Burnify

Calories tracker and HAR app

Francesco De Vita,
Basma M. A. G. Adawy,
Tsegay T. Gebrelibanos,
Samay A. S. Ruiz Muenala

Mobile and social sensing systems
Artificial Intelligence and Data Engineering,
a.y. 2023-2024

IN SUPREMÆ DIGNITATIS 1343
UNIVERSITÀ DI PISA

Introduction

- Human Activity Recognition (HAR) plays a vital role in modern wellness management
- Our smartphone-based HAR system leverages accelerometer, gyroscope, and magnetometer sensors.
- Android app provides real-time activity tracking and calorie estimation.
- Implemented ML models: AdaBoost, Random Forest, LSTM
    - Random Forest outperforms both
- Personalized tracking based on age, weight, and height

Problem and Solution

- The HAR system is essential for healthy lifestyle
- **Challenges:**
  - ➢ Traditional HAR systems rely on costly wearable devices
  - ➢ Need for accessible wellness monitoring solutions
- **Our Solution:**
  - ➢ Cost-effective smartphone-based approach
  - ➢ Leverages built-in sensos
  - ➢ ML model to classify human activities [walking, running, standing, downstairs, and upstairs]
- **Real-time activity tracking** with a list of recent activities and calculated calories burned

Img source

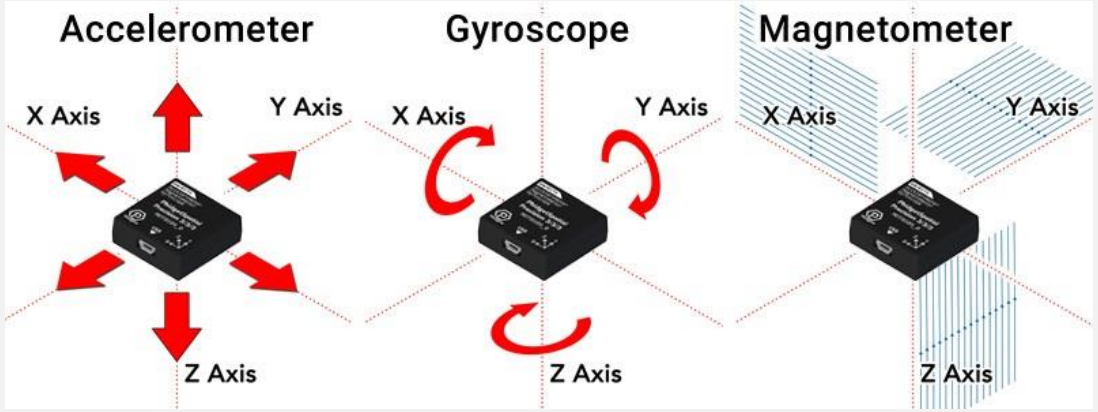
System Architecture

- *The system architecture starts by collecting sensor data from the smartphone's built-in accelerometer, gyroscope, and magnetometer. The Android app preprocesses and extracts features locally. The processed data is then analyzed using on-device machine learning models to classify the activity. The predicted results are displayed within the app, providing real-time insights into recognized activities and estimated calories burned, ensuring seamless wellness tracking without relying on external servers.*

01	02	03	04	05
SMARTPHONE SENSORS (DATA COLLECTION)	ANDROID APP (PREPROCESSING & FEATURE EXTRACTION)	ML MODEL (CLASSIFY ACTIVITIES)	ANDROID APP (RESULTS RECEIVED)	USER SCREEN (ACTIVITY DISPLAY & INSIGHTS)

Sensor Data Collection & Processing

- ❑ Smartphone Sensor Data
  - ➢ **Gyroscope (X, Y, Z)**
    - ✓ Measures rotational velocity
  - ➢ **Magnetometer (X, Y, Z)**
    - ✓ Measures magnetic field strength
  - ➢ **Accelerometer (X, Y, Z)**
    - ✓ Measures linear acceleration
- ❑ Data Processing
  - ✓ Window size: 50 samples
  - ✓ Sliding window with 25-sample overlap
  - ✓ Feature extraction for ML models



Img source

Machine Learning Models

- Random Forest
  - Ensemble method combining multiple decision trees
  - Best performing model
  - 99% accuracy achieved
- AdaBoost
  - Focus on error correction
  - Label encoding for categorical data
  - 65% accuracy achieved
- LSTM
  - Specialized for sequential data
  - 200-time step sequences
  - 89% accuracy achieved

Model Performance Metrics

Random forest

	precision	recall	f1-score	support
downstairs	1.00	0.99	0.99	680
running	0.99	1.00	0.99	631
standing	1.00	0.99	1.00	702
upstairs	0.99	1.00	0.99	712
walking	1.00	0.99	0.99	705
accuracy			0.99	3430
macro avg	0.99	0.99	0.99	3430
weighted avg	0.99	0.99	0.99	3430

