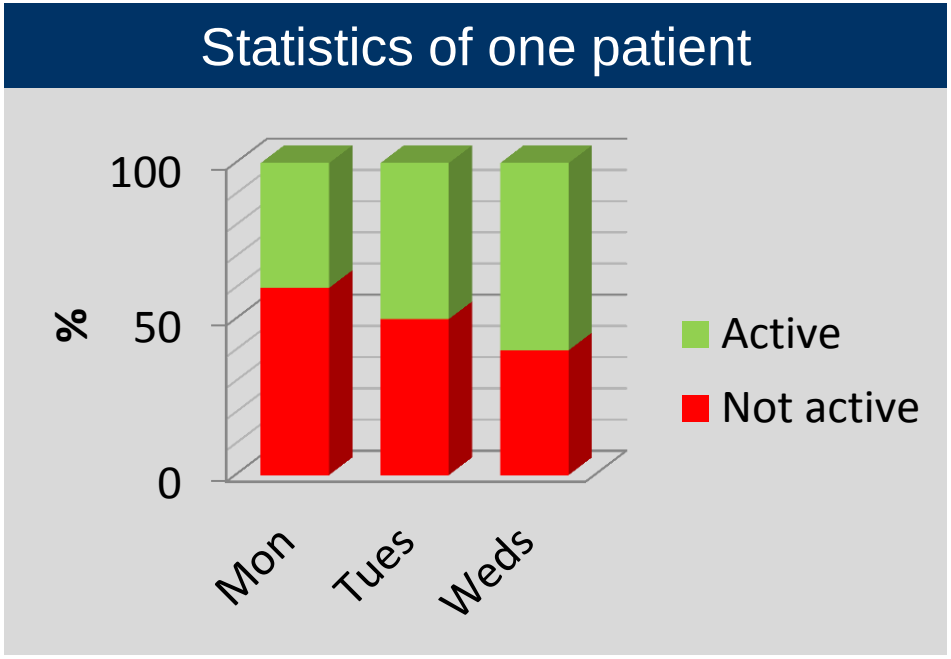
Sports Application

[www.onwardstate.com]



Medical Application

[www.dispensepoint.com]

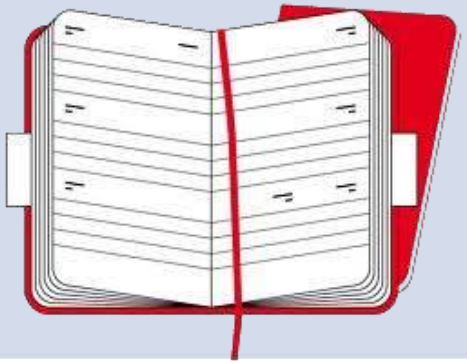


Activity Recognition

Activity recognition

Monitoring of Activities

Self reports



[www.mojolondon.co.uk]

[www.shimmersensing.com]
[www.adidas.com]

Sensor-based Activity Recognition

Literature

- 2004: Bao et al.
- 2006: Pärkkä et al.
- 2012: Liu et al.
- 2012: Varkey et al.
- 2013: Leutheuser et al.

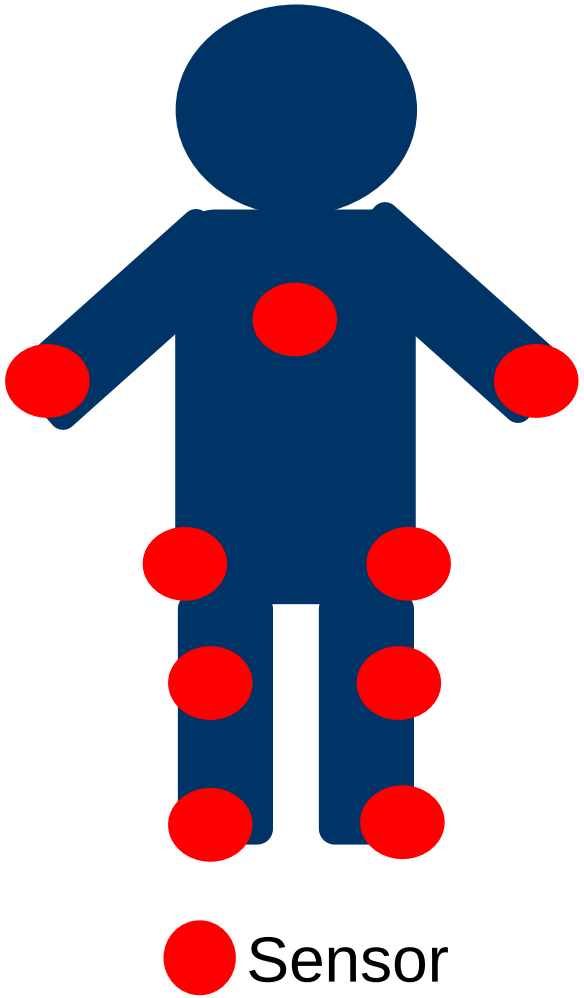
Multiple sensors

Classification of daily life activities

- Sitting
- Walking
- Vacuuming
- ...

