Computationally Efficient Human Activity Modeling and Its Application as a Service in Android Application Framework

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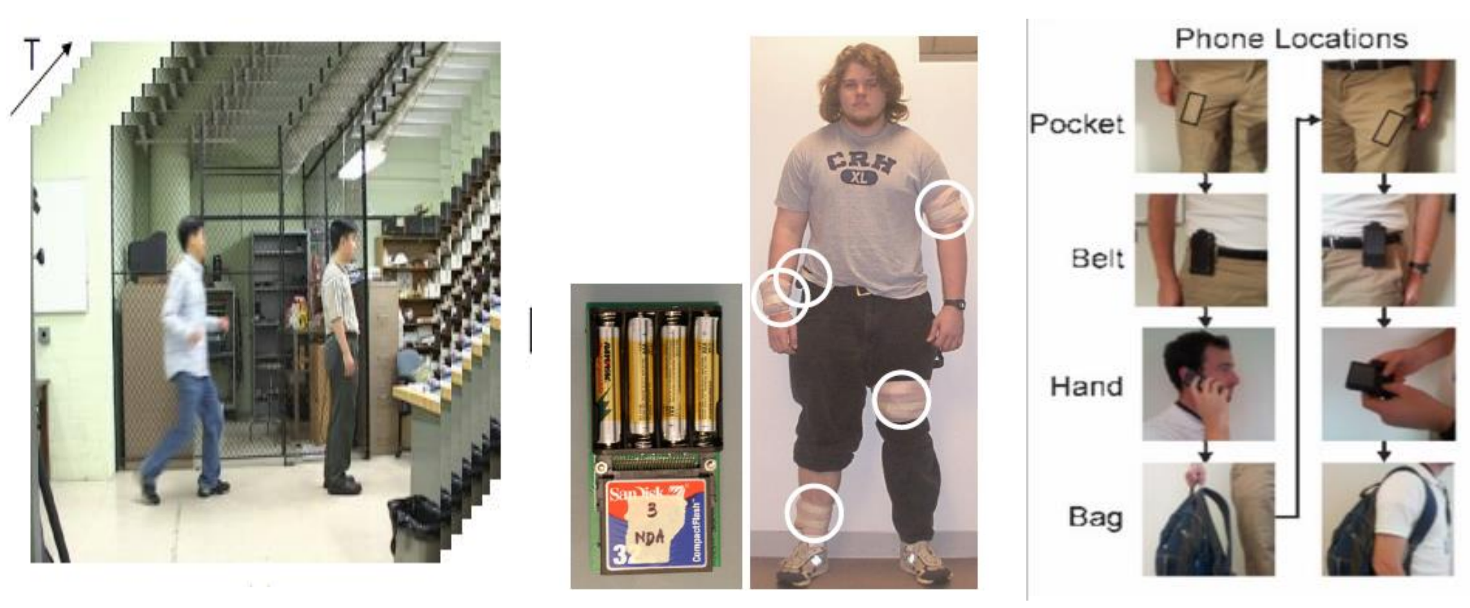
Introduction

- Human Activity Recognition (HAR) is important in many research areas such as pervasive computing, human computer interaction, assistive living and technologies, and rehabilitation engineering, because of its application in context-aware applications [1].
- Despite its been an active research area for more than a decade, there many major issues need to be addressed such as: classification accuracy, computational cost, energy consumption, and real-time implementation [1].