Model saved as 'movement_detection_rf_model.pkl'

Adaboost

	precision	recall	f1-score	support
downstairs	0.48	0.39	0.43	680
running	0.87	0.79	0.83	631
standing	0.83	0.79	0.81	702
upstairs	0.55	0.62	0.58	712
walking	0.58	0.69	0.63	705
accuracy			0.65	3430
macro avg	0.66	0.66	0.66	3430
weighted avg	0.66	0.65	0.65	3430

Model saved as 'movement_detection_adaboost_model.pkl'

LSTM

	precision	recall	f1-score	support
0	0.87	0.89	0.88	419
1	0.96	0.83	0.89	250
2	0.98	0.94	0.96	462
3	0.83	0.89	0.86	332
4	0.84	0.86	0.85	437
accuracy			0.89	1900
macro avg	0.90	0.88	0.89	1900
weighted avg	0.89	0.89	0.89	1900

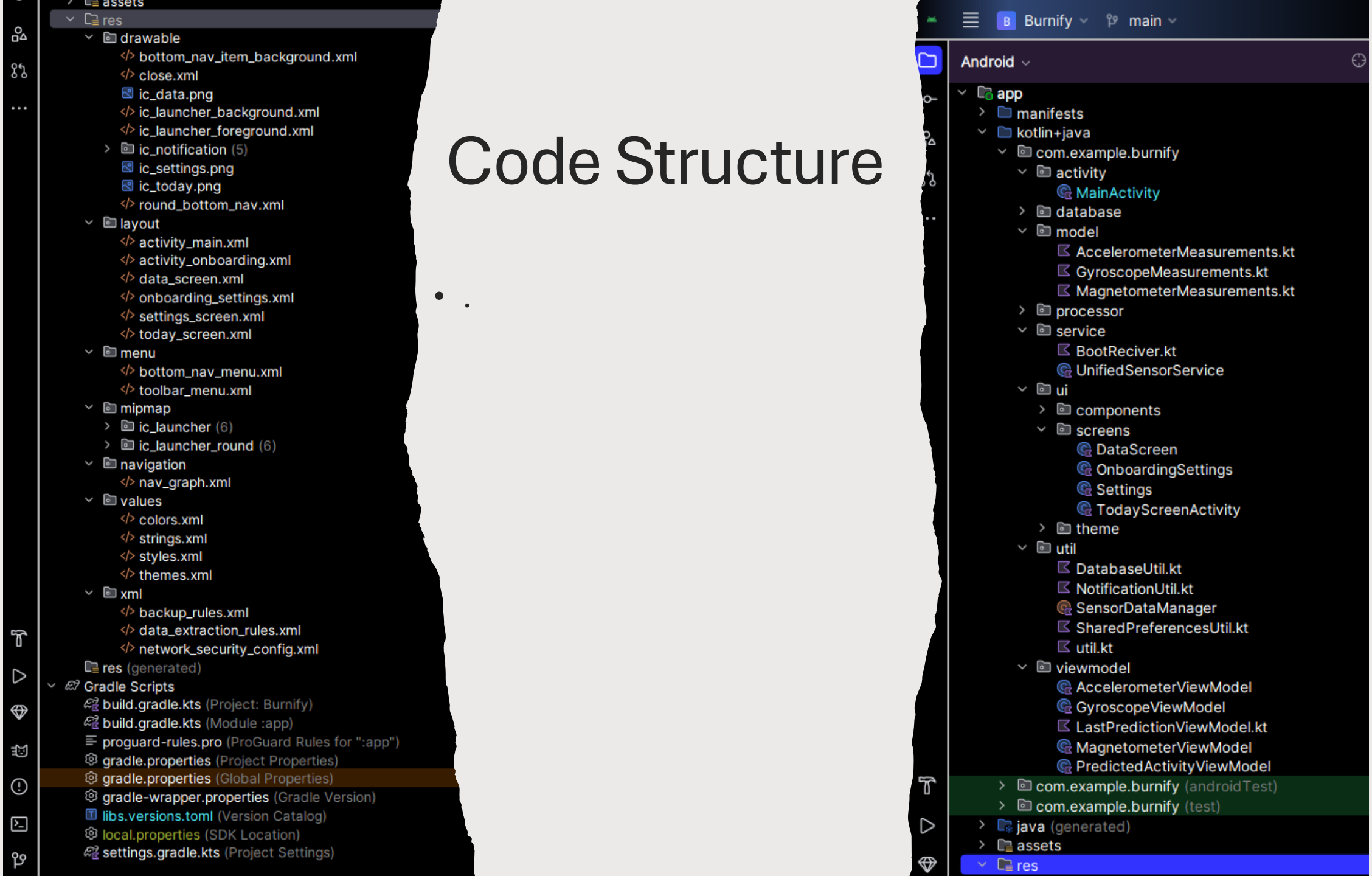
UI Components

- Today Screen Activity:
  - Calories burned chart
  - Activity duration histogram
  - Daily progress tracking
  - Visual analytics
- Data Screen Activity:
  - Real-time activity display
  - Recent activity history
  - Chronological activity log
  - Timestamp tracking
- Settings Screen Activity:
  - User customization features
  - Sampling mode selection
  - Personal metrics input
  - Sensor control options

