Fog-centric Localization for Ambient Assisted Living

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Outline

- Behavioural tracking for Ambient Assisted Living (AAL)
- Fog Computing
- Edge Mining
- Proposed architecture
- Iterative Edge Mining (IEM)
- Evaluation
- Conclusions and Future work

Behavioural tracking for AAL

- Ageing population
- Dementia - affects memory, orientation and mobility
- AAL - use of ICT to improve quality of life
- Activity monitoring and localization of the user - enables safe and independent living
- Applications: Indoor and outdoor activity monitoring, health monitoring, social inclusion
- Localization techniques
  - GPS units - costly and energy intensive
  - Dense sensor networks (static and inertial) and cloud infrastructure - cumbersome

Fog Computing

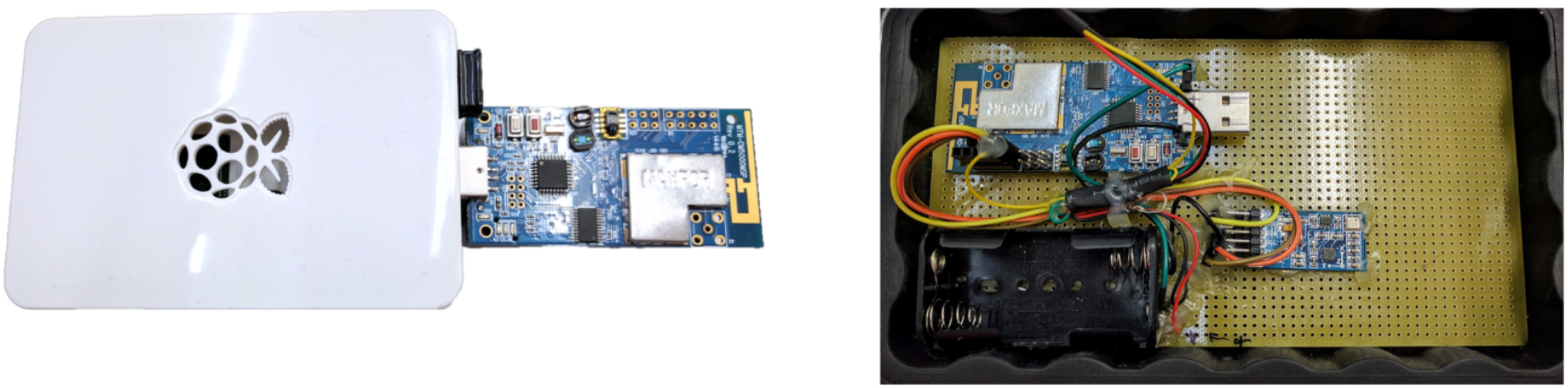
- Improvements in the design and capabilities of network devices at the edge the IoT
- Extension of the cloud computing to network edges - gateways, switches, mobile phones or sensors
- Improved energy efficiency and reduced latency
- Sensor analytics
  - WSN-based localization - noisy measurements and dense deployments
  - Data Fusion - signal specific algorithms
  - Artificial Neural Networks - energy intensive learning
  - Edge Mining - generic algorithms

Edge Mining

- Aim: Improve energy efficiency
- Light-weight data mining on sensor devices
- Based on the Spanish Inquisition Protocol (SIP)
  - Linear SIP - point-in-time and rate of change
  - ClassAct - decision-tree based activity classifier
  - Bare Necessities (BN) - histogram encoding
- Edge Mining based approach for mobility tracking and localization in the context of AAL

Proposed architecture

- Two kinds of nodes - wearable device and cloud gateway node
- Prior knowledge of topology and user behaviour
- Real-time activity tracking using on-board analysis using IEM
- Location estimated using the mobility traces and user speed
- Delay-tolerant communication of results to the gateway node
- Cloud-based learning to improve on-board analysis



(a) (b)

Figure 1: (a) Cloud gateway node (b) Wearable activity tracker

Iterative Edge Mining (IEM)

