Université 2020

Le numérique au service de l'environnement

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Digital Traces & Mobility Computing

Studies of Floating Car Data mining

Université 2020 – Le numérique au service de l'environnement, Novembre 2020

Agenda

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

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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

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Data

Traditional data:

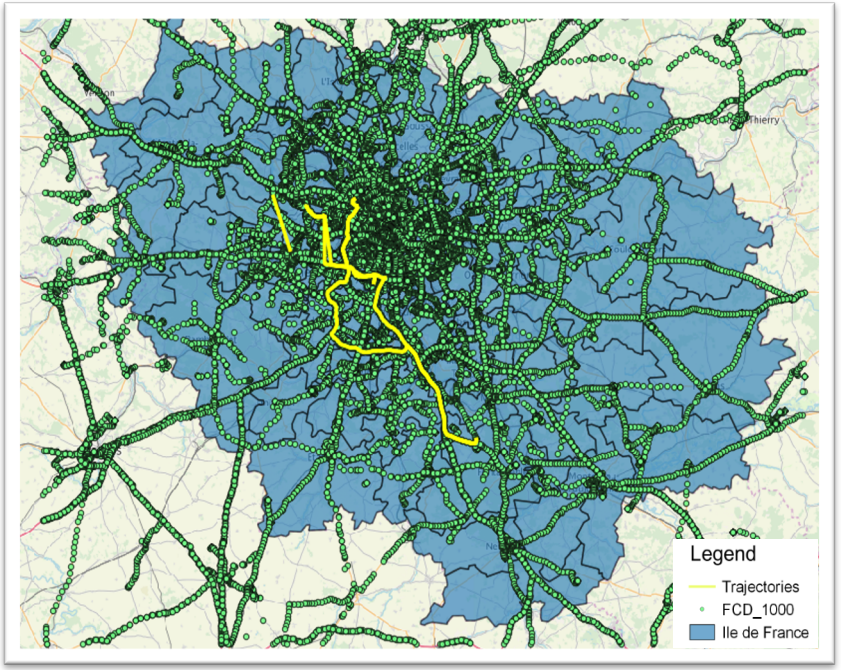
- Source: surveys (EGT), loop detectors, camera etc.
- Shortcomes: inherently limited for deploying

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)

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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.

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Case studies and key results

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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

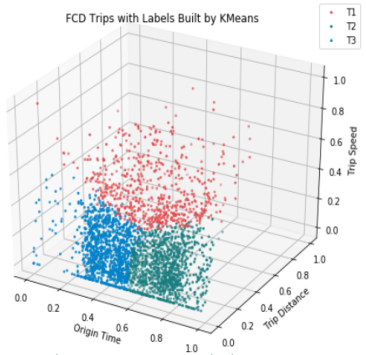
1 *Unsupervised learning Vehicle type discovery* 2

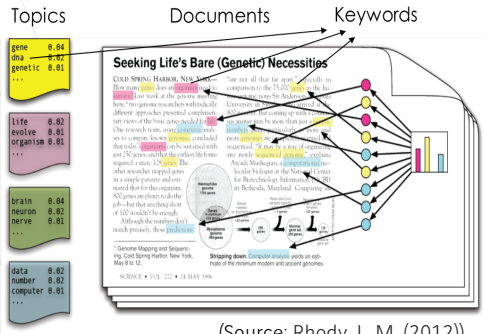
Identify trip types
(by trip features)
Clustering

Identify vehicle types
(by trip profiles)
Topic modeling

Clustering-> trip clusters

Topic Modeling-> usage "topics"





(Source: Rhody, L. M. (2012))

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

4 Vehicle Clusters

- **Long Distance Traveling**
  (fewer but long trips, commuting)
  #Trip:2.05 (aveg); Tot dist.: 48%
- Morning & Evening
  - **Morning Activity Based**
    (moderate trips, temporally imbalanced)
    #Trip:2.53 (aveg); Tot dist.: 25%
  - **Evening Activity Based**
    (moderate trips, temporally imbalanced)
    #Trip:2.58 (aveg); Tot dist.: 12%
- **Frequent Activity Based**
  (more trips, frequent activity)
  #Trip:6.50 (aveg); Tot dist.: 15%

