Reconstitution of the journeys to crime and location of their origin in the context of a crime series

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ULg

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1 Geographic profiling and its limits
2 Other constraints for an original methodology
3 Context of the study
4 Objectives
5 Methodological steps
6 Results
7 Conclusions
Time and space are modes by which we think and not conditions in which we live! (A. Einstein)
Space has been recognized as primordial in criminal investigations

- Geographic profiling
  - Distance as the essential component
  - Proximity as the main constraint

⇒ Most used methodology: Distance decay function
But this methodology presents several **restrictive conditions** for its application.
But this methodology presents several **restrictive conditions** for its application

- Suppose uniform distribution
- Limited distance between crimes
- Marauder behaviour
- Calibration with solved cases (reliance on aggregated trip distribution)
What if we have additional information?
The offender search area can be restricted with additional constraints

**Total** distance

**Time is also essential**
- **Chronology**
- **Duration**
- **Moment**
- **Time span**

⇒ It is possible to present a *methodology* that is *independent* of the **distance decay** function!
Which context for which data?

Specific context of **Charleroi** agglomeration

A **short** period of **time** between 4 events (15 days)

Recorded **essential elements** for the research

- Total distance
- Moments and chronology
- Locations
- Series
- Transportation mode (only **one** vehicle)
Objectives

Reconstitution of the journeys-to-crime

Delineate an area as small as possible where looking for the withdrawal site

Remarks

- Case study for validation
- Solution not provided by the police before treatment
A methodology based on propagation in raster mode

Cost surface

- Cumulated distance from each crime site
- Function of the chosen scenario for the movement between crime sites

**Total distance**: 100 km (10% of precision)

⇒ **Withdrawal area**: cumulated distance between 95 and 105 km
Step 1

- Identify the shortest path for each pair of event locations
- Identify the minimal distance connecting all the crimes

Goal

- Check the existence of a withdrawal area
- Check the coherence of data
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- Identify the minimal distance connecting all the crimes

Goal
- Check the existence of a withdrawal area
- Check the coherence of data

How?
Methodological steps

Iso-distance maps

Sum 2-2 of the iso-distance map in function of the chronology
**Methodological steps**

**Sum 2-2 of the iso-distance map**

![Map and table](image)

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Step 2: choice of the scenario

1. Iso-distance maps
2. Sum 2-2 of the iso-distance map
3. Scenarios
According to the chosen scenario, iso-distance maps will be differently combined
Scenarios

Scenario 1

- Theft of the car
- Withdrawal site
Scenarios

Scenario 1

- Theft of the car
- Withdrawal site
- Criminal acts
Scenarios

Scenario 1

- Theft of the car
- Withdrawal site
- Criminal acts
- Location where the car was found
Scenarios

Scenario 2

- Theft of the car
- Withdrawal site
- Criminal acts
- Location where the car was found
Scenario 3

- Theft of the car
- Withdrawal site
- Criminal acts
- Location where the car was found
- Observation site on the way back
Step 3: **Cost surface**

1. **Iso-distance maps**
2. **Sum 2-2 of the iso-distance map**
3. **Scenarios**
4. **Weighted sum of the maps**
How did we choose the scenario?
How did we choose the scenario?

Cost distance $\geq 105$ km for pixels in scenario 1

The second scenario was chosen.
Cost surface

**Chosen scenario**: Scenario n°2

**Single** distance for the first event (theft of the car)

**Double** distance for the others

- **Except** for the last crime site (**Single** distance + **Shortest path** to the car location)
Methodological steps

- Iso-distance maps
- Sum 2-2 of the iso-distance map
- Scenarios
- Weighted sum of the maps
- Classification
Results

Scenario 2

Charleroi

Legend:
- Red: [95 - 100]
- Blue: [100 - 105]
- Green: [105 - 110]
- Black: >110 km
How can we restrict this area?
Non-uniformity of the environment

Multi-criteria analysis

- **Constraint**: Withdrawal area inside a built-up area
- **Factor 1**: Rural commune (via PCA)
- **Factor 2**: Proximity to the main road
- **Factor 3**: Distance to road segments determined by the previous operations
Non-uniformity of the environment

Multi-criteria analysis

- **Constraint**: Withdrawal area inside a built-up area (Binary mask)
- **Factor 1**: Rural commune (via PCA) 0.1
- **Factor 2**: Proximity to the main road 0.2
- **Factor 3**: Distance to road segments determined by the previous operations 0.7

\[
\left( \sum_{i=1}^{n} p_i F_i \right) \prod_{j=1}^{m} C_j
\]
Conclusions

Method that has no to be calibrated

Specific conditions of application

If space has been deeply used, temporal information can lead to new effective methodologies
Thank you for your attention

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