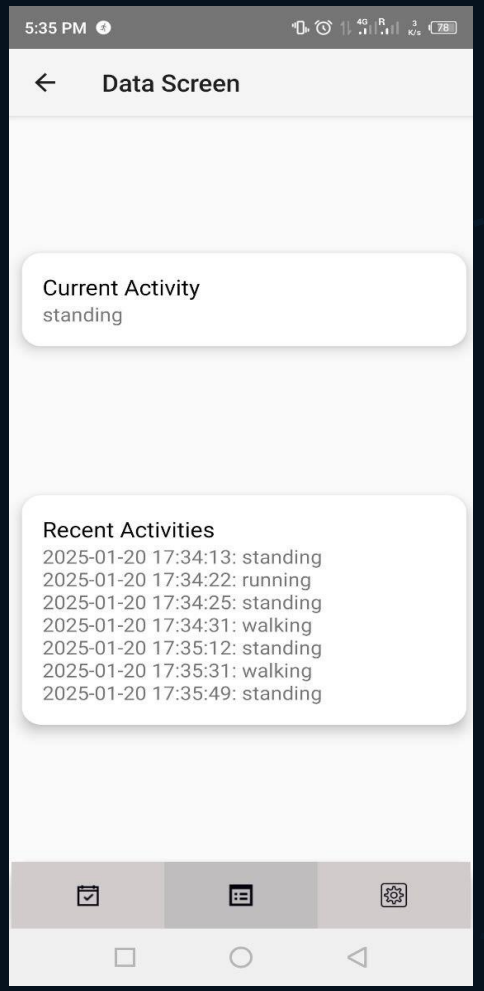
Application Features

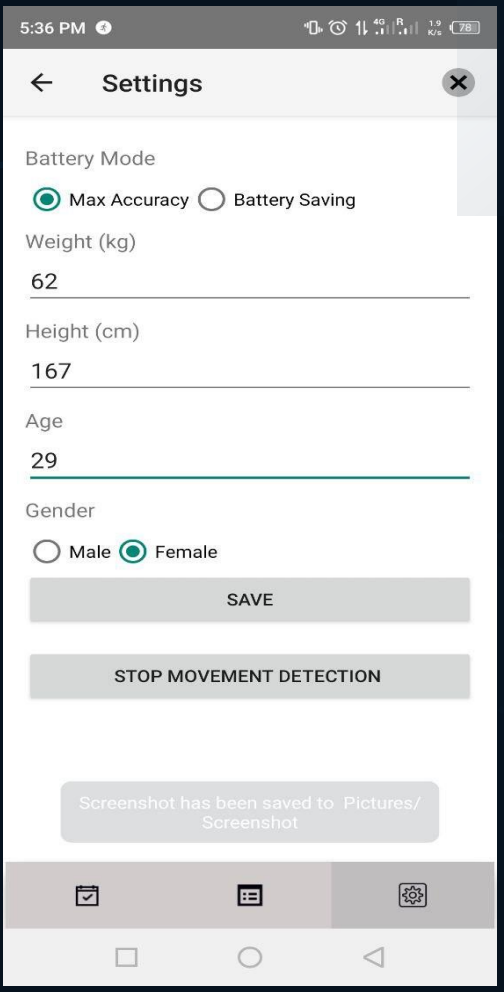
- **Real-time Tracking:**
  - Current activity display
  - Recent activities list (last 10)
  - Precise timestamps
  - Activity transitions
- **Analytics:**
  - Calorie expenditure tracking
  - Activity duration visualization
  - Daily progress monitoring
  - Performance metrics

Code Structure



Application Demo





Conclusion

- Successfully developed a smartphone-based HAR system for wellness management
- Random Forest outperformed AdaBoost and LSTM in classifying five distinct physical activities
- The Android app provides real-time tracking and personalized insights using user metrics
- Random Forest was the most effective model.
- Personalized wellness tracking using anthropometric inputs.
- **Future Enhancements:**
- Expand recognized activities (e.g., cycling, driving)
- Optimize energy consumption for prolonged use
- Improve UI/UX with additional analytics features

Reference

1. Tarafdar, P., & Bose, I. (2021). Recognition of human activities for wellness management using a smartphone and a smartwatch.
2. Javed, A. R., et al. (2021). A smartphone sensors-based personalized human activity recognition system.

Thank you!