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Study 2: Individual place recognition and significant places

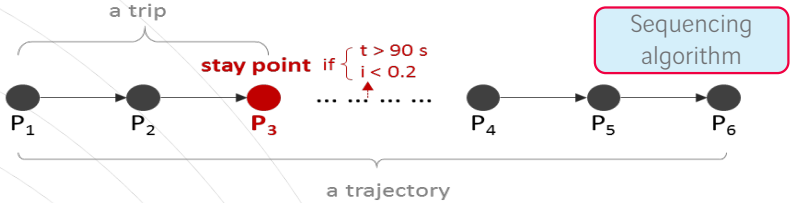
Conference communication: Danyang Sun, Fabien Leurent, Xiaoyan Xie. *Mining Vehicle Trajectories to Discover Individual Significant Places: Case Study Using Floating Car Data in the Paris Region*, Accepted for Transportation Research Board Annual Meeting, 2021, Washington DC

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

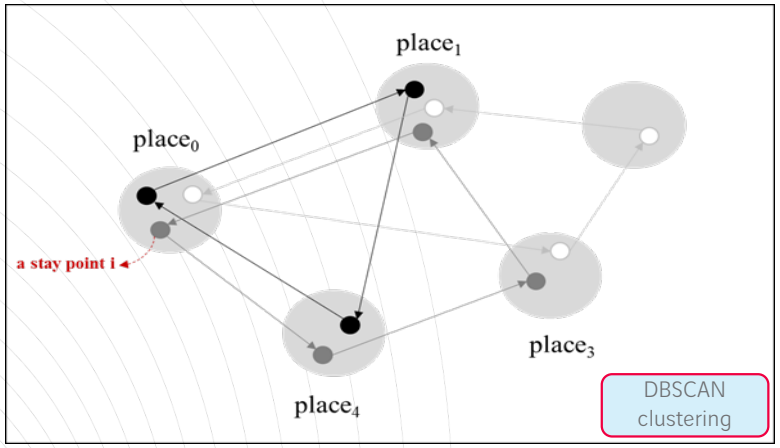
Approach: trajectory data mining

1) Extract significant-place locations

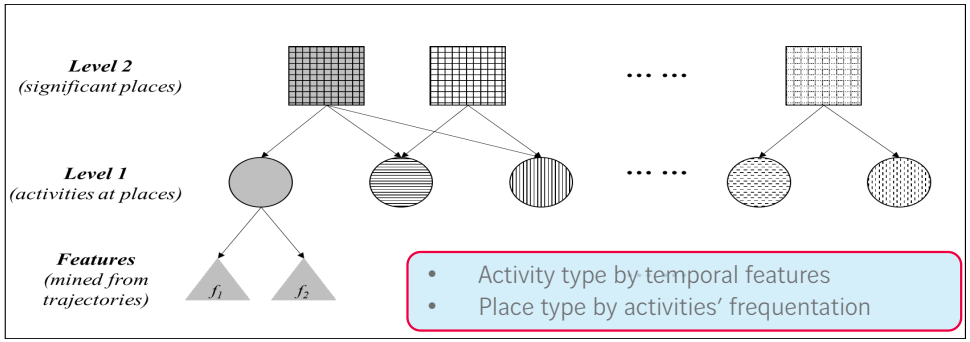
- *Trajectory processing: stay points detection (stops for activities)*



