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

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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

$\Rightarrow$ **Most used methodology : Distance decay function**

But this methodology presents several **restrictive conditions** for its application

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- 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

$\Rightarrow$ 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 c**hosen scenario** for the movement between crime sites

Total distance : 100 km (10% of precision)

$\Rightarrow$ **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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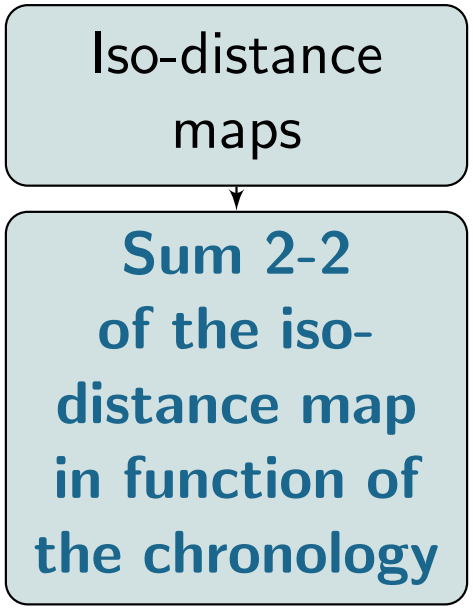
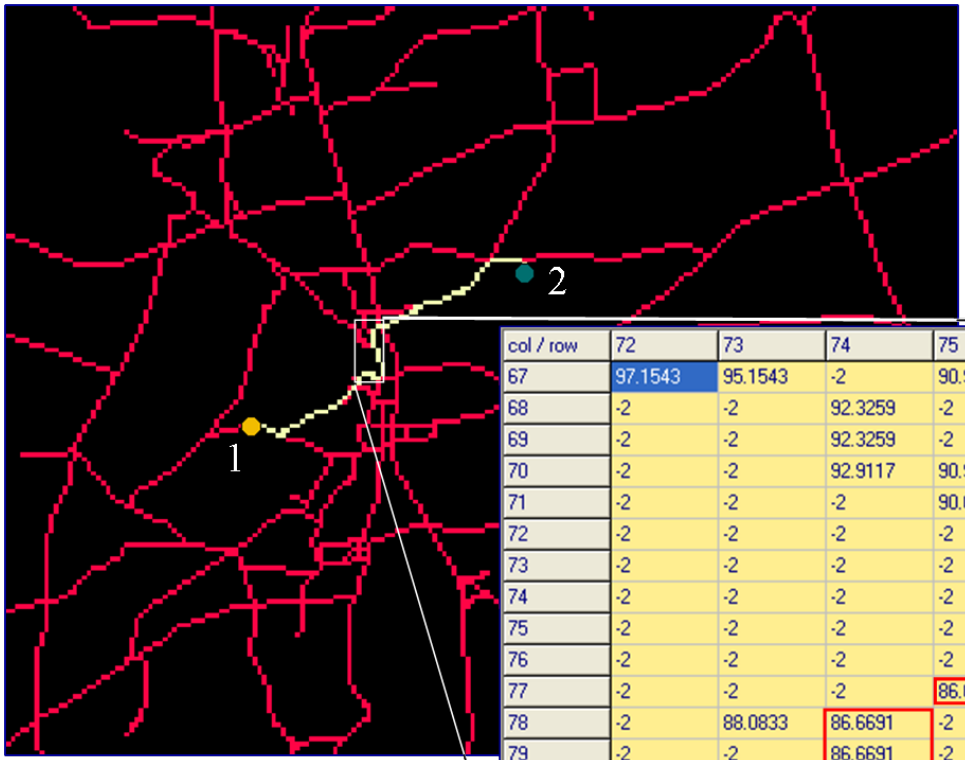
How ?

