 Université 2020
Le numérique au service de l’environnement

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Studies of Floating Car Data mining

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Context and objectives

Study 1: Vehicle usage typology identification

Study 2: Individual significant place recognition

Study 3: Travel time estimation

Study 4: Territory functional zone discovery
Introduction

A Ph.D. thesis (2019-2021 @LVMT, ENPC, supervised by Fabien LEURENT and Xiaoyan XIE)

“FCD Mining to Feature out Mobility Patterns: Individual-Centered and Place-Based Analyses”

Context

• Understanding human movements -> critical in resolving mobility issues
• Massive digital-trajectory data -> Potentials for mobility insights
  - Fundamental knowledge of mobility entities all day long (vehicle & pedestrian)
  - A variety of sources: GSM(Mobile phone data), GPS (Floating Car Data), AFC (Smart cards, Navigo etc.)

2 key issues

• Mobility pattern analysis
• Trajectory data mining

Up-to-date solutions
Data

Traditional data:
- Source: surveys (EGT), loop detectors, camera etc.
- Shortcombes: inherently limited for deploying

Trajectory data

New Digital Alternative Floating Car Data
- GPS vehicle traces
  Timestamped localizations and vehicle speeds (per 30s)
  (data source: Coyote)

A cost-effective data solution
- Wide coverage (temporally 7*24 and spatially large-scale)
- Rich information along the path (intermediate points)
Overall objective

Study mobility patterns by FCD mining

• **What is “mobility patterns”:**
  • Recurring forms of human movements

• **What to analyze:**
  • urban dynamics : 1) travel demand of people ↔ 2) spatial configuration

• **Specific issues and aims:**

  Two levels of issues

  **Individual-Centered Mobility Patterns**
  • Vehicle usage type (trips)
    • Roadway user differentiation
  • Individual mobility context (stays)
    • Anchor place & significant locations

  **Place-Based Mobility Patterns**
  • Travel time estimation (planning)
  • Territorial functional zone (intra-)
    • Zone segmentation
  • Region organization (inter-)
    • Jobs-housing relation etc.
Case studies and key results
**Study 1: Vehicle usage typology identification**

**Publication:** Danyang Sun, Fabien Leurent, Xiaoyan Xie (2020). *Floating Car Data mining: Identifying vehicle types on the basis of daily usage patterns*, Transportation Research Procedia. DOI:10.1016/j.trpro.2020.03.087

**Objective:**
- Identify vehicle usage type by mobility making
- User segmentation and differentiation

**Approach:** machine learning techniques

1. **Identify trip types**
   - (by trip features)
   - Clustering

2. **Identify vehicle types**
   - (by trip profiles)
   - Topic modeling

**Outcome:** 68,613 vehs with 196,554 trips; 2.9 trips/veh (IDF one day)

- **Long Distance Traveling**
  - (fewer but long trips, commuting)
  - #Trip: 2.05 (avg); Tot dist.: 48%

- **Morning Activity Based**
  - (moderate trips, temporally imbalanced)
  - #Trip: 2.53 (avg); Tot dist.: 25%

- **Evening Activity Based**
  - (moderate trips, temporally imbalanced)
  - #Trip: 2.58 (avg); Tot dist.: 12%

- **Frequent Activity Based**
  - (more trips, frequent activity)
  - #Trip: 6.50 (avg); Tot dist.: 15%
Study 2: Individual place recognition and significant places

Objective: Mine individual mobility context and “anchor” places (homeplaces, workplaces, etc)

Approach: trajectory data mining

1) Extract significant-place locations
   - Trajectory processing: stay points detection (stops for activities)
   - Place recognition: adjacent stay points -> functional place

2) Identify significant-place type by visits' frequentation and duration

   - Activity type by temporal features
   - Place type by activities' frequentation

Outcomes: Hierarchy of places
   - Homeplace & Workplace, Secondary places, Other places
Study 3: Travel time estimation

Conference communication: Fabien Leurent, Danyang Sun, Xiaoyan Xie. Roadway Travel Times: Maximum Likelihood Estimation Based on Floating Car Data Intervals. Accepted for 9th Symposium of the European Association for Research in Transportation, hEART 2020

Objective:
- Exploit massive observations from FCD to estimate local travel times
- Compare with conventional method (point-wise average: currently widely used in the industry)

Methodology: Stochastic model

pros:
- Probabilistic specifications
- A measure of reliability
  (estimation with confidence intervals rather than unique values)

Achievements:
- obtained more precise estimations with fewer data by stochastic model
- resolved the underestimation of travel time problem in conventional methods

Outcomes

Site 1: A4 segment (Highway)
Site 2: Avenue Foch (Urban)
Study 4: Territory functional zones discovery

Publication: Danyang Sun, Fabien Leurent, Xiaoyan Xie. Uncovering mobility typologies of territorial zones based on Floating Car Data mining, Transportation Research Procedia. (in press)

Objective: Discover territory functional divisions by vehicle movements

Approach: machine learning techniques
- Retrieved zonal usage attributes
  - traffic flow
  - accessibility
  - building functions
- Discover functional zone by cooperative clustering

Outcomes: 5 major types of zones in IDF (by vehicle mobility)
C0: Residence oriented areas
C1: Amenity-residence mixed areas (local-accessible-based)
C2: Amenity-residence mixed areas (intermediate-range-accessible-based)
C3: Business/employment oriented areas
C4: Day-time mobility-oriented areas
Potential contributions

Data driven framework for automated mobility analysis
  - Up-to-date and large-scale

Prevision of mobility demand
  - Human mobility regularity and predictability
  - Aid in proposing alternatives (mode shifting etc.)

Mobility system diagnostic
  - Traffic state: congestion, road network LOS evaluation
  - Planning guidance: city structure and geographical correlations etc.