- *Place recognition: adjacent stay points -> functional place*

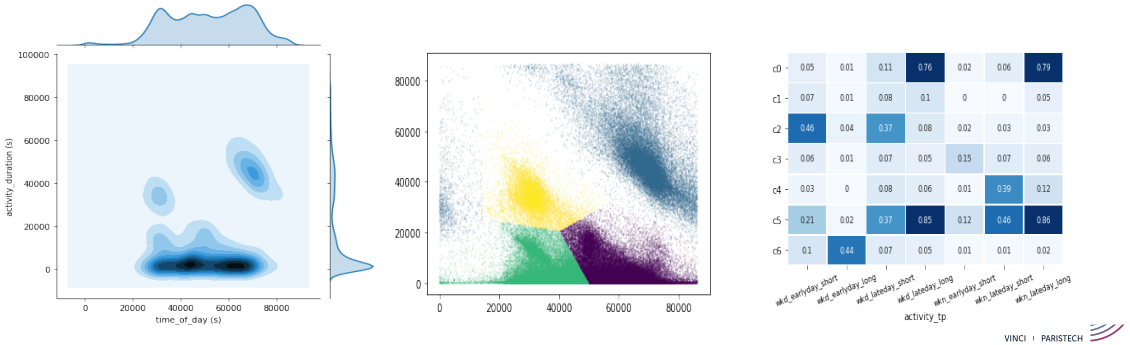


2) Identify Significant-place type by visits' frequentation and duration



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:

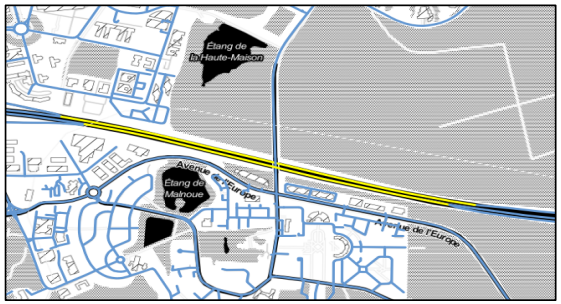
- Probabilistic specifications
- A measure of reliability

(estimation with confidence intervals rather than unique values)

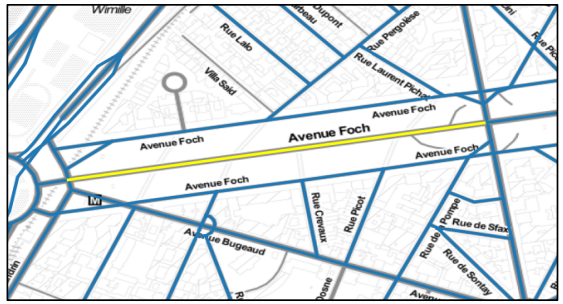
Achievements:

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

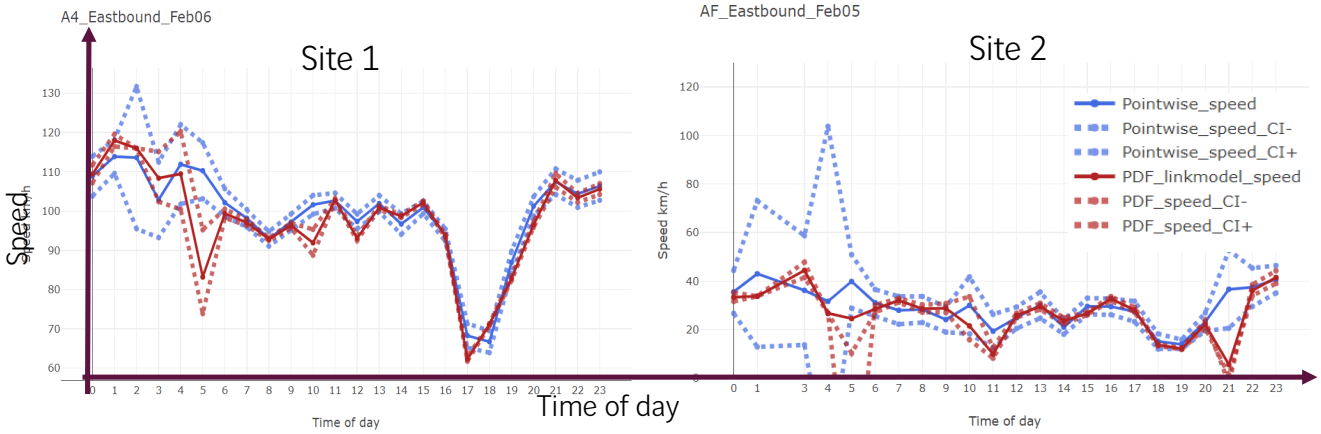
Outcomes



Site 1: A4 segment (Highway)



Site 2: Avenue Foch (Urban)