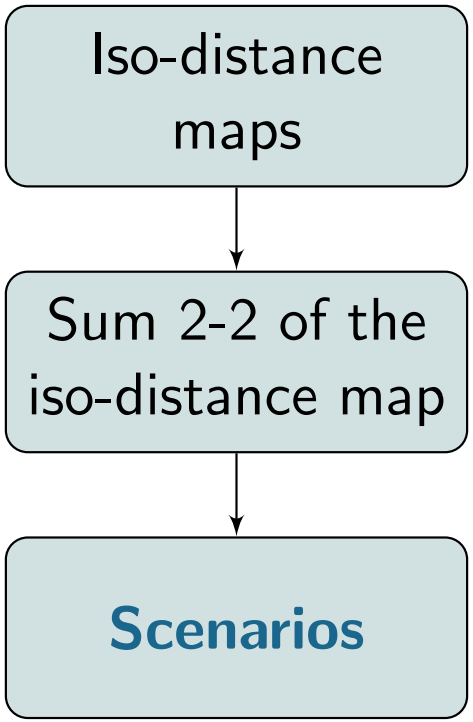

Iso-distance maps
Sum 2-2 of the iso-distance map in function of the chronology

Sum 2-2 of the iso-distance map



col / row	72	73	74	75	76	77	78	79
67	97.1543	95.1543	-2	90.9117	-2	-2	86.6691	86.6691
68	-2	-2	92.3259	-2	88.0833	86.6691	-2	87.4975
69	-2	-2	92.3259	-2	-2	86.6691	-2	-2
70	-2	-2	92.9117	90.9117	-2	86.6691	-2	-2
71	-2	-2	-2	90.0833	88.0833	86.6691	-2	-2
72	-2	-2	-2	-2	-2	-2	86.6691	-2
73	-2	-2	-2	-2	-2	-2	86.6691	-2
74	-2	-2	-2	-2	-2	-2	86.6691	-2
75	-2	-2	-2	-2	-2	-2	-2	86.6691
76	-2	-2	-2	-2	-2	-2	-2	86.6691
77	-2	-2	-2	86.6691	86.6691	86.6691	-2	86.6691
78	-2	88.0833	86.6691	-2	-2	86.6691	86.6691	87.2548
79	-2	-2	86.6691	-2	-2	-2	87.2548	-2
80	87.2548	86.6691	87.2548	87.2548	87.2548	-2	87.2548	-2
81	86.6691	-2	-2	-2	87.2548	87.2548	87.8406	-2
82	87.2548	-2	-2	-2	-2	88.6691	-2	-2