Motivation

- Computationally efficient modelling of Human Activity
  - Less computation
  - Less memory
  - Less energy consumption
- Activity Recognition (AR) as a Service
  - Increasing demand of AR
  - Few existing services: Google AR API
  - Offers few number of activities

State-of-the-art



Computer Vision [J K Aggarwal 1997] | Wearable Sensor [L Bao 2004] | Smartphone [S A Antos 2013]

Background: Time-Delay Embedding

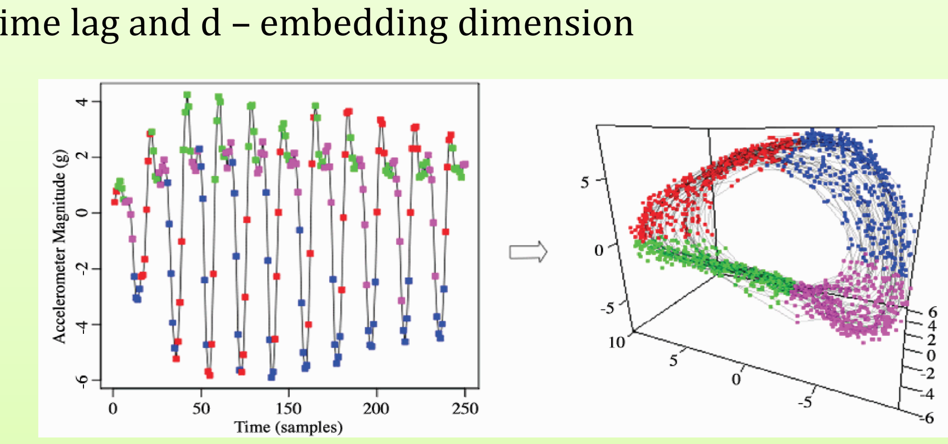
- **Reconstructed Phase Space (RPS)**
  Based on Takens' delay embedding theorem [F. Takens', 1980].
  Time series,