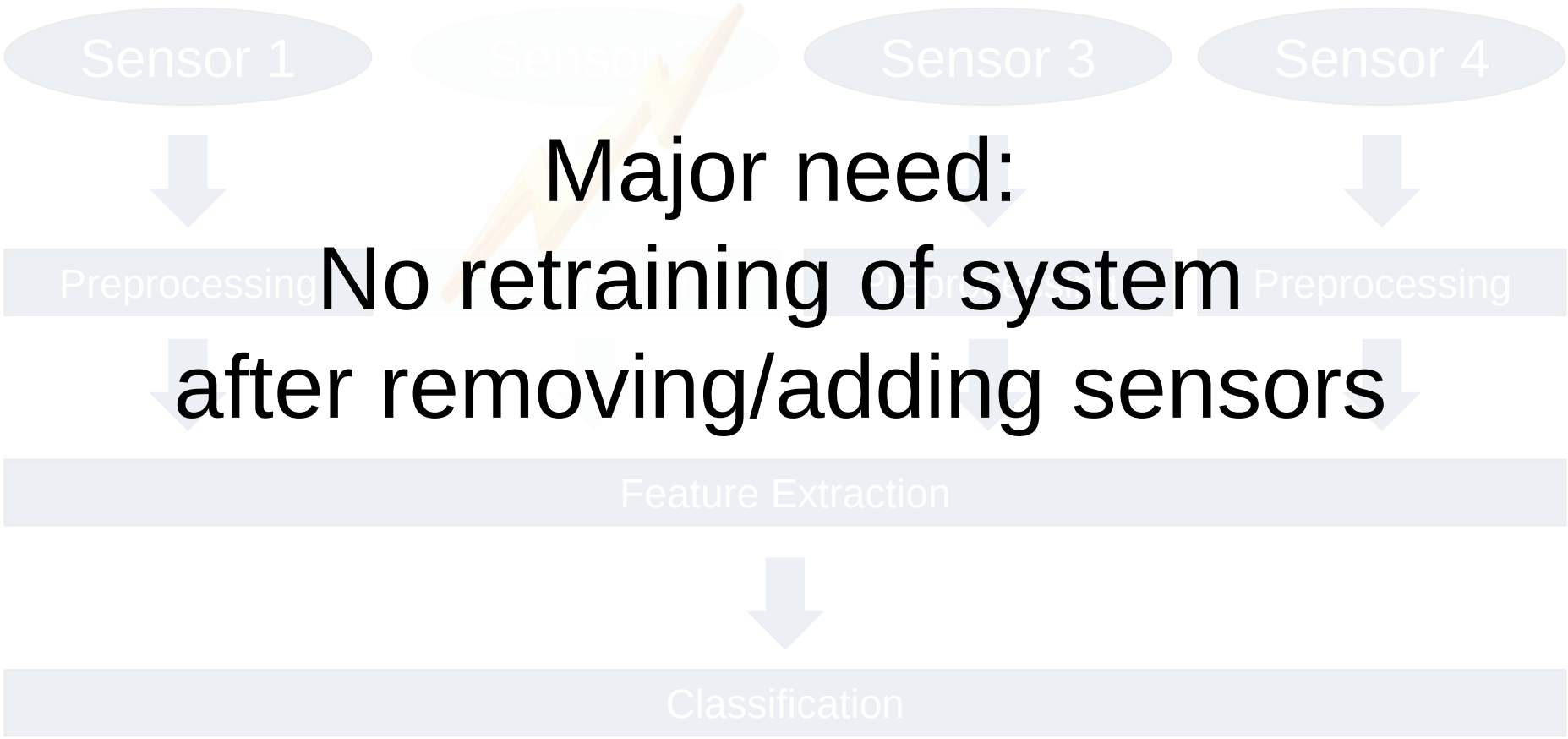
Comparison of algorithms difficult

- No common used benchmark dataset



Leutheuser H, Schuldhaus D, Eskofier B M (2013), Hierarchical, Multi-Sensor Based Classification of Daily Life Activities: Comparison with State-of-the-art Algorithms Using a Benchmark Dataset.
PLoS ONE. doi:10.1371/journal.pone.0013636.

Feature Level Fusion



Major need:
No retraining of system
after removing/adding sensors

[Hall et al. 1997]

Feature Level Fusion

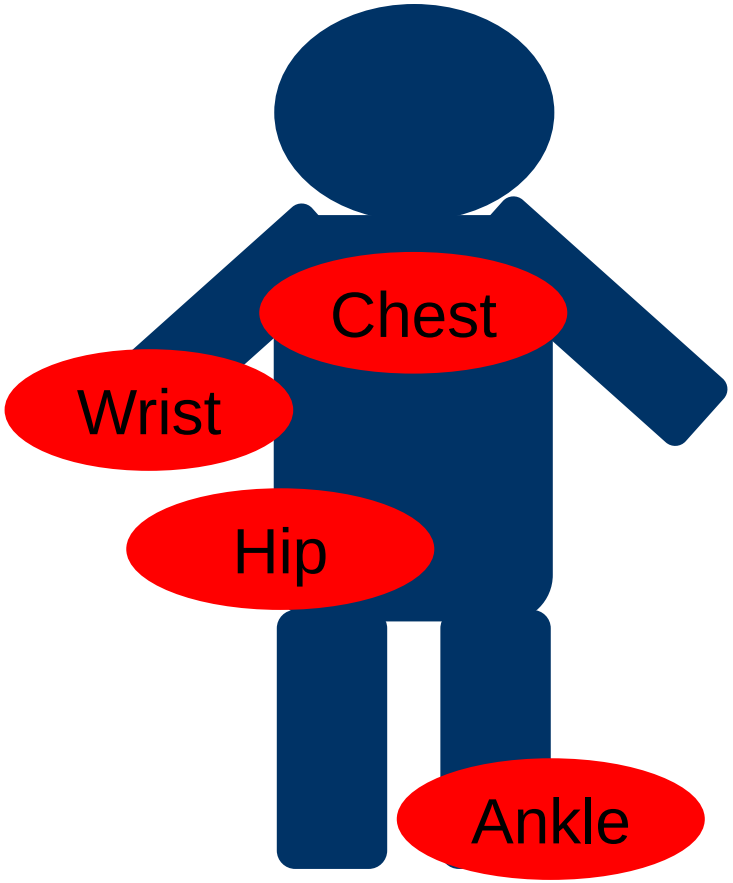
Major need:
No retraining of system
after removing/adding sensors

Decision level fusion

[Hall et al. 1997]

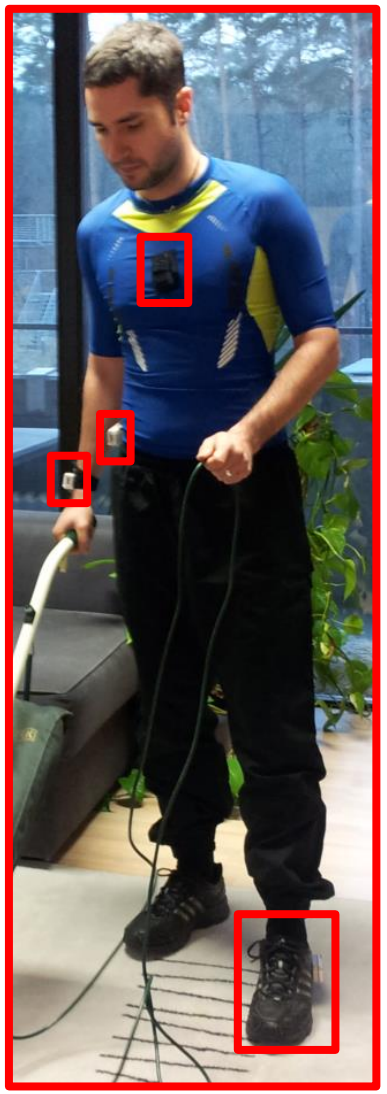
Data Collection

# Participants	19
Age [years]	[18, 55]
Height [cm]	[158, 196]
Weight [kg]	[54, 108]

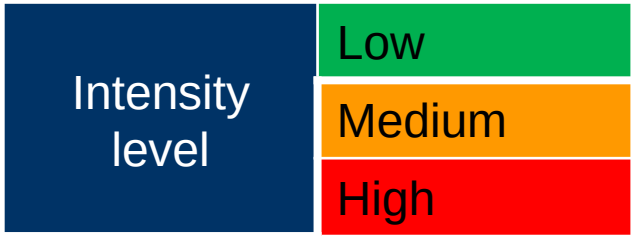


Data Collection (2)

SHIMMER	
3-D accelerometer	6 g
3-D gyroscope	500 deg/s 2000 deg/s (ankle)
Sampling rate	204.8 Hz
Storage	SD-card

