An Empirical Study of Combining Participatory and Physical Sensing to Better Understand and Improve Urban Mobility Networks

Xiao-Feng Xie, Zun-Jing Wang

WIOMAX LLC: The Robotics Institute, Carnegie Mellon University; Department of Physics, Carnegie Mellon University

MOTIVATION
- Using of location-based services grows fast worldwide. Users share footprints through Checkin: <user, location, time, [comment]> - But the instant sampling rate of user trajectories is still very limited.
- Increasing attention on smart traffic control systems of urban road networks.
- Vehicle flows are recorded by physical sensors with Vehicle Record: <location, time,>. Primary objectives: to reduce travel congestion and vehicle emissions.
- Social and traffic activities are complementary with partial overlaps. Therefore, combining participatory and physical data improves urban mobility applications.

DATA DESCRIPTION

Spatial Features
- Checkin Locations
- Physical Sensing Region

Temporal Features
- Checkin Counts in the Participatory Sensing Region
- Checkin Frequency in the Participatory Sensing Region
- Vehicle Flow Patterns at Intersection D
- Vehicle Flow Patterns at Intersection P

Checkin Locations
- Pittsburgh Metropolitan Area
- Time: 1/1/2012, 7/1/2014
- Locations: 2,198,572

User Checkin Statistics
- Checkin places (cluster) : DBSCAN Clustering
- User Checkins: 74,658 Users; 3,399,376 Checkins

User Entropy and Regularity
- User Entropy: \( H(U_i) = -\sum_{k=1}^{K} p_i(k) \log_2 p_i(k) \) for cluster \( i \) visited by user \( U \)

URBAN MOBILITY APPLICATIONS

Change Point Detection and Reasoning
- Find exact time and reason leading to events
  - Combining geo-tagged and non geo-tagged tweets

Topic-Based Traffic Information Extraction
- Mostly on highways
- Mostly at intersections
- Accidents" Sub-Topic

Real-Time Traffic Incident Detection
- Vehicle Flow Patterns near Checkins of the “Traffic” Topic
  - Road closure at T1, Traffic flow at Intersection A
  - Narrow down searches

Traffic Demand Analysis
- Vehicle Flow Patterns
  - Zone D1: Higher traffic flow in weekends: Contains a major store
  - Zone Z2: Lower traffic flow in weekends: Contains a major company

Checkins Patterns
- Zone D1: Move lacking traffic, but still higher checkins in weekends
- Zone Z2: With much noise, not apparent lower checkins in weekends