$$x = x_n, \qquad n = 1 \dots N$$

  Time delay embedding,

$$X = \left[x_n \ x_{n-\tau} \ \dots \ x_{n-(d-1)\tau} \right]$$

  where τ – time lag and d – embedding dimension



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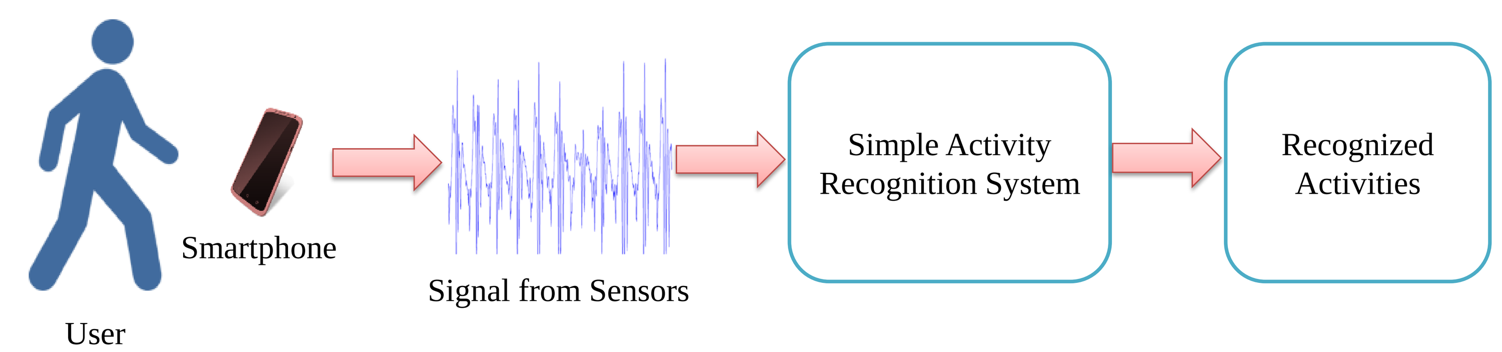
