



# Foundations of Cyber Physical Information Networks

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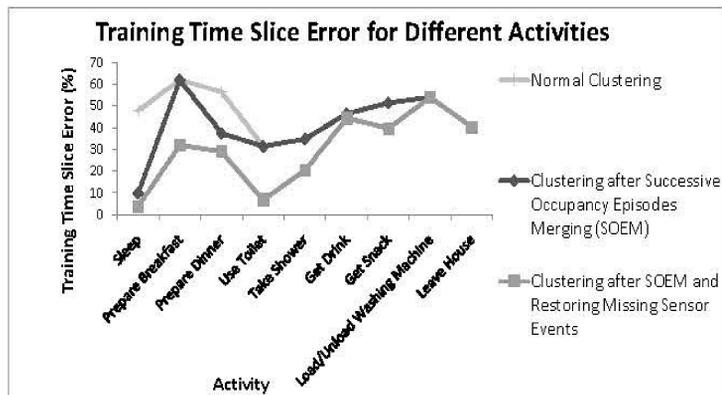
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## Task 1: Activity Recognition and Pattern Mining in Cyber-Physical Networks

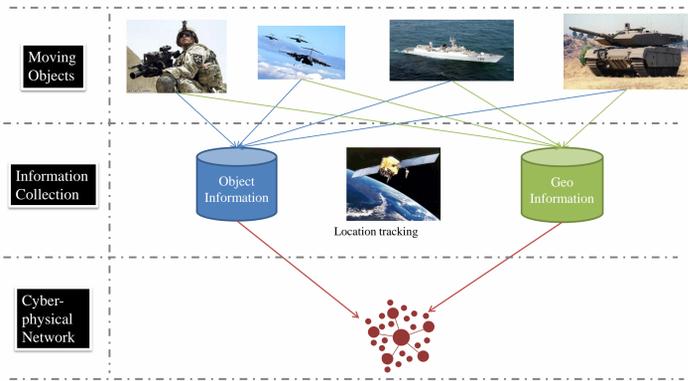
- Pattern mining and activity recognition: Find movement patterns and distinguish activities in CPS
- Challenges: Activity recognition in **complex, open, physical** environments
  - Multiple overlapping activities
  - Missing sensor data
- Unsupervised Learning Method
  - 26 day data set from real home with 16 activities
  - Reduces training time slice errors by 44% for sleep and 17% on average over all activities

## Accuracy Evaluation

- Outperforms Naïve Bayes, matches performance of HMM and HSMM but is unsupervised



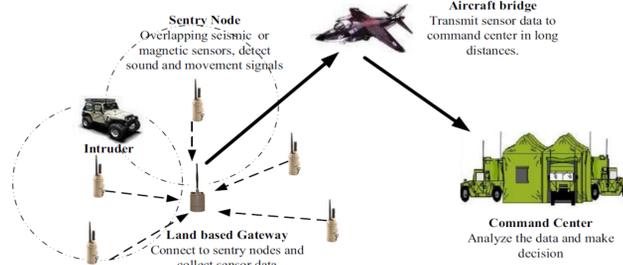
## Task 2: From Movement Mining to Cyber-Physical Networks



- Location tracking + moving objects information + geo information
- Anomaly detection
  - Association mining between object features and motions
    - Travel: young/senior people may choose different routes
    - Social recommendation
    - Similar objects may take similar actions

## Intruder Detection with Trustworthy Alarms

- *TruAlarm*: Analyze alarm trustworthiness in CPS data
- *IntruMine*: Detect intruders in cyber-physical information networks
  - Construct a graph model from the physical network (sensor)
  - Carry out the calculation in cyber space
  - Validate the calculated results and update the graph model



Lu-An Tang, Xiao Yu, Sangkyum Kim, Jiawei Han, Chih-Chieh Hung, and Wen-Chih Peng, "Tru-Alarm: Trustworthiness Analysis of Sensor Networks in Cyber-Physical Systems", Proc. of 2010 Int. Conf. on Data Mining (ICDM'10)

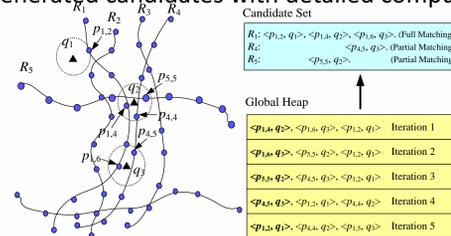
Lu-An Tang, Quanquan Gu, Xiao Yu, Jiawei Han, Thomas La Porta, Alice Leung and Tarek Abdelzaher, "IntruMine: Mining Intruders in Wireless Sensor Network of Cyber-physical Systems", submitted to ICDM'11

## MoveMine System <http://dm.cs.uiuc.edu/movemine>

Zhenhui Li, Ming Ji, Jae-Gil Lee, LuAn Tang, Yintao Yu, Jiawei Han, and Roland Kays, "MoveMine: Mining Moving Object Databases" (system demo), Proc. 2010 ACM SIGMOD Int. Conf. on Management of Data (SIGMOD'10), Indianapolis, Indiana, June 2010.

## Retrieve k-Nearest Neighboring Trajectories

- Large set of trajectory data are acquired from GPS, satellite and other ubiquitous computing devices
- *k*-NNT query: Given a sequence of locations, find the top-*k* trajectories that pass by (or close to) those locations
- Query Framework
  - Generate *k*-NNT candidates by search the neighboring region of query points
  - Verify the generated candidates with detailed computation



Lu-An Tang, Yu Zheng, Xing Xie, Jing Yuan, Xiao Yu, Jiawei Han, "Retrieving k-Nearest Neighboring Trajectories by a Set of Point Locations", Proc. of 2011 Int. Symp. on Spatial and Temporal Databases (SSTD'11), Minneapolis, MN, Aug. 2011