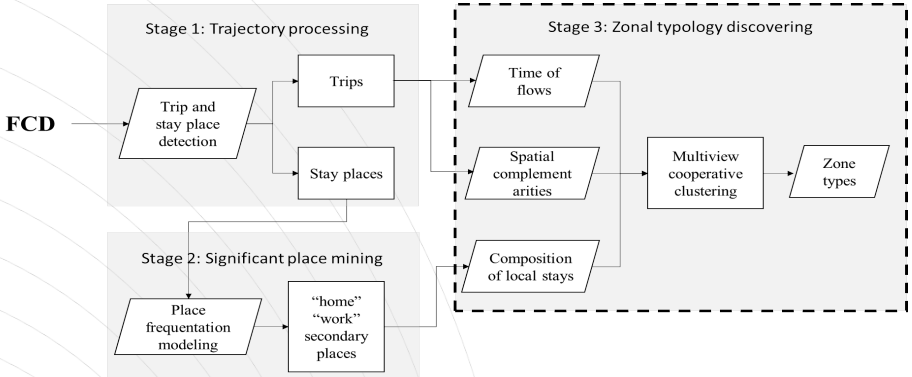
Study 4: Territory functional zones discovery

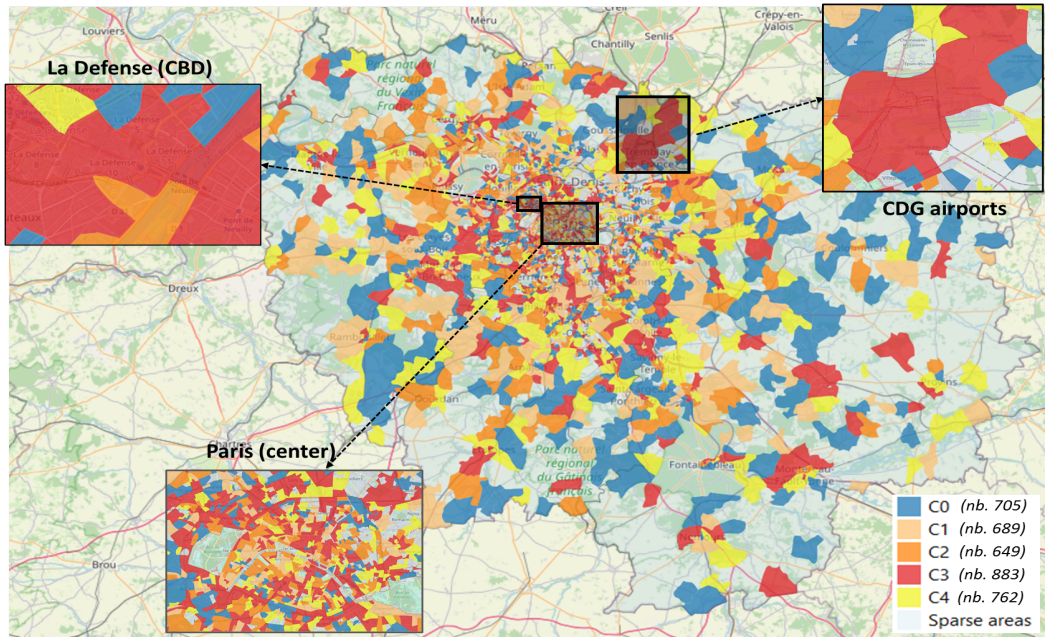
Publication: Danyang Sun, Fabien Leurent, Xiaoyan Xie. *Uncovering mobility typologies of territorial zones based on Floating Car Data mining*, Transportation Research Procedia. (in press)

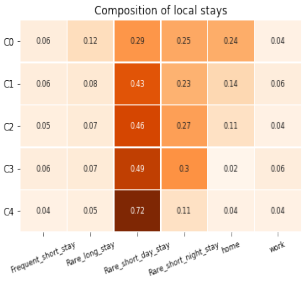
Objective: Discover territory functional divisions by vehicle movements