Step 2 : **choice of the scenario**

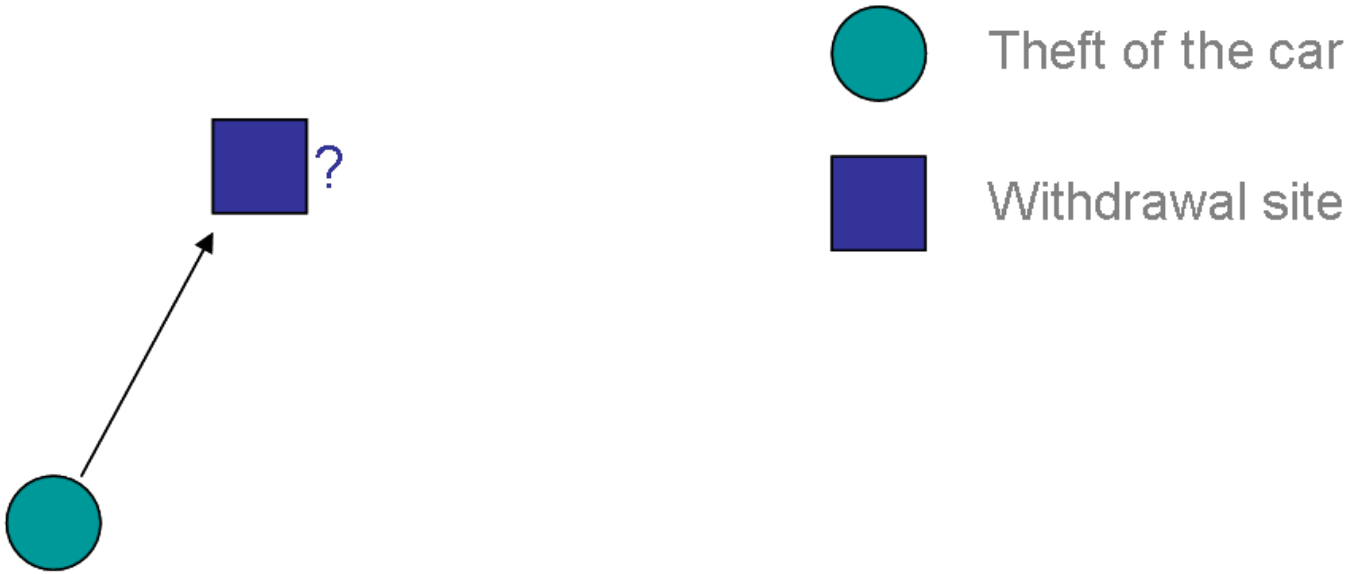


Scenarios

According to the chosen scenario, iso-distance