Methods for Analysis of Participatory and Mobile Crowd Sensing Data

Dragan Stojanovic

Computer Science Department, Faculty of Electronic Engineering
University of Nis, Serbia
Participatory and mobile crowd sensing

- A new sensing and geo-crowd sourcing paradigm
  - Based on the power of various mobile devices/objects
    (e.g., smartphones, wearable devices, smart sensors, vehicles, etc.)

- Ability to acquire local geospatial knowledge through sensor-enhanced mobile devices:
  - Physical, virtual, social sensors
  - Location, trajectory, personal status and surrounding context, noise level, air pollution, traffic and road conditions, etc.

- Possibility to share this knowledge with other participants/users and wide community
Participatory and mobile crowd sensing – Applications

- **DriveSensing**
  - Traffic events monitoring, driver/vehicle behavior, traffic and road condition detection, vehicle and environmental status

- **ExposureSense**
  - Mobile diaries – registering activities and environment conditions (air pollution, noise level, etc.) in indoor/outdoor environments

- **CitySensing**
  - Sensing, reporting, reviewing, or discussing local problems by using social media and participatory sensing
DriveSensing - participatory sensing in traffic domain

- Detect (sense), process, and report:
  - Driver/vehicle activities and behavior, sudden traffic events and risky/aggressive driving
    - Data from GPS, motion sensors, in-car sensors processed locally
    - J48 decision tree (WEKA) adapted to Android
  - Traffic status (dynamic travel time, traffic congestions, etc.)
  - Road conditions monitoring (potholes, road bumps, slippery road, etc)
  - Air pollution (sensors attached to vehicles), vehicle fuel consumption, emission, etc.

- Analysis goals
  - Detection of real-time traffic events, dynamic black spots and bad driver profile
ExposureSense: mobile diary and analysis of mobility

- Integrating daily activities with air quality
  - Using motion sensors and air pollution sensors integrated in mobile device
- Correlation of outdoor/indoor activities, personal status and air quality data estimates user’s exposure to air pollution
  - Standing, running, walking, up stairs, elevator, biking, etc.
  - CO₂, NOₓ, etc.
- Analysis goals
  - Detection of moving behaviors and patterns in relation to background geographic information, and city events.
CitySensing – registering city problems

- User generated geo-content
- Detect and report urban problems
  - Waste disposal,
  - Damaged park furniture,
  - Street holes,
  - Street lights,
  - Drain blocked,
  - Etc.
- Analysis goals
  - Hots spots
  - Heat maps
  - Trends/patterns
Crowd sensing data

- Demo participatory sensing and crowd sourcing applications provide necessary data
  - DriveSensing – driver/vehicle behavioral events, traffic events and status, road condition
  - ExposureSense – user trajectories, activities, air pollution in surrounding, etc.
  - CitySensing – user generated geo-content related to communal and local problems

- Problem
  - Relatively small data sets
  - Collection of large real-world participatory sensing data sets needs a “campaign”, such as Nokia Mobile Data Challenge and CoenoSense (ETHZ)
Methods and tools for analysis in participatory sensing

- Semantic enrichment of VGI (mobility data)
  - Locally at the smart device
  - Bringing semantics to plain geographic information
  - Semantics of mobility and events (ontologies)

- Aggregation and fusion at servers (cloud)
  - Clustering (DBSCAN, OPTICS, etc.) – to improve the accuracy of reporting (sensing)
  - Data stream processing and CEP – to detect complex online events, behaviors, goals, etc. And generate notifications

- Big mobility data processing and analysis
  - MapReduce/Hadoop, Mahout, Spark, etc.
  - STORM, S4, Esper, etc.
Further research/collaboration - Semantics of VGI

- Users generate and send **semantic** geo-information related to their mobility, by processing and analysing raw geo-referenced data at their mobile devices, to
  - Servers (cloud)
  - Mobile devices in surrounding (MANET)

- Various aspects of mobility of moving objects (people, vehicles, assets, animals,...) related to locations/trajectories
  - User and environment context, personal and social status, activity, goal, behavior, physiological status, vehicle condition, traffic condition, air pollution, social media, etc.

- ...at different levels of granularity
Further research/collaboration – Integration with background geo-info

- Personalized daily diaries
  - next generation personalized healthcare and urban mobility applications

- Inference based on semantics:
  - Reasons of movement/behaviour, detection of anomalies and predictions of future movement/behavior

- Analyse moving behaviors and patterns of citizens/tourists and relate them to:
  - background geographic information (POI, road network data, indoor maps),
  - time context,
  - weather conditions, means of transport,
  - social/cultural events in the city/indoors, etc.
Research challenges

- Incentive mechanisms
  - To attract mobile users to participate in crowd sensing activities

- Privacy preservation
  - Basic movement data is enhanced with rich semantics of the participating moving objects and their trajectories; privacy is at higher risk
Thank you for your attention

Dragan Stojanovic

dragan.stojanovic@elfak.ni.ac.rs