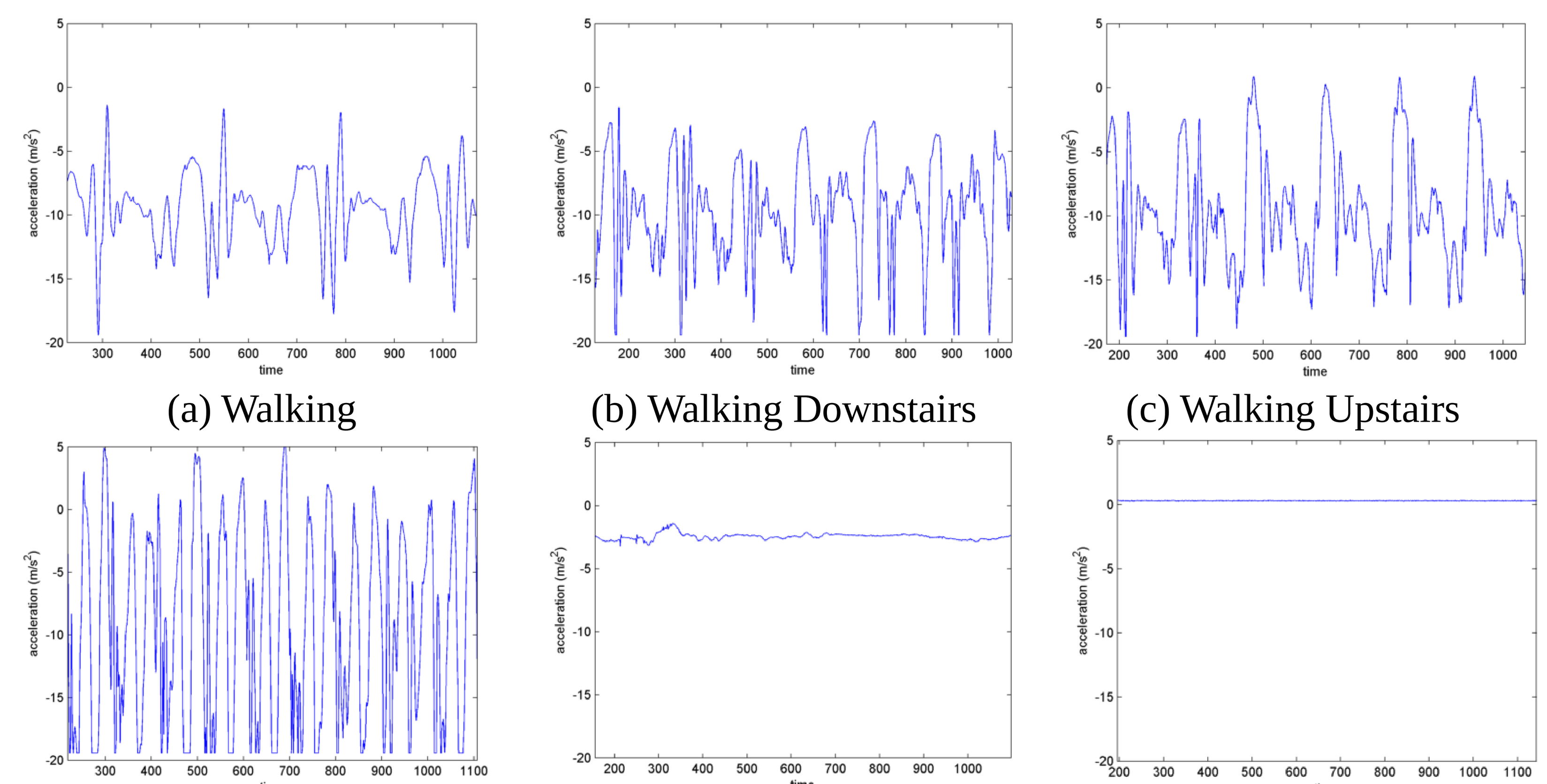
- **Gaussian Mixture Model (GMM)**
  A parametric probability density function. Weighted sum of M Gaussian density function.

$$p(x|\lambda) = \sum_{i=1}^{M} w_i \, p_i(x) = \sum_{i=1}^{M} w_i \, N(x, \mu_i, \Sigma_i)$$