maps will be differently combined

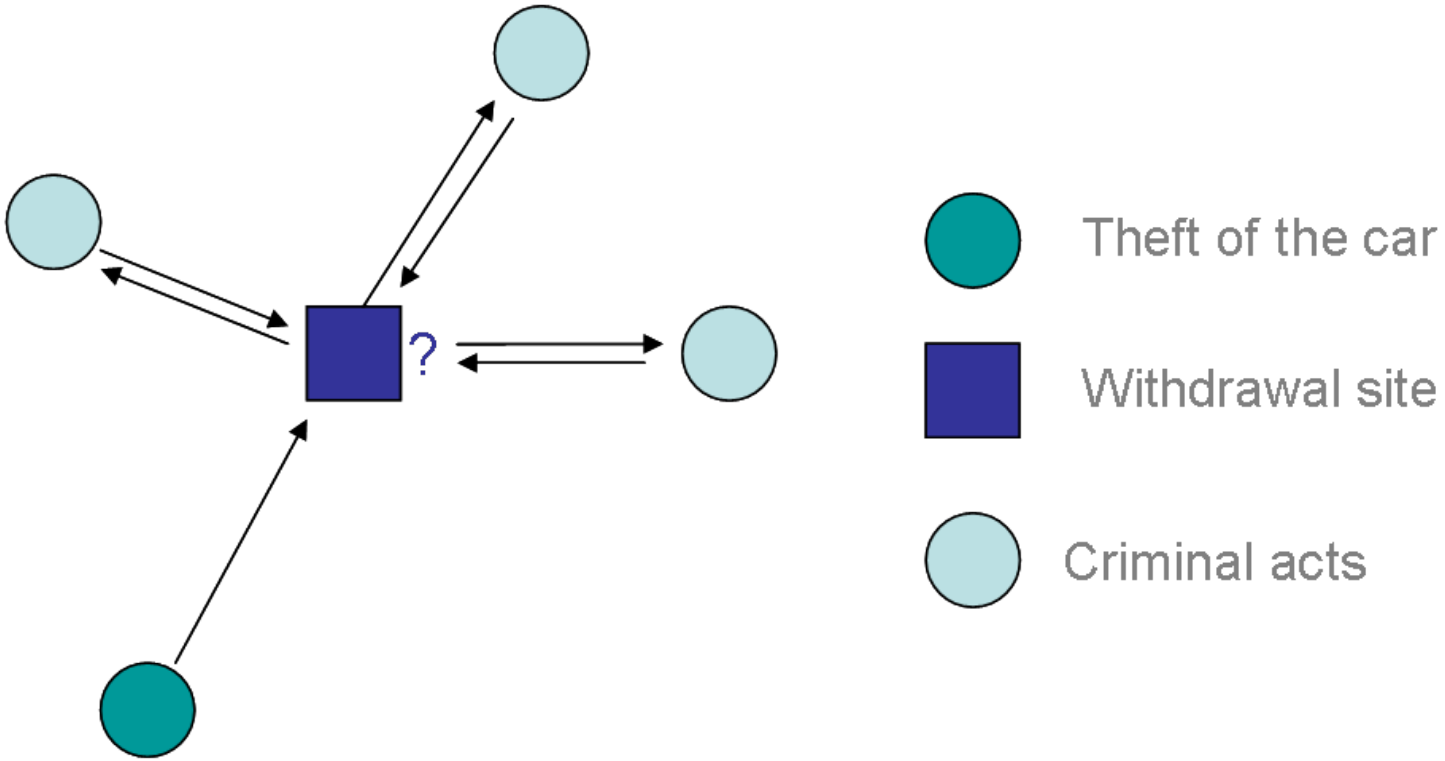
Scenarios

Scenario 1



Scenarios

Scenario 1



Scenarios