- Activity state classifier
- Based on superimposition of BN and ClassAct
- Raw data $\rightarrow$ signal distribution using BN
- BN events $\rightarrow$ decision-tree classifier
- Input parameters - decay factor (γ), threshold (ε) and heartbeat ($t_{heartbeat}$)
- Trade-off between classification frequency (localization accuracy) and resource utilization
- Captures the nature of signal unlike ClassAct

Localization process using IEM

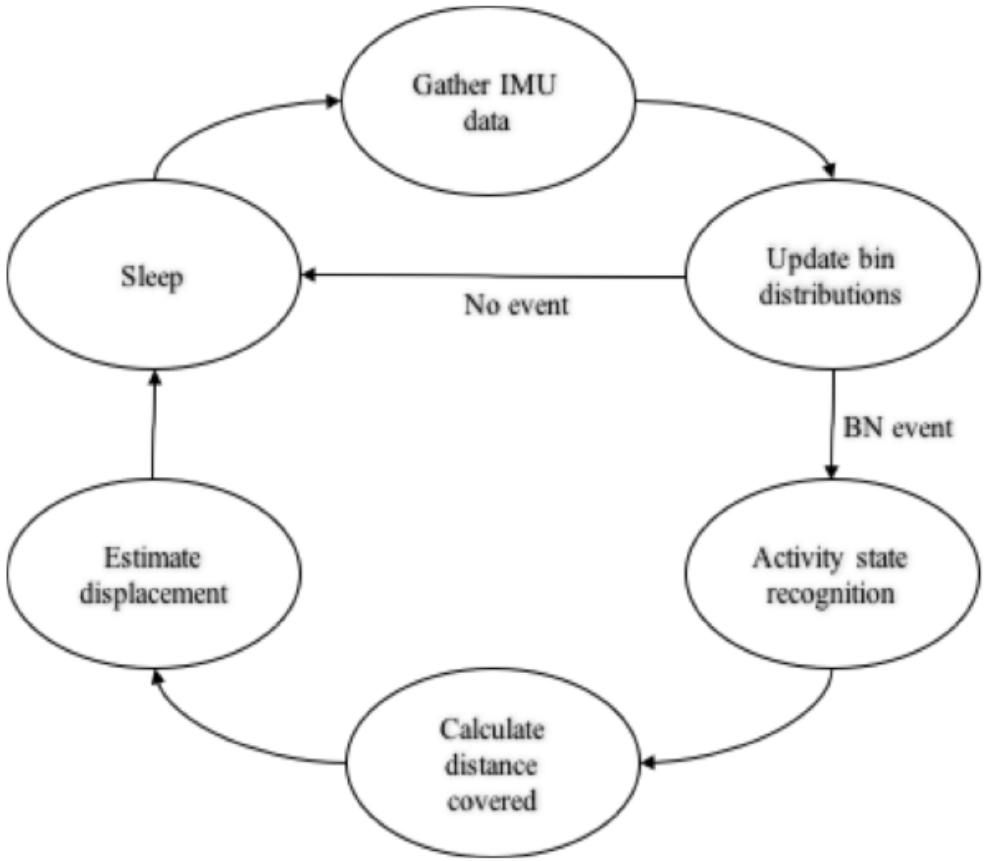


Figure 2: State diagram for on-board analysis on wearable device

Evaluation

- Metrics - accuracy of classification, cumulative error in distance calculation, and reduction in classification frequency
- Input parameters - γ, ε, $t_{heartbeat}$
- Data collection - @frequency of 10Hz
  - Duration - 16mins - walk and stand (4 mins each)
  - Number of iterations - 12 (train and test datasets)

