Recognition of Human Activities for Wellness Management Using a Smartphone and a Smartwatch: A Boosting Approach

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Introduction

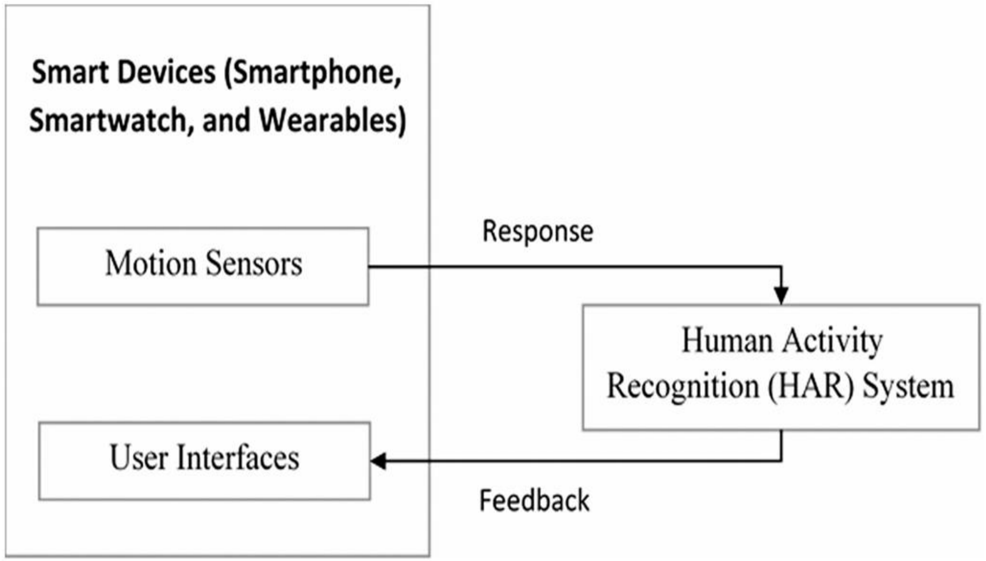
Wellness Management: Systematic management of daily activities to achieve health goals.

Mobile Health (mHealth): Use of smart devices (smartphones, smartwatches) for health monitoring.

Problem: Human Activity Recognition (HAR) in natural settings is challenging due to noise and variability.

Research Question: How accurate are machine learning methods in identifying human activities using naturally used devices in natural settings?

Research Objectives



Develop a HAR system using multimodal sensors in smartphones and smartwatches.

- Investigate the use of boosting algorithms for Human Activity Recognition (HAR).
- Compare performance of smartphones and smartwatches in activity detection.

Methodology

- **Data Collection**: Used the publicly available Extrasensory dataset.
  - **Dataset**: 308,320 labelled examples from 60 users.
  - **Sensors**: Accelerometer, gyroscope, magnetometer (smartphone), and accelerometer, compass (smartwatch).
- **Activities**: Walking, standing, sitting, exercise, and sleeping.
- **Feature Extraction**: 138 features extracted from sensor data.
- **Classification Algorithms**: XgBoost, AdaBoost, Boosted C5.0

Data Preprocessing

- **Data Cleaning**: Removed data points with missing sensor information.
- **Feature Scaling**: Normalized all features.
- **Data Partitioning**: 60% training, 40% testing.
- **Class Imbalance Handling**: Used undersampling to balance the dataset.

Boosting Algorithms

XgBoost:

- Gradient boosting framework.
- Implements system optimization and regularization.
- Prevents overfitting using shrinkage and feature subsampling.

AdaBoost:

- Adaptive boosting with weighted decision trees.
- Adjusts weights based on misclassification rates.
- Combines weak learners to form a strong classifier.

Boosted C5.0:

- Extension of C4.5 algorithm.
- Converts decision trees into rule sets.
- Adaptive boosting with iterative improvement.

Feature Engineering

Step 1: Compare smartphone vs. smartwatch sensor features.

Step 2: Identify important features using Gini index and feature importance scores.

Results:

Smartphone sensors (accelerometer, magnetometer) contributed more to HAR.	Smartwatch sensors were less effective but useful for specific activities (e.g., walking, exercise).

Performance Metrics

Metrics:

- **F1 Score**: Harmonic mean of precision and recall.
- **Accuracy**: Average of recall and specificity.

Results:

- **AdaBoost** outperformed other algorithms for most activities.
- **Boosted C5.0** was best for detecting "sleeping."
- **XgBoost** showed competitive performance but was slightly less accurate than AdaBoost.

Comparison with Standard ML Algorithms

- **Benchmark Algorithms**: Neural Networks, SVM, Logistic Regression, Multi-Layer Perceptron.
- **Results**:
  - Boosting algorithms (AdaBoost, XgBoost, Boosted C5.0) outperformed standard ML algorithms.
  - SVM performed relatively well among standard ML techniques but was less accurate than boosting methods.

Feature Engineering Impact

- **Smartphone Sensors**:
  - Accelerometer and magnetometer were most important.
  - Improved accuracy for standing, sitting, and sleeping.
- **Smartwatch Sensors**:
  - Accelerometer was useful for walking and exercise.
  - Combined smartphone and smartwatch features improved accuracy for walking and exercise.

Conclusion

- **Key Findings**:
  - Boosting algorithms (AdaBoost, XgBoost, Boosted C5.0) are highly effective for HAR in natural settings.
  - Smartphone sensors are more effective than smartwatch sensors for most activities.
  - Feature engineering significantly improves classification accuracy.
- **Future Research**:
  - Explore deep learning and bagging techniques for HAR.

Reference

You can find the presented paper here

https://www.sciencedirect.com/science/article/abs/pii/S0167923620301810?casa_token=qMi78D6VH7MAAAAA:g6tso1VLj_JbqaWgUimtgv8DWAE7TgrpNSm6n-n8iIUkMrP8UHi2pdNMq4gnw_f7WgFm26o

Thank you