Our Approach



Smartphone based Human Activity Recognition System

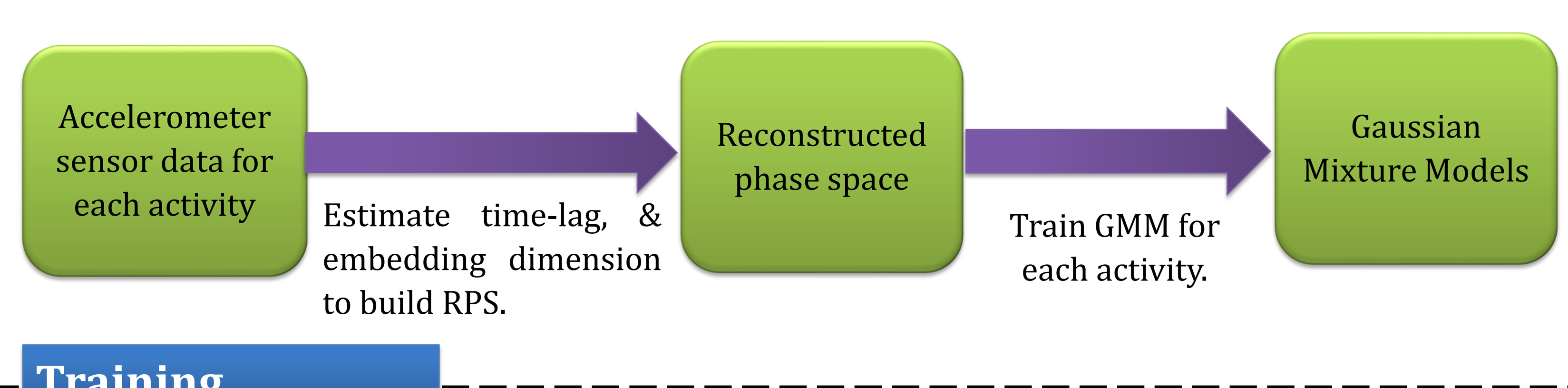


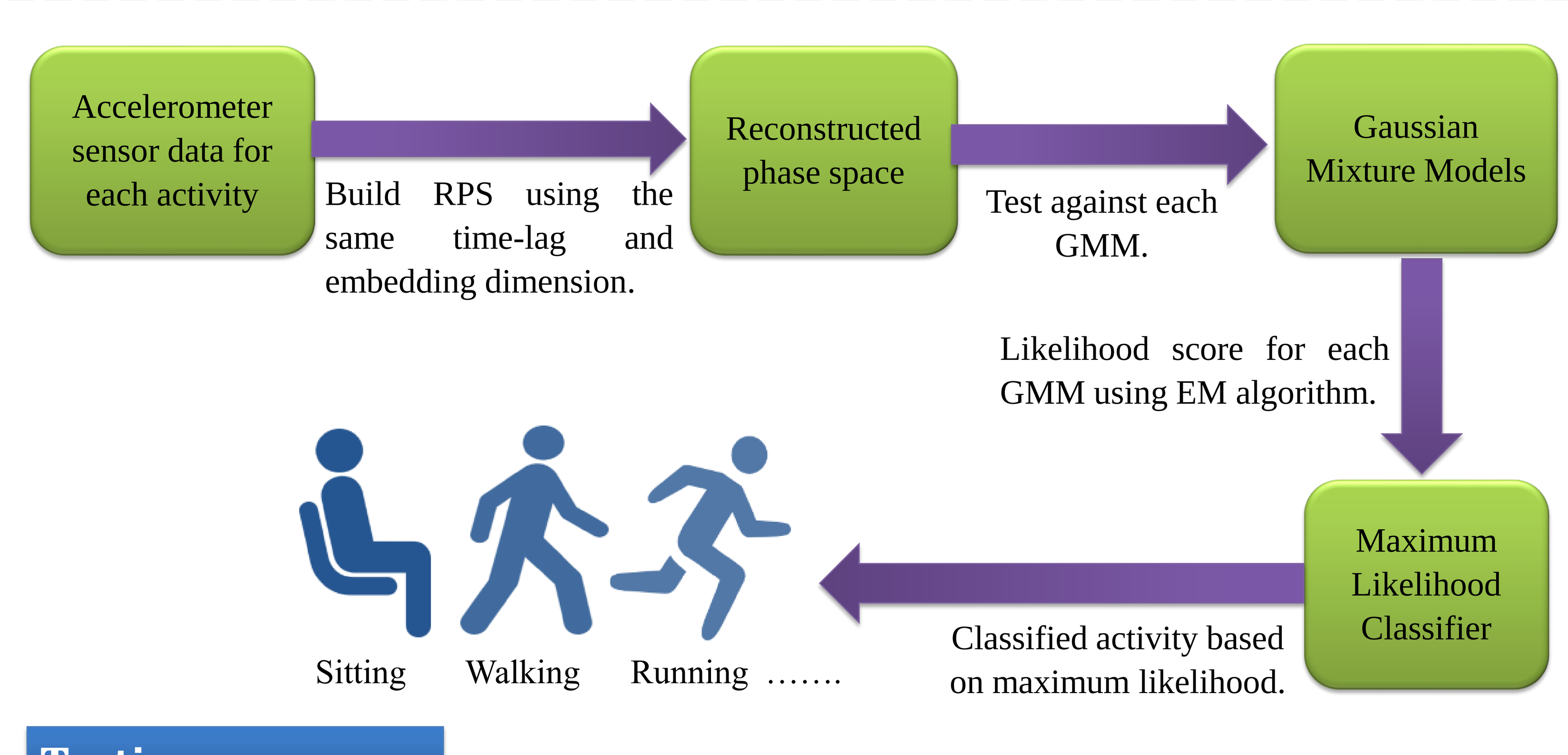
(a) Walking | (b) Walking Downstairs | (c) Walking Upstairs

