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

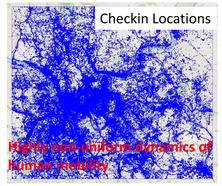
Project Site

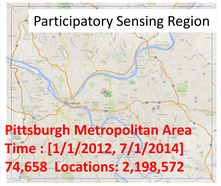
MOTIVATION

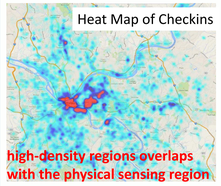
- Using of location-based services grows fast worldwide. Users share footprints through ***Checkin***: <user, location, time, [comment]>. But the instant sampling rate of user trajectories is still very limited.
- Increasing attention on smart traffic control systems of urban road networks. Vehicle flows 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.

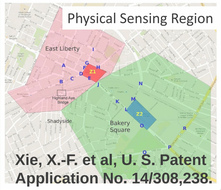
DATA DESCRIPTION

Spatial Features









Xie, X.-F. et al, U. S. Patent Application No. 14/308,238.

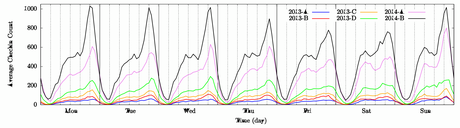
Data Collection

- Participatory Data: 74,658 Users; 3,399,376 Checkins
- Physical Data: 125,369,318 Vehicle Records

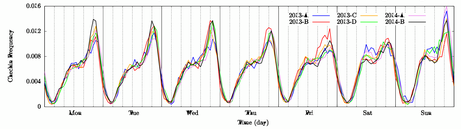
Temporal Features

Participatory

Checkin Counts in the Participatory Sensing Region

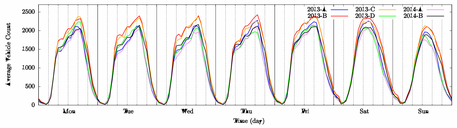


Checkin Frequency in the Participatory Sensing Region

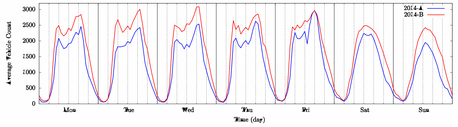


Physical

Vehicle Flow Patterns at Intersection **D**



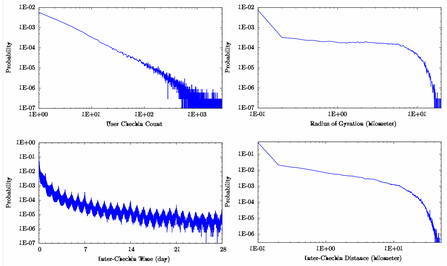
Vehicle Flow Patterns at Intersection **P**



HUMAN MOBILITY PATTERNS

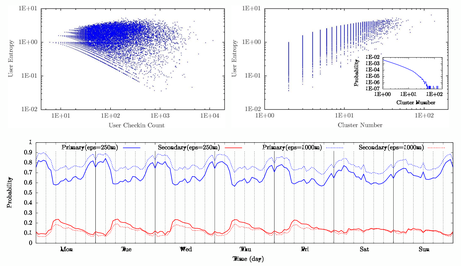
User Checkin Statistics

- User checkin *places* (clusters) : DBSCAN Clustering



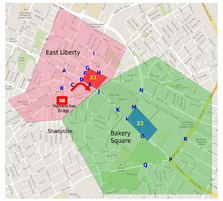
User Entropy and Regularity

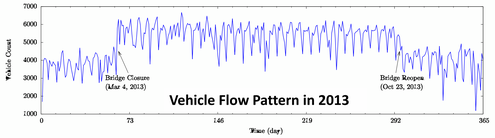
- User Entropy : $-\sum_{k=1}^{K} p_i(k)\log_2 p_i(k)$ for cluster k visited by user i



URBAN MOBILITY APPLICATIONS

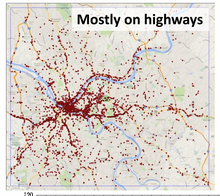
Change Point Detection and Reasoning

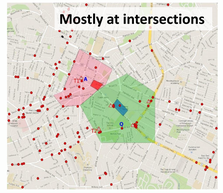


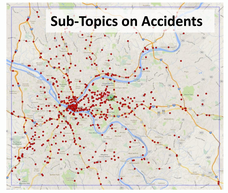


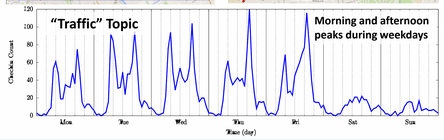
- Find exact time and reason leading to events
  - Combining geo-tagged and non-geo-tagged tweets

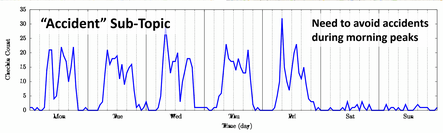
Topic-Based Traffic Information Extraction



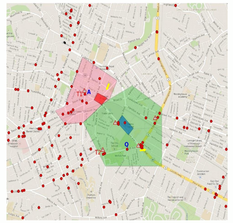








Real-Time Traffic Incident Detection

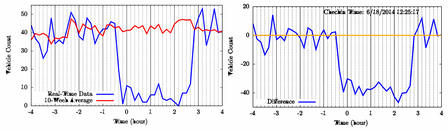


Using checkins are able to:

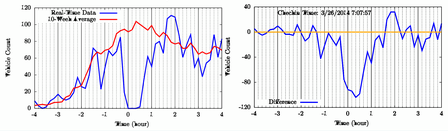
- pinpoint events at early stage
- Narrow down searches

Vehicle Flow Patterns near Checkins of the "Traffic" Topic

- *Road closure* at **T1**, Traffic flow at Intersection **A**



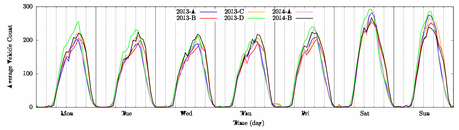
- *Road accident* at **T2**, Traffic flow at Intersection **Q**



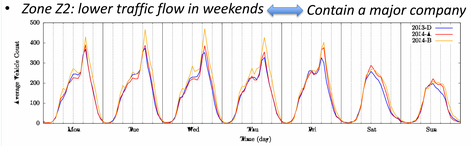
Traffic Demand Analysis

Vehicle Flow Patterns

- *Zone Z1: higher traffic flow in weekends* ⟷ *Contain a major store*

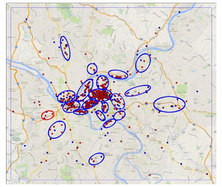


- *Zone Z2: lower traffic flow in weekends* ⟷ *Contain a major company*

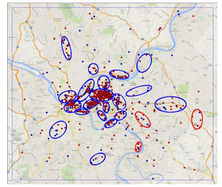


Origin and Destination Checkins

- Zone Z1

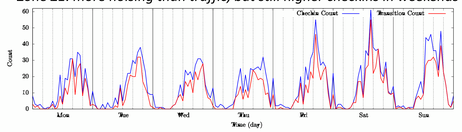


- Zone Z2



Checkin Patterns

- *Zone Z1: more noising than traffic, but still higher checkins in weekends*



- *Zone Z2: with much noise, not apparent lower checkins in weekends*