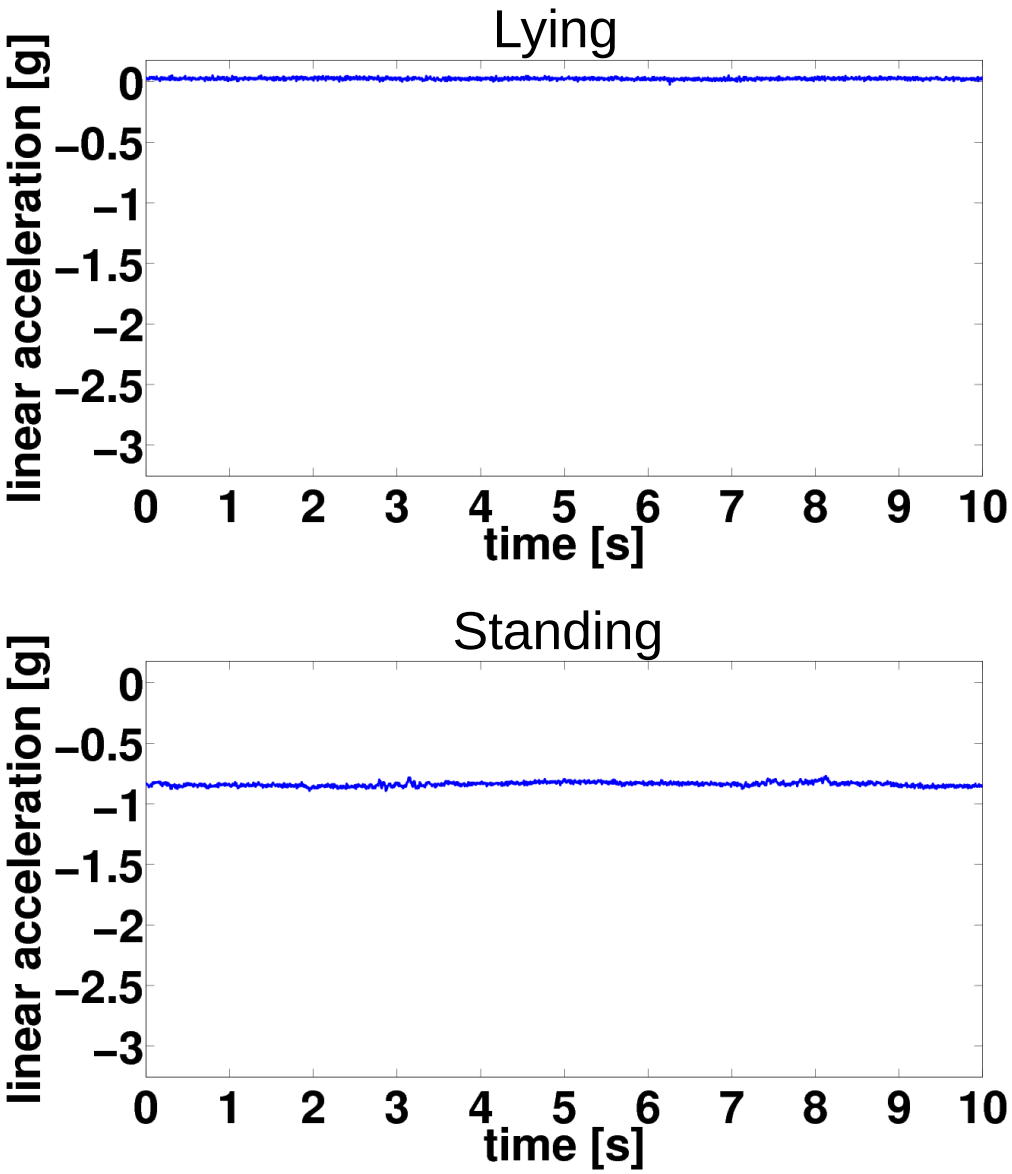


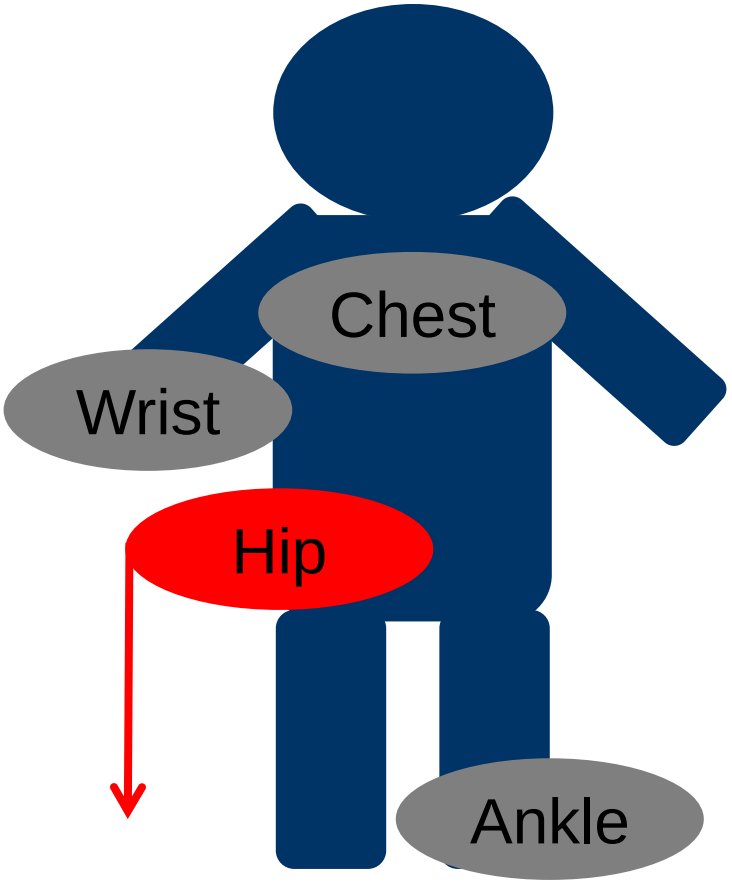
Study: List of Activities



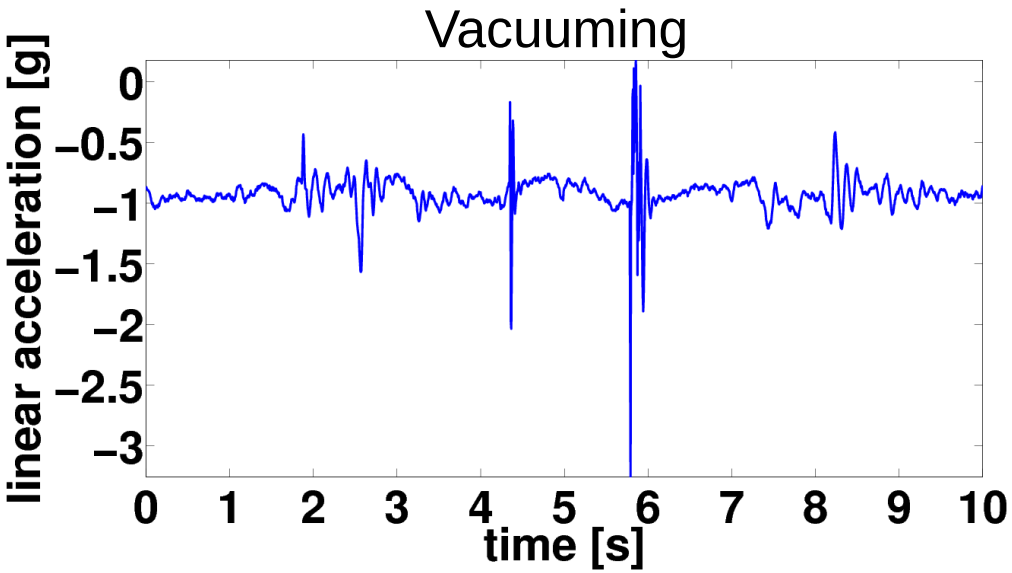
[DaLiAc: www.activitynet.org]
[Schuldhaus et al. 2013]