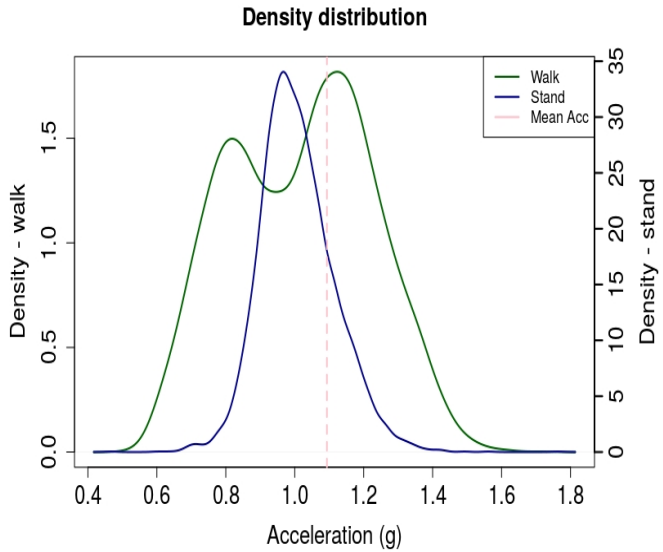
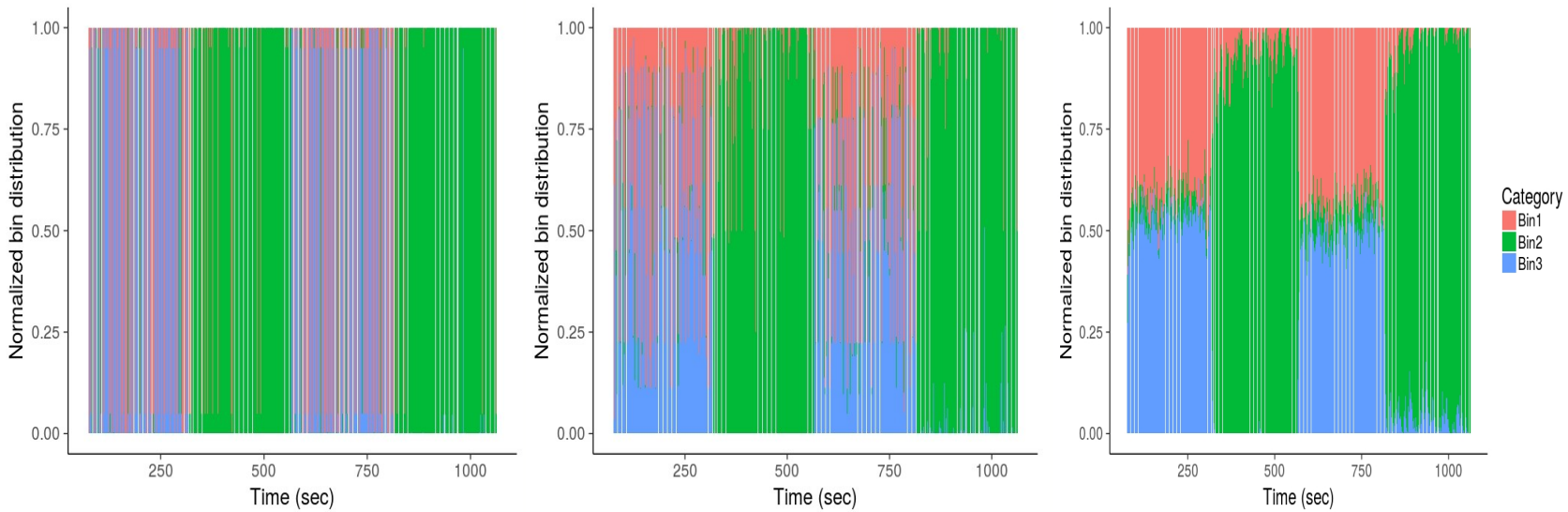


Figure 3: Density distribution for walk and stand acceleration values

- Smoothing phenomenon - effect of γ
- $\varepsilon = 0 \rightarrow$ highest sensitivity to changes in signal distribution



(a) (b) (c)

Figure 4: Smoothing effect of γ on signal distributions (a) $\gamma = 0.05$ (b) $\gamma = 0.5$ (c) $\gamma = 0.95$