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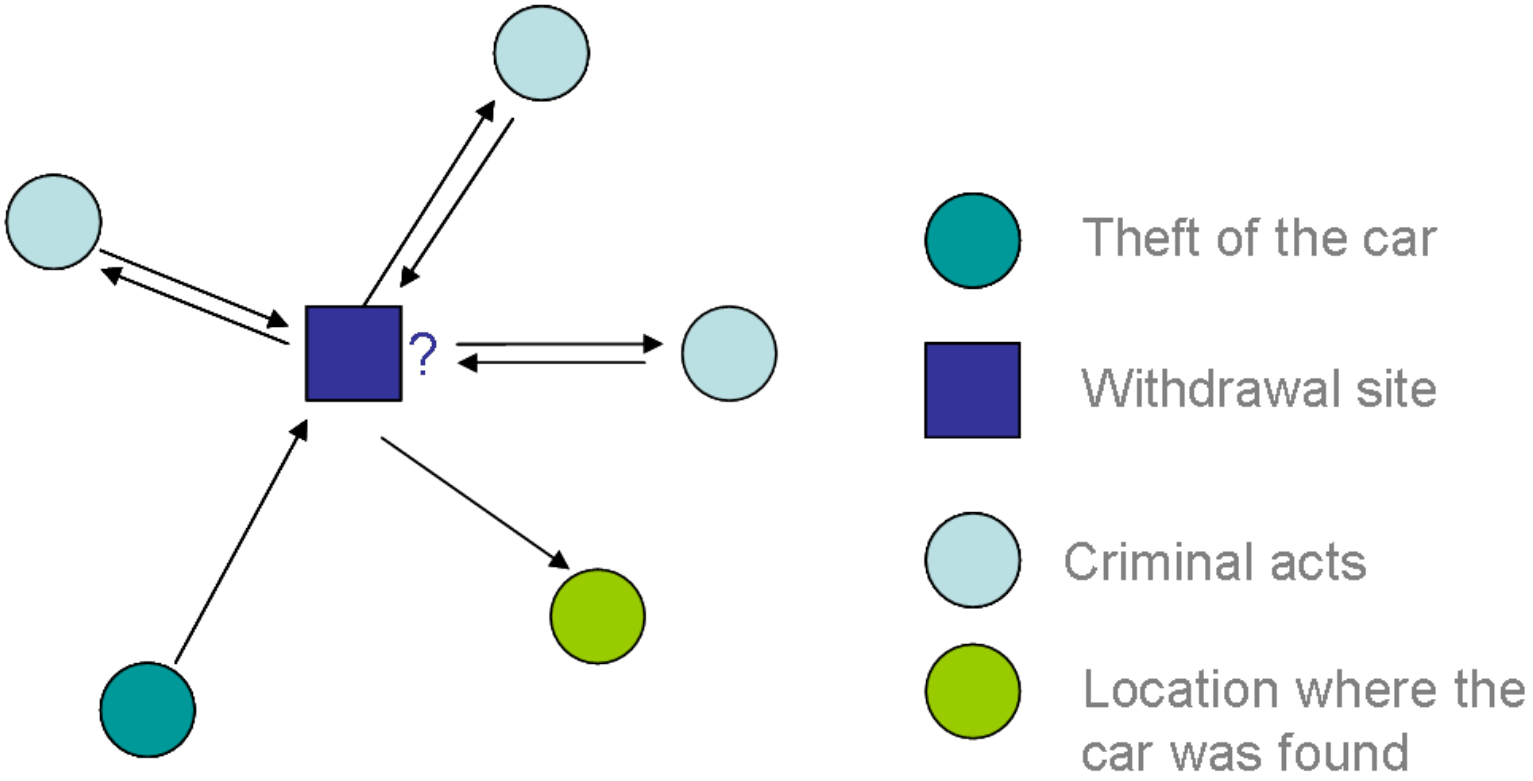
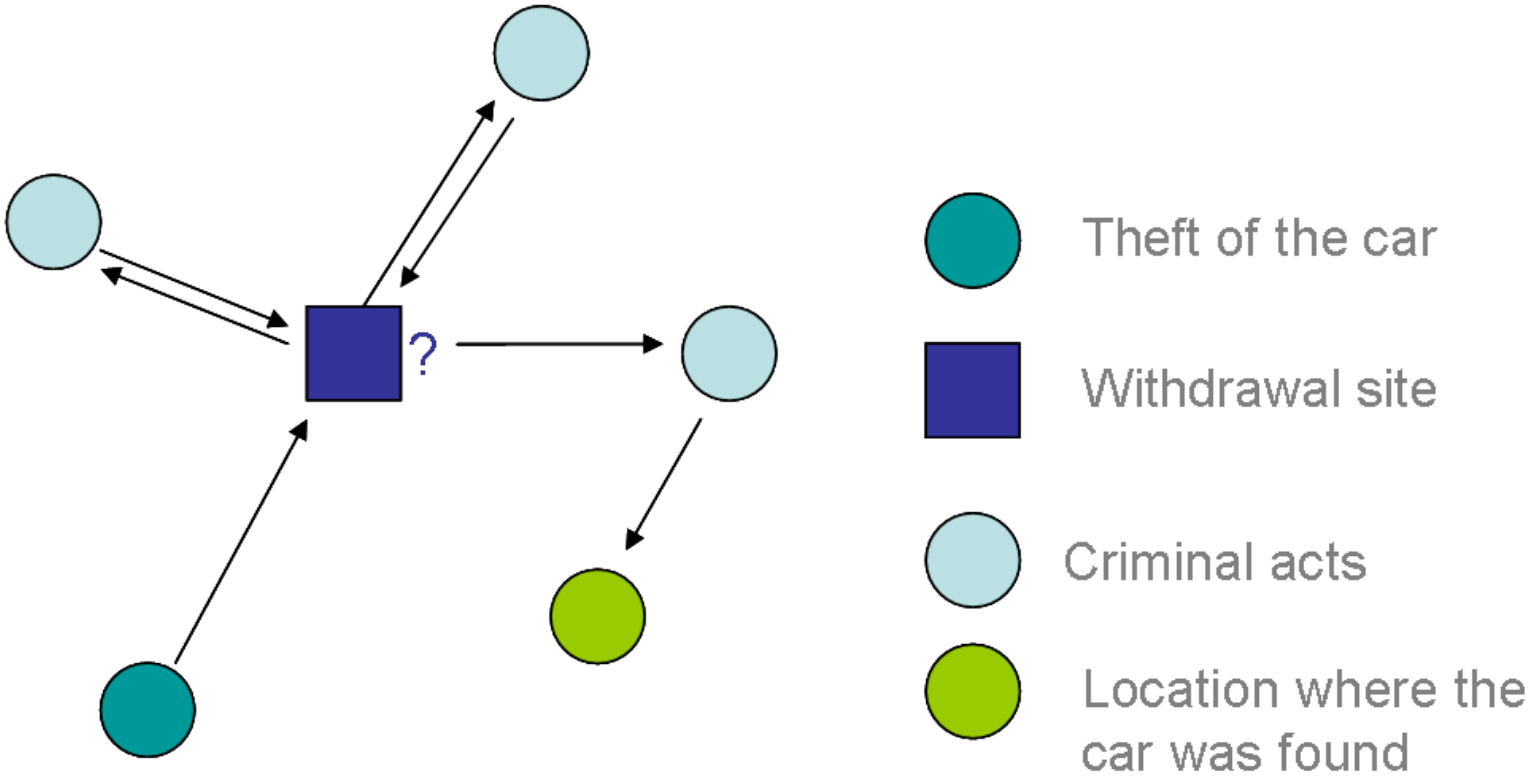