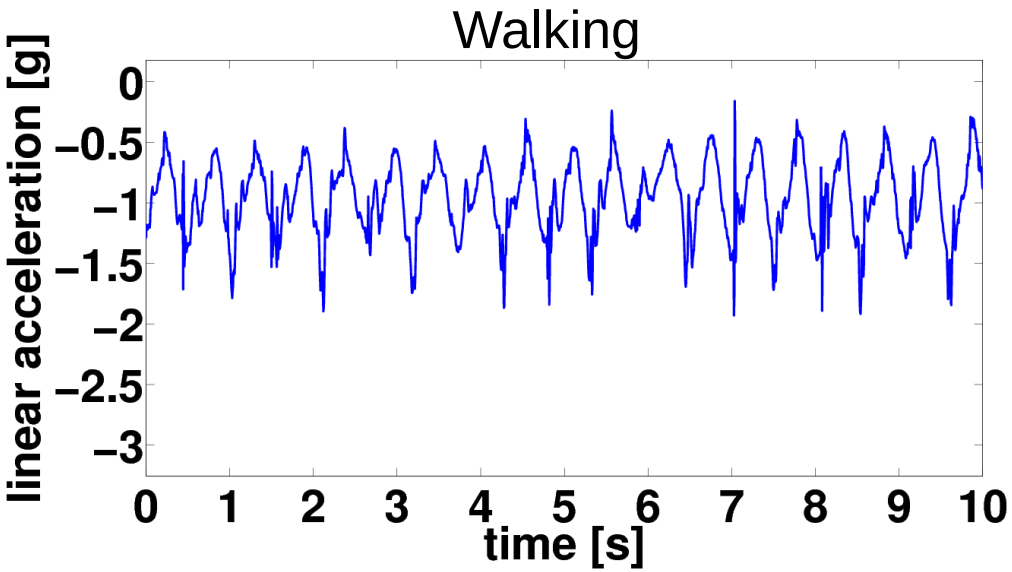
Signal Example

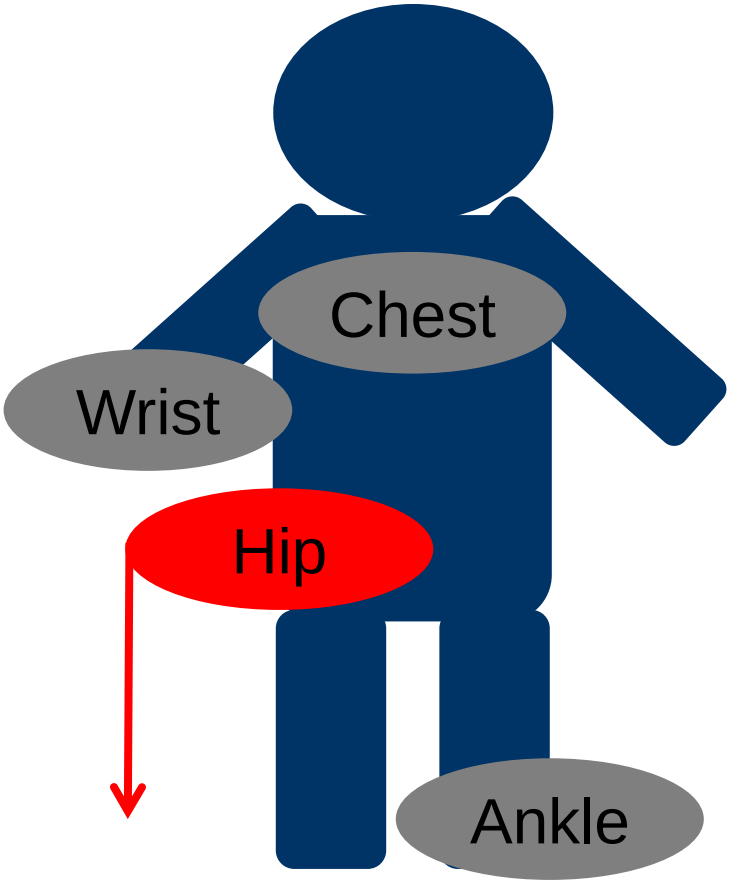




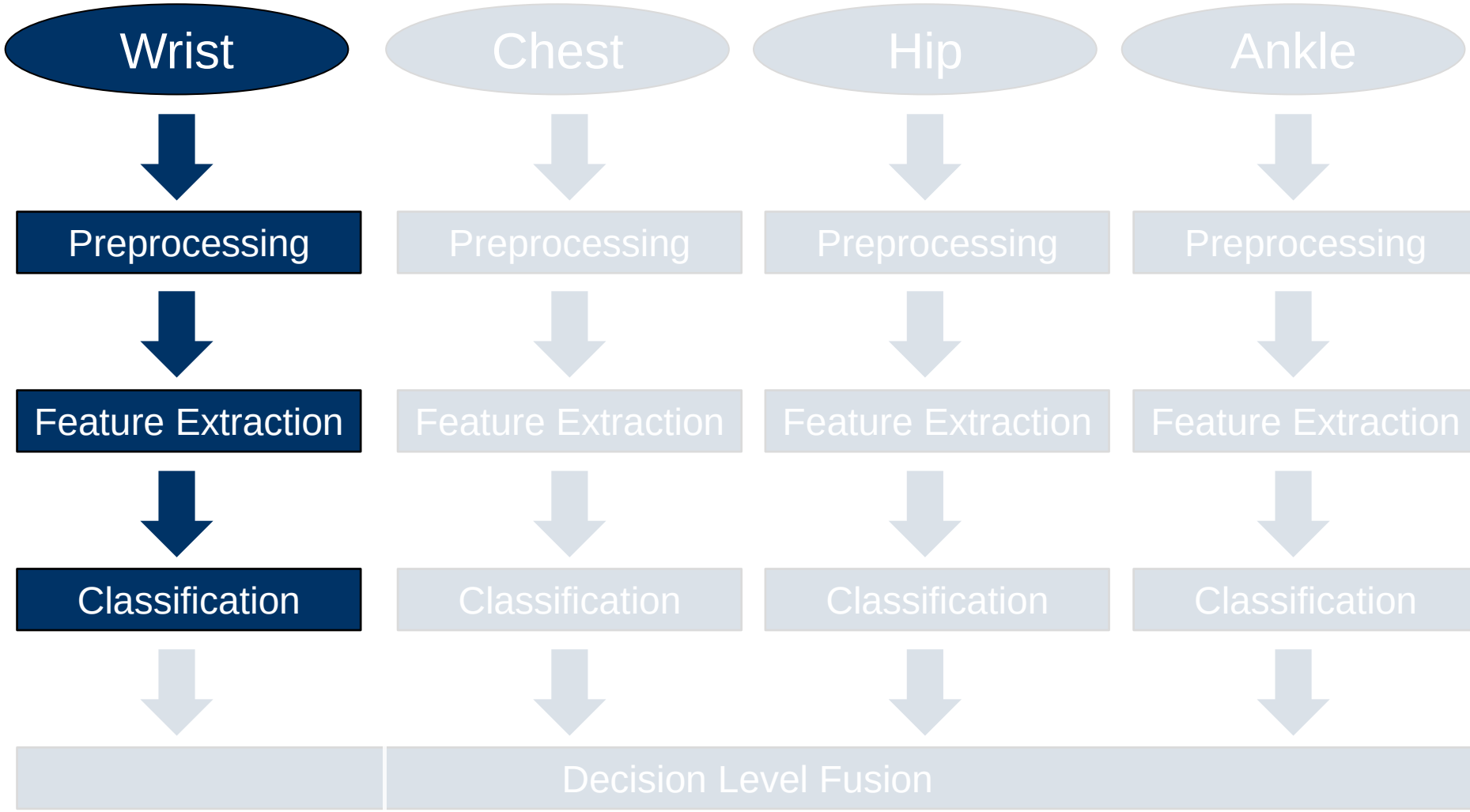
Signal Example (2)