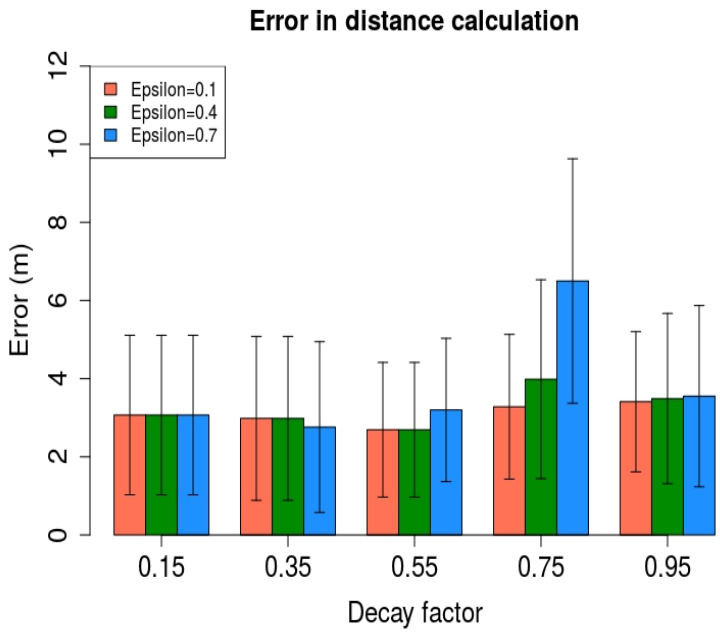
- C5.0 decision-tree classifier in R
- Combined effect of γ and ε

TABLE I. CLASSIFICATION ACCURACY (%)

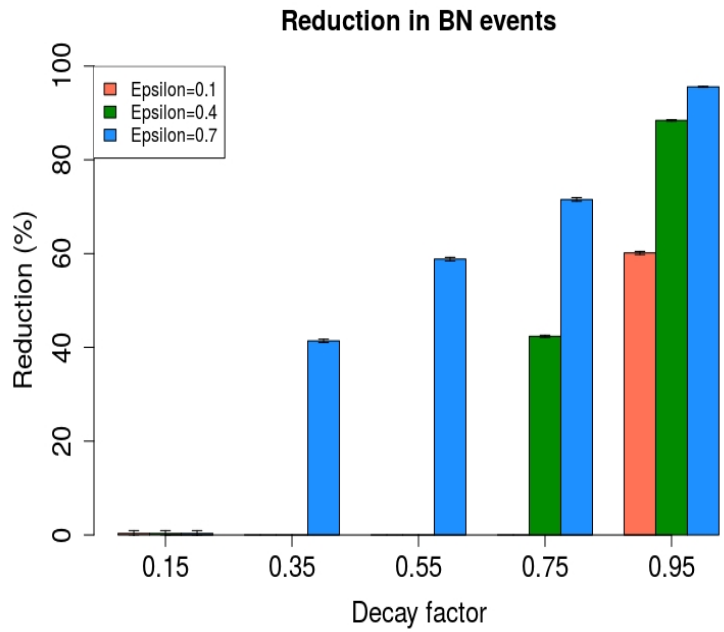
Error Threshold (ε)	Decay Factor (γ)				
	0.15	**0.35**	**0.55**	**0.75**	**0.95**
0.1	99.36	99.31	99.17	99.12	99.01
0.4	99.36	99.31	99.17	98.77	98.75
0.7	99.36	99.19	98.75	98.59	97.95

Figure 5: Classification accuracy for different values of γ and ε

- Cumulative error in distance and reduction in classification frequency
- Total distance covered in each experiment - 600m



(a)



(b)

Figure 6: Variation in cumulative error and BN events with 95% CI

Conclusions and Future work

- Fog-centric WSN system for localization
- Reliance on self-tracking and sensor based analytics
- IEM based activity classification - $> 97.9\%$
- Cumulative error percent - $0.4 - 1\%$
- Reduction in classification frequency - upto 95%
- Real-time event detection with improved energy profile
- Ease of deployment
- Evaluate IEM for different mobility patterns.
- Transmission of alerts to caregivers

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Thank You

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