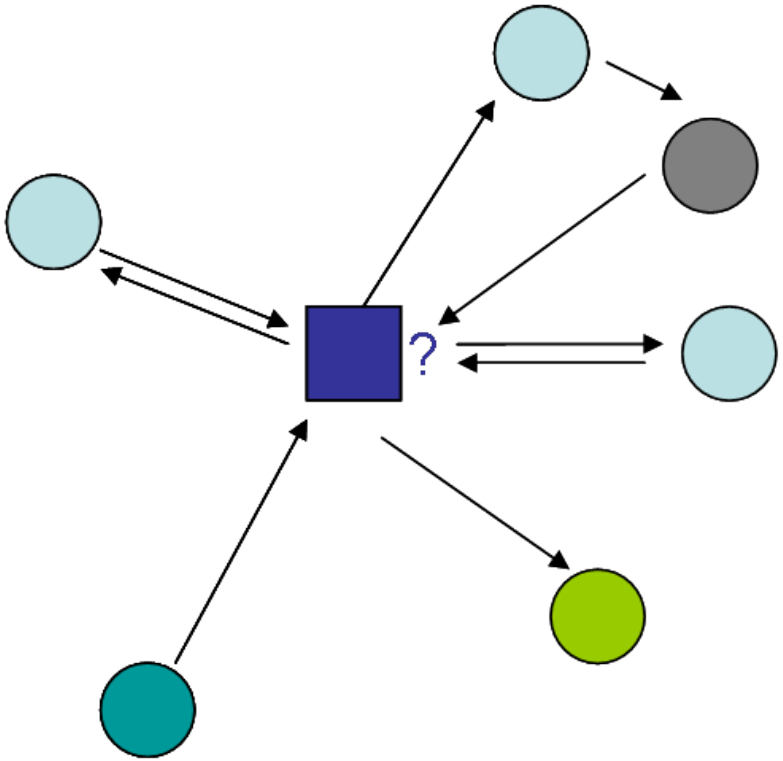
Scenarios

Scenario 2

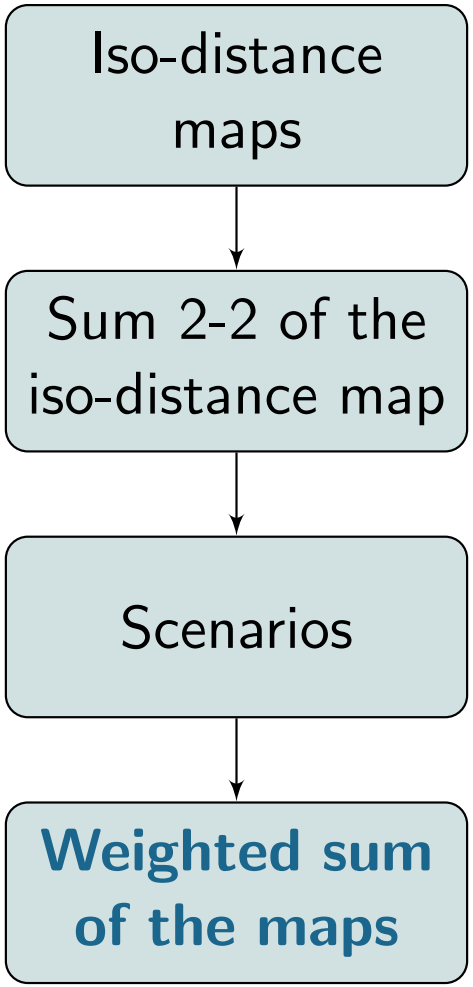


Scenarios

Scenario 3



Step 3 : **Cost surface**



How did we choose the scenario ?