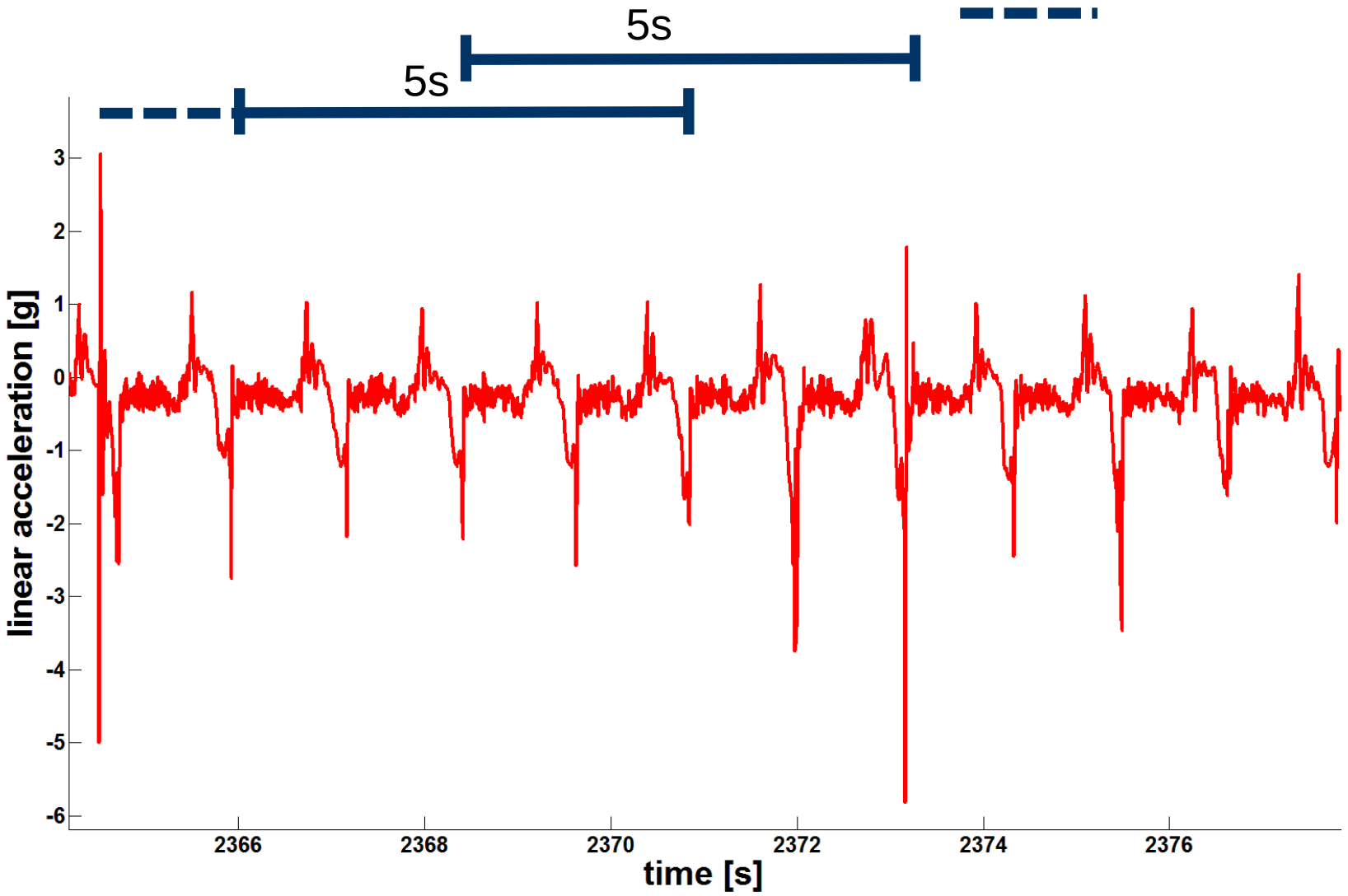


Proposed System

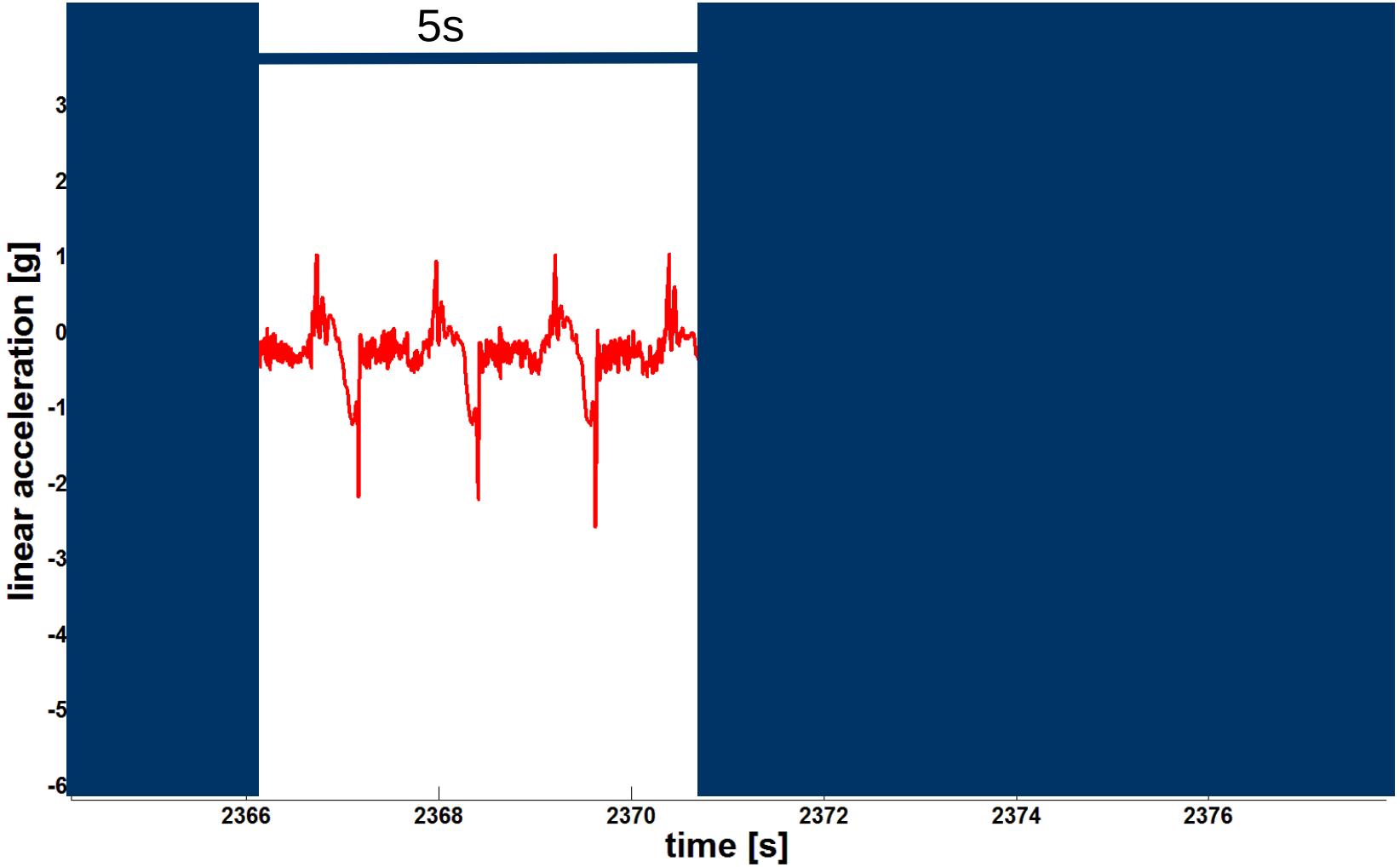


[Schuldhaus et al. 2013]

Preprocessing



Preprocessing



Feature Extraction

Features

Extrema

- Minimum
- Maximum

Statistical

- Mean
- Variance