(c) Running | (d) Sitting | (c) Baseline

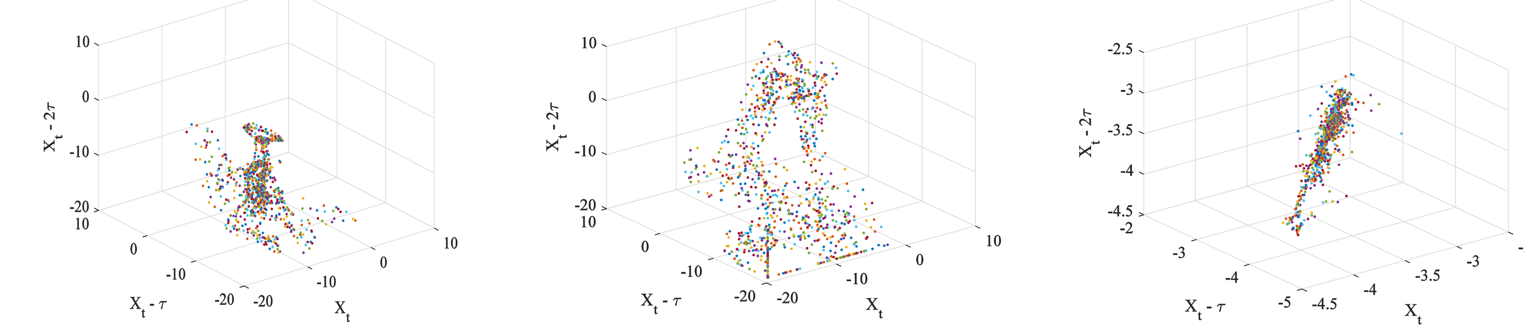
Acceleration along Y-axis vs. Time

Methodology

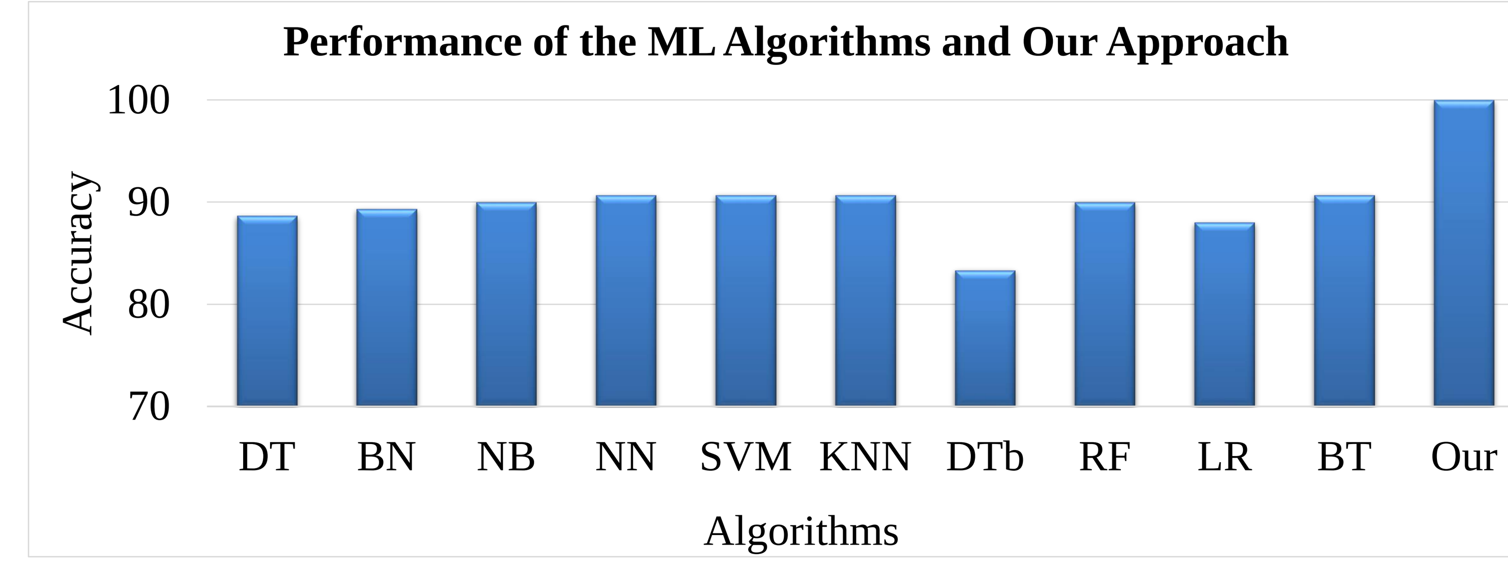




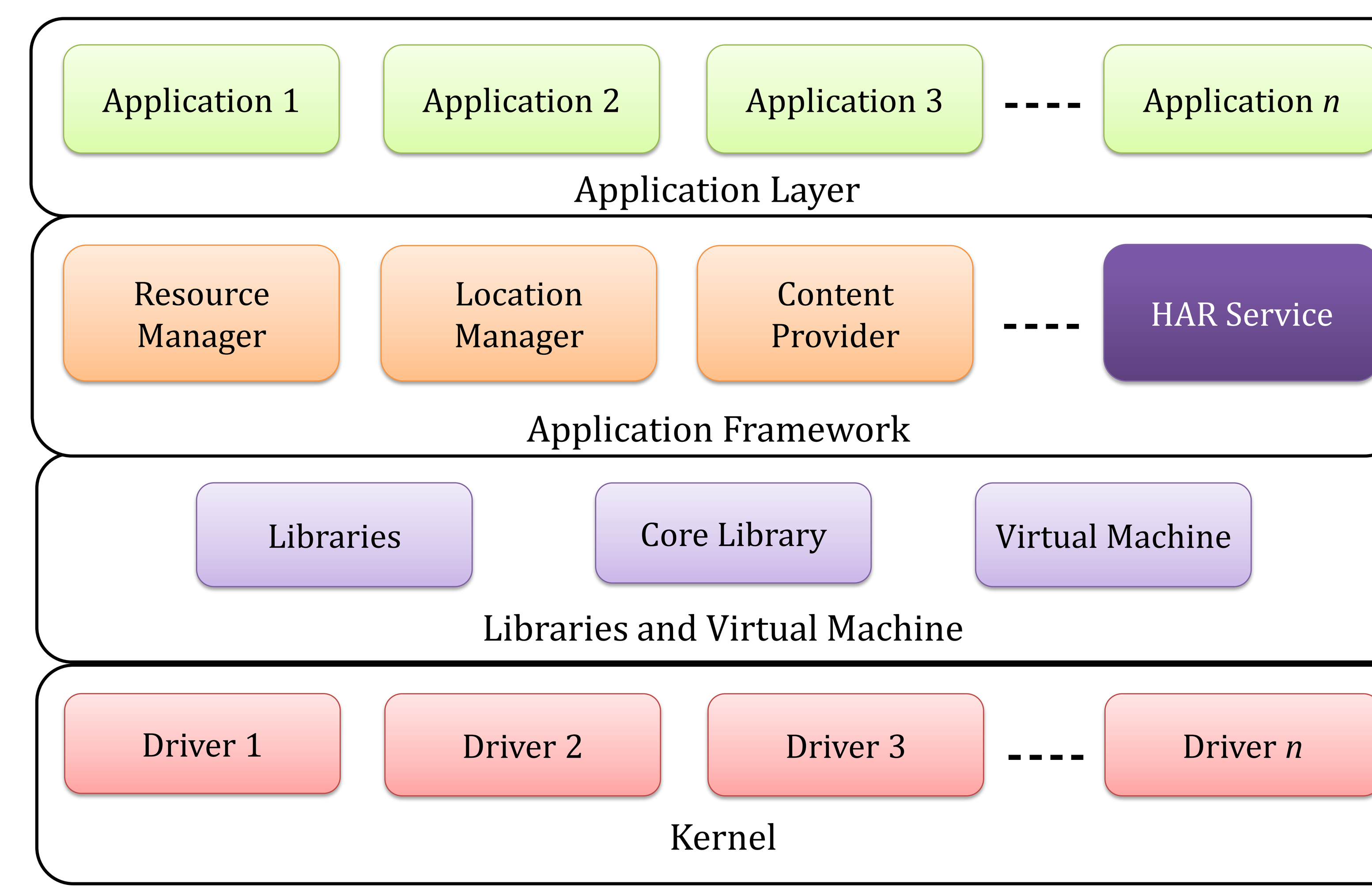
Experiment & Result



RPS of Walking | RPS of Running | RPS of Standing



HAR as a Service



Conclusion

- The proposed approach achieved 100% accuracy on individualized model and above 90% accuracy over 11 activities.
- Outperformed existing techniques using 1 axis acceleration.
- Reduces computational and memory complexity by reducing data from 6-7 time series to 1 time series.
- Development of the Human Activity Recognition as a Service in the application framework.

References

[1] O. D. Lara and M. a. Labrador, "A Survey on Human Activity Recognition using Wearable Sensors," *IEEE Communications Surveys & Tutorials*, vol. 15, no. 3, pp. 1192–1209, 2013.

[2] Z. He and L. Jin, "Activity recognition from acceleration data based on discrete consine transform and SVM," *in IEEE International Conference on Systems, Man and Cybernetics. IEEE*, 2009, pp. 5041–5044.

[3] L. Bao, S. Intille, "Activity Recognition from User-Annotated Acceleration Data" *Pervasive Computing, Springer*, 1-17, 04.