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

The **second** scenario was **chosen**

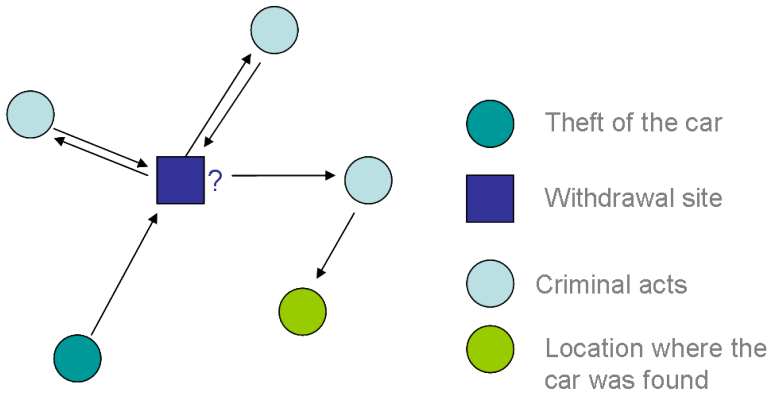
Cost surface

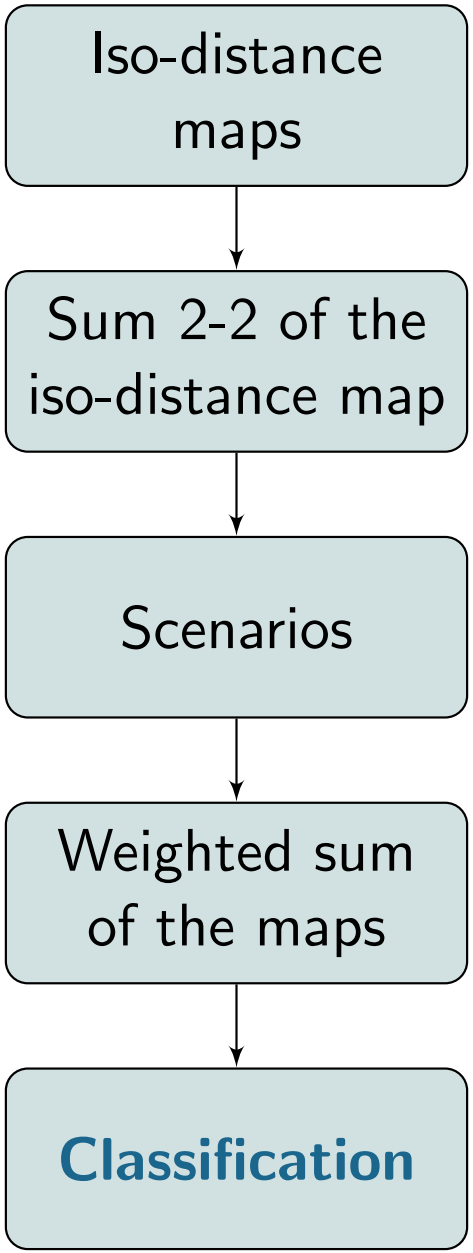
Chosen scenario : Scenario **n°2**

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

Double distance for the others

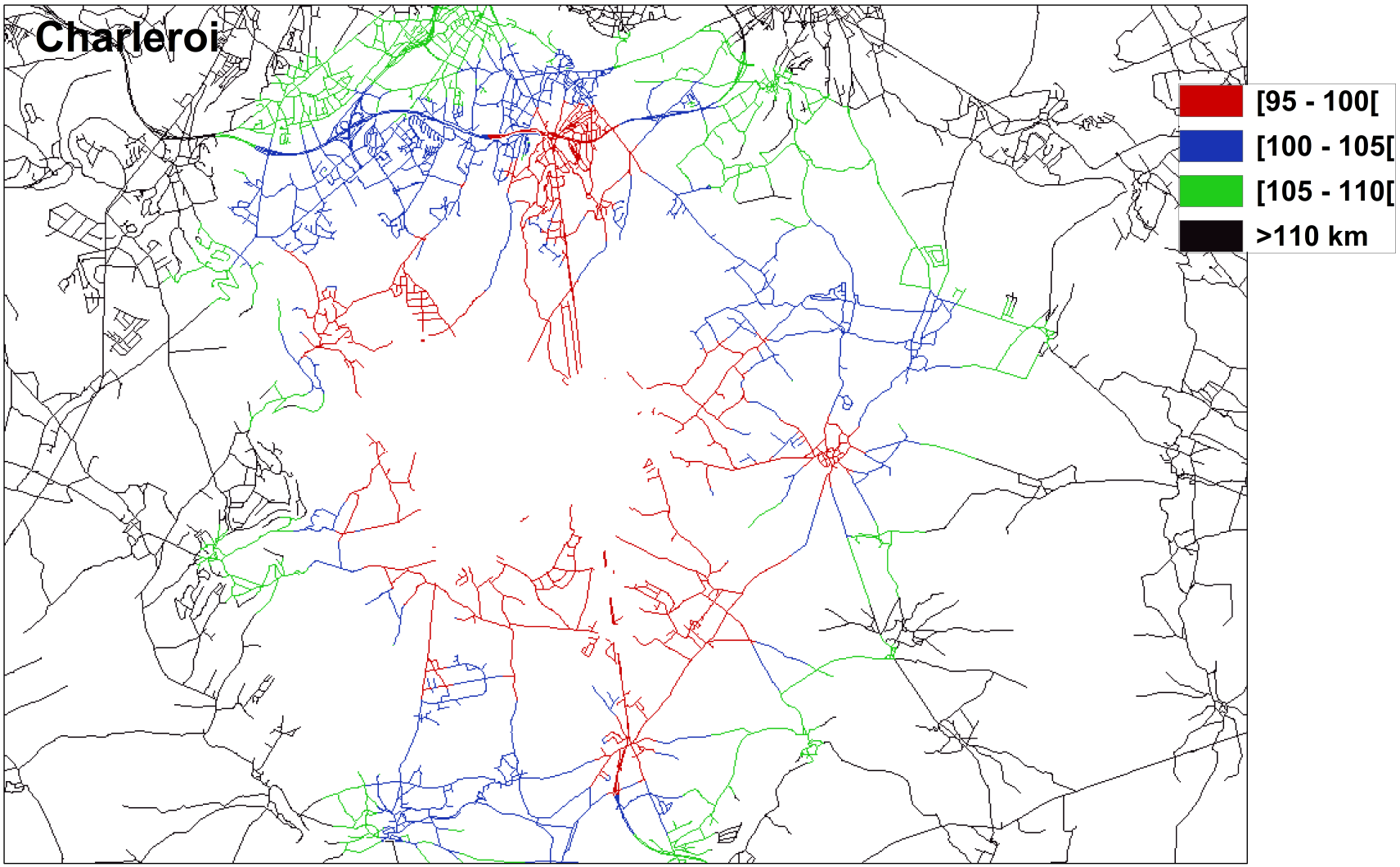
- **Except** for the **last** crime site (**Single** distance + **Shortest path** to the car location)




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

Results

Scenario 2



How can we restrict this area ?

Non-uniformity of the environment

Multi-criteria analysis

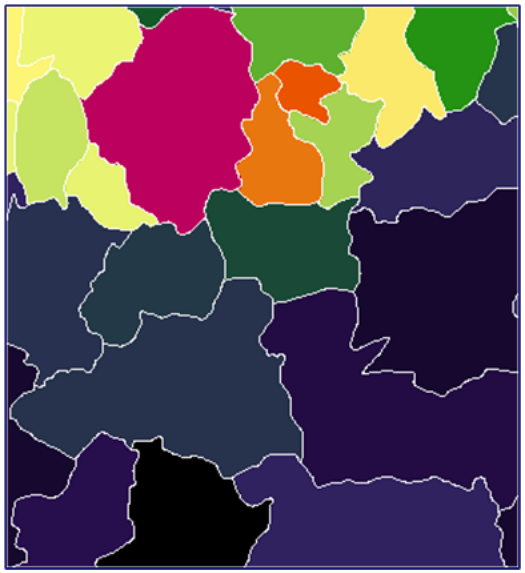
- **Constraint** : Withdrawal area inside a built-up area
- **Factor 1** : Rural commune (via PCA)
- **Factor 2** : Proximity to the main road
- **Factor 3** : Distance to road segments determined by the previous operations

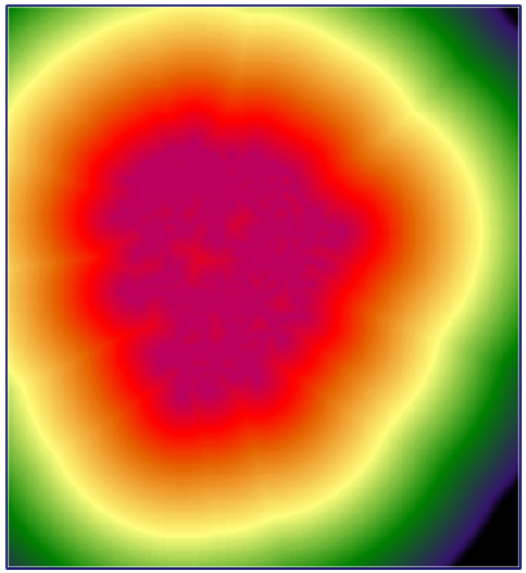
Non-uniformity of the environment

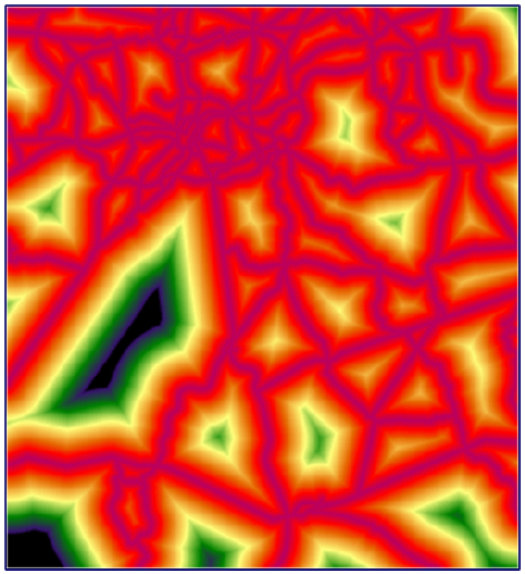
Multi-criteria analysis