- Skewness
- Kurtosis

6 / axis
x
(3 axes accel + 3 axes gyro)
=
36 / sensor

Classification

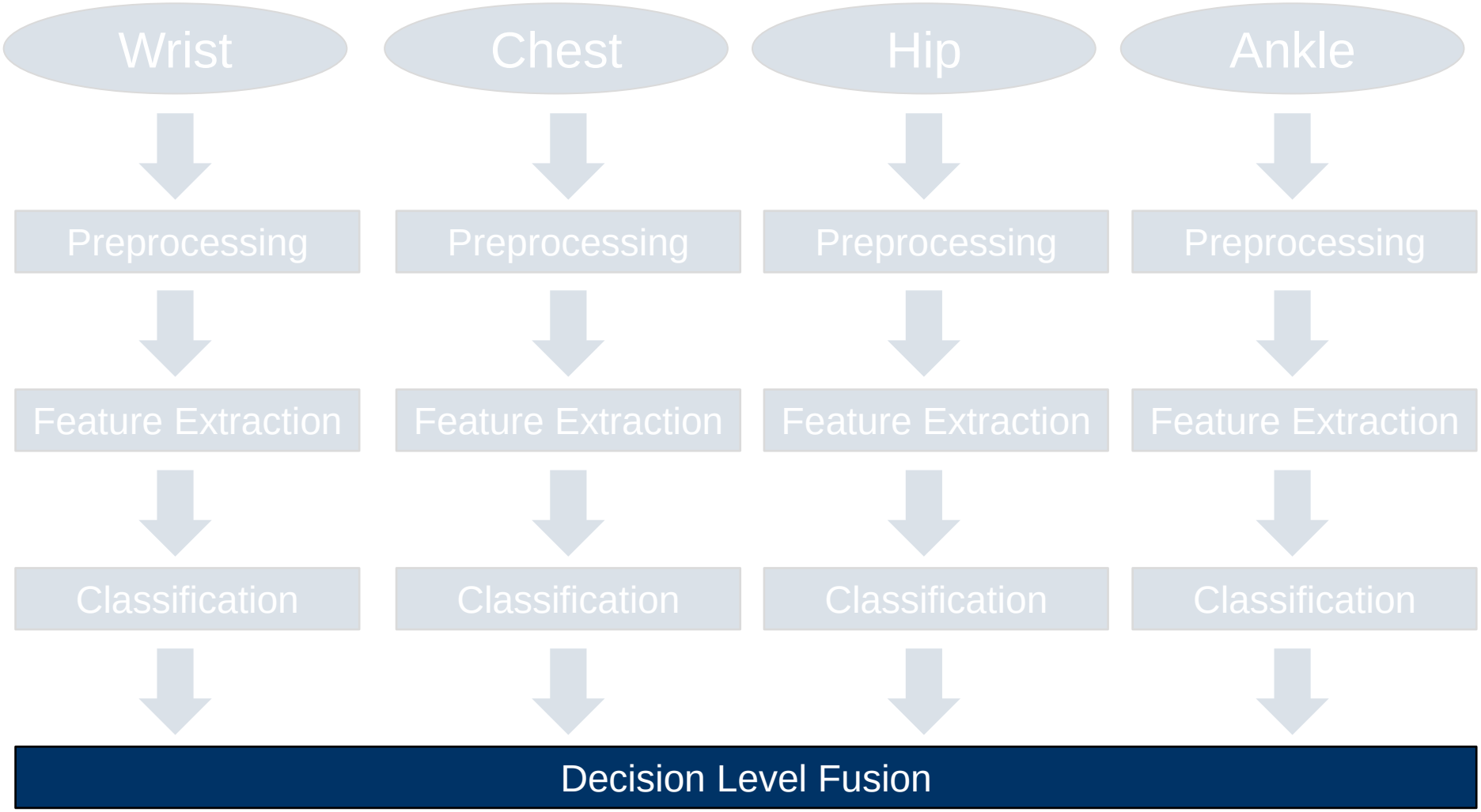
Comparison of classifiers

- Classification and regression tree (CART)
- Random Forest
- Support Vector Machine (SVM)