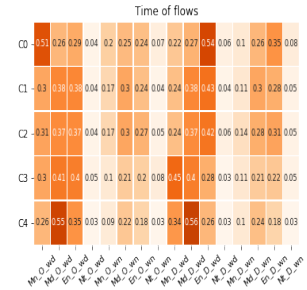
Approach: machine learning techniques

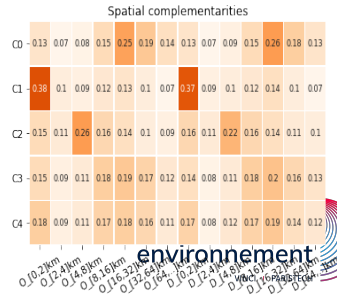
- Retrieved zonal usage attributes
  - traffic flow
  - accessibility
  - building functions
- Discover functional zone by cooperative clustering





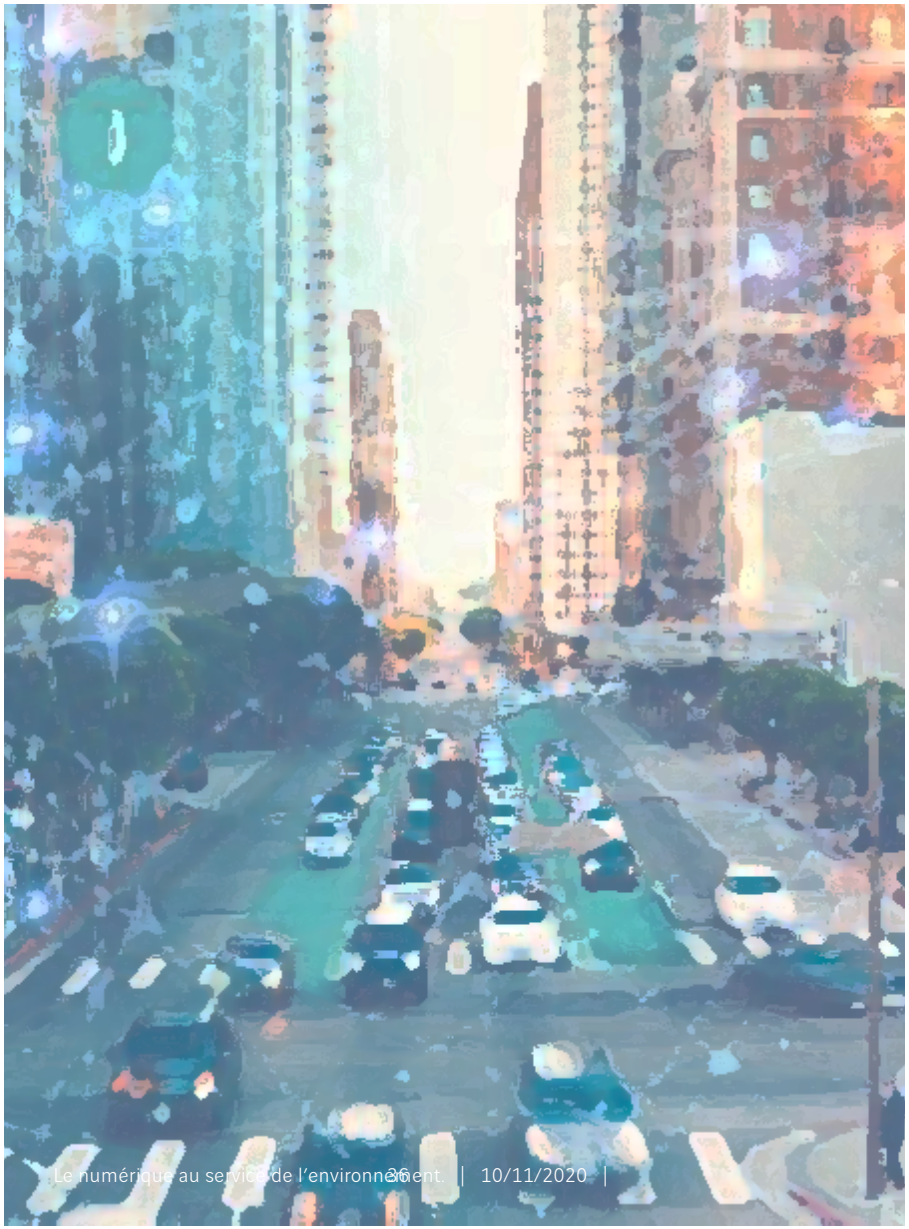






Outcomes: 5 major types of zones in IDF (by vehicle mobility)

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.