Performance assessment

- Mean classification rate [%]
- Leave-one-subject-out cross-validation
- Parameter optimization by grid search

Proposed System



Decision Level Fusion

Only adjustment after removing/adding sensors:

Majority voting

No retraining of system

Experiments

Single sensors

Decision level fusion

- Best classifier for each sensor

Removing/adding sensors

- Averaging over all combinations

Experiments: Single Sensors

Classification rates [%]

Sensor	CART	RandomForest	SVM
Wrist	74.6	84.7	83.7
Chest	84.5	91.0	89.0
Hip	86.1	93.1	91.0
Ankle	88.2	91.9	91.6

Experiments: Decision Level Fusion

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Activity	Classification rate [%]
Sitting	91.0
Lying	100.0
Standing	97.2
Vacuuming	99.8
Walking	99.0
Ascending stairs	95.9
Descending stairs	92.5
Mean	96.5

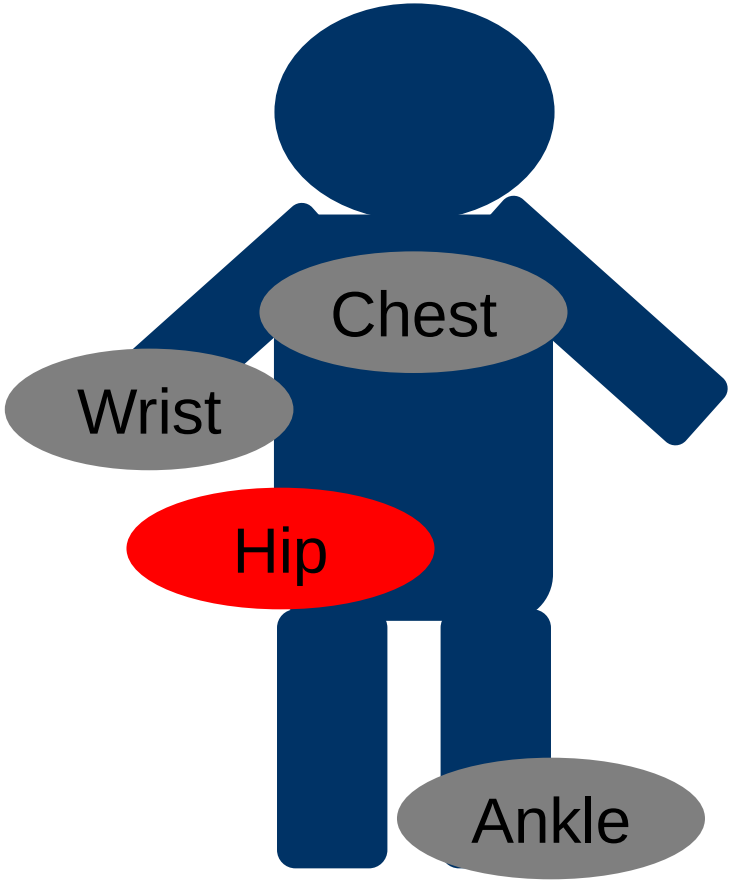
Experiments: Number of Sensors

# Sensors	Classification rate [%]
1	90.2
2	92.2
3	95.8
4	96.5

Discussion

Best sensor position

- Hip



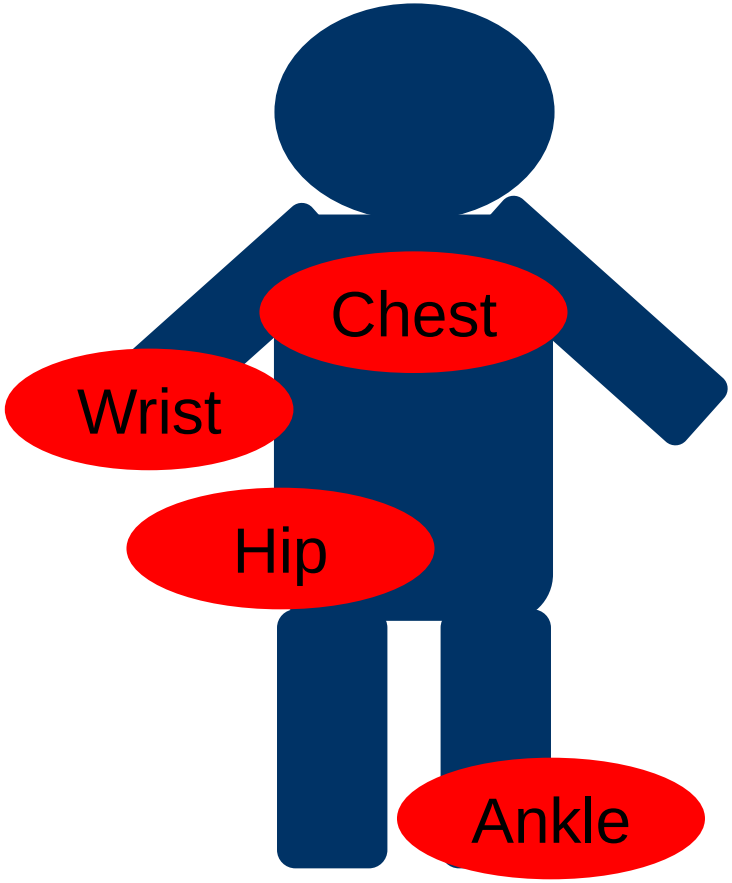
Discussion

Best sensor position

- Hip

Decision level fusion

- Improvement by 3.7 %



Discussion

Best sensor position

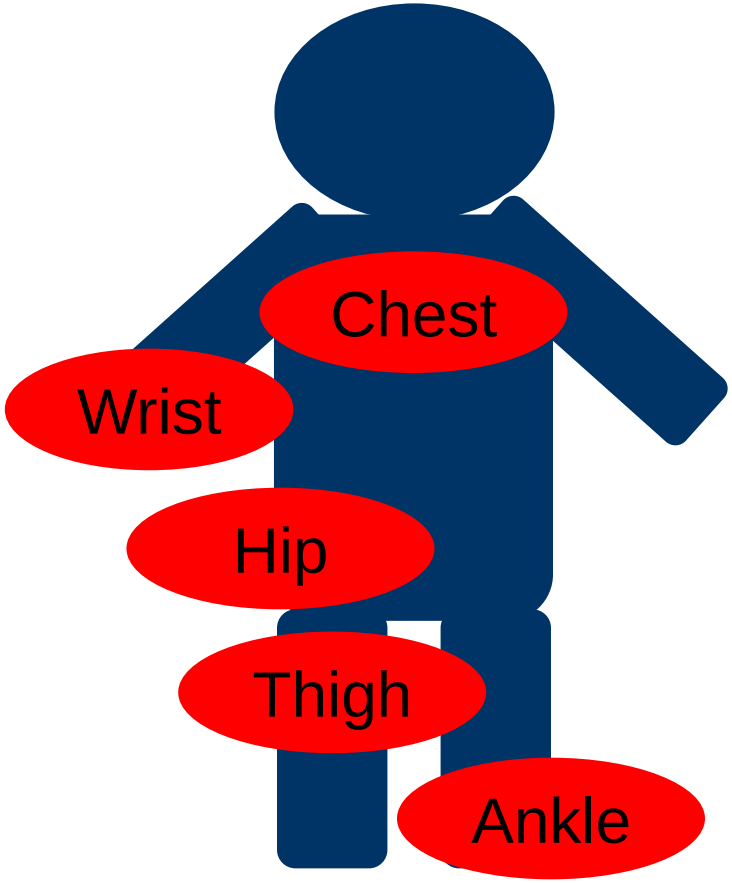
- Hip

Decision level fusion

- Improvement by 3.7 %

Misclassifications

- Sitting / standing
- Ascending / descending stairs



Discussion

Best sensor position

- Hip

Decision level fusion

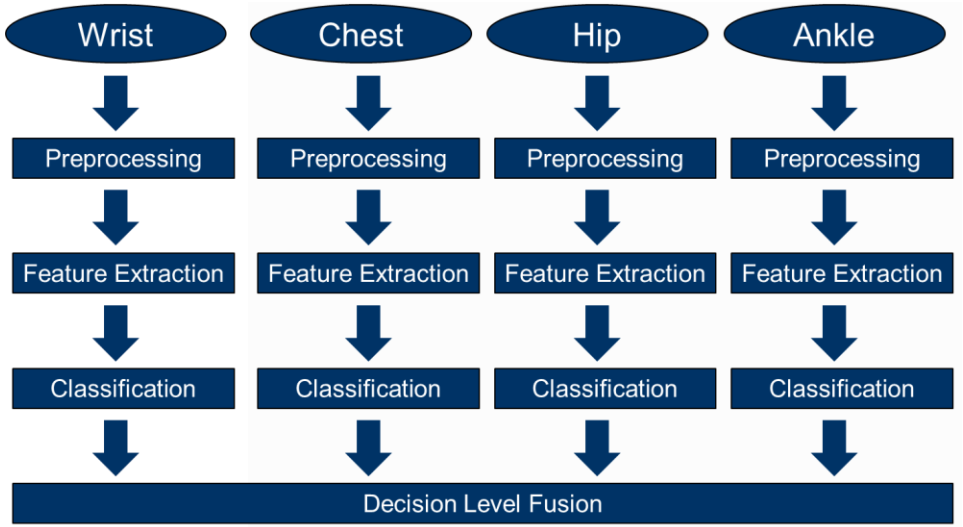
- Improvement by 3.7 %

Misclassifications

- Sitting / standing
- Ascending / descending stairs

Removing/adding sensors

- No need for retraining of system



Discussion: Benchmark Dataset

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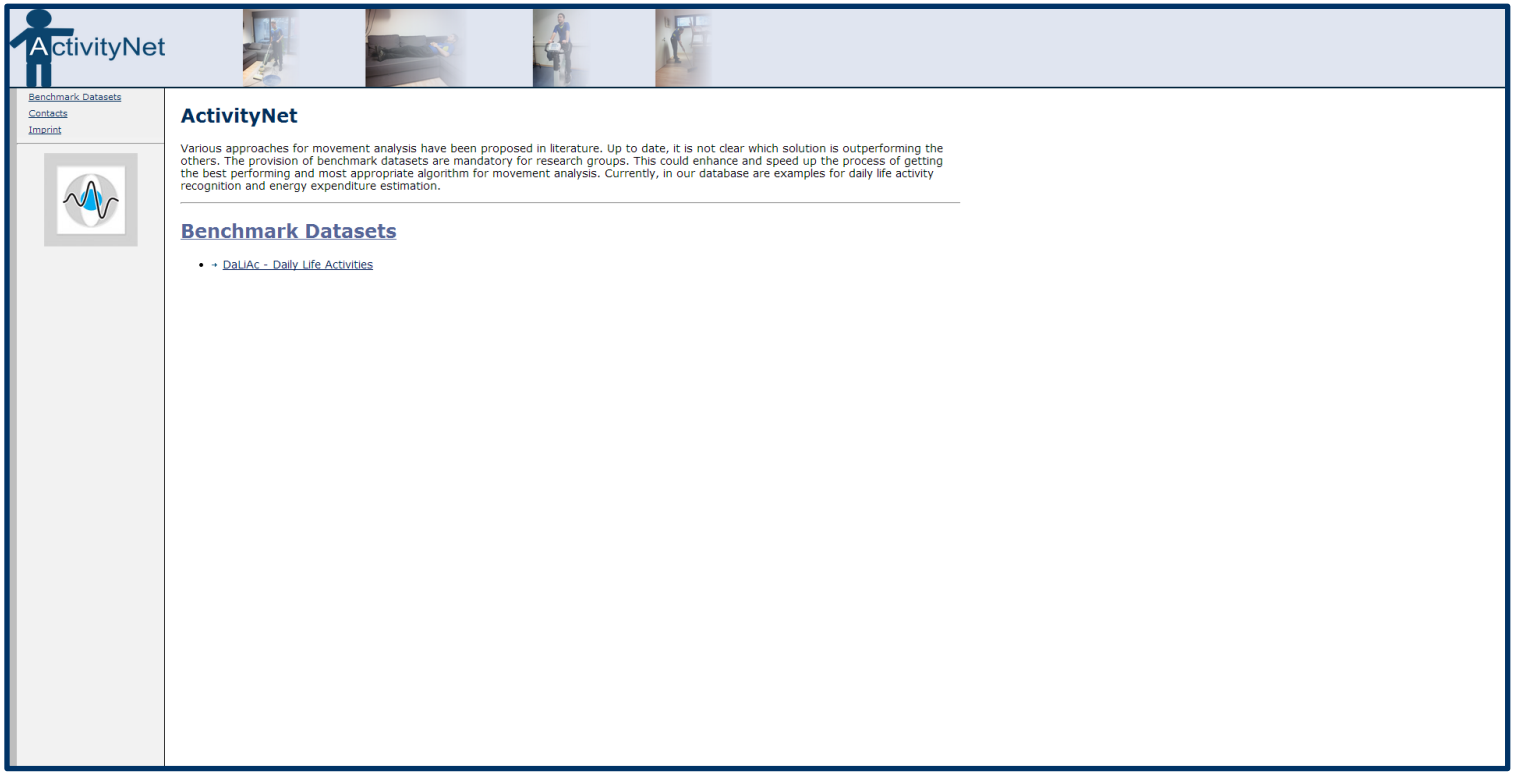
DaLiAc: www.activitynet.org



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PLoS ONE. doi:10.1371/journal.pone.0013636.

Summary

Activity recognition

Decision level fusion

- Classification rate: 96.5 %

No retraining of system after removing/adding sensors

Outlook

Activity recognition

Comparison of fusion algorithms

Adding physiological sensors

Test on more activities

Thank you for your attention!

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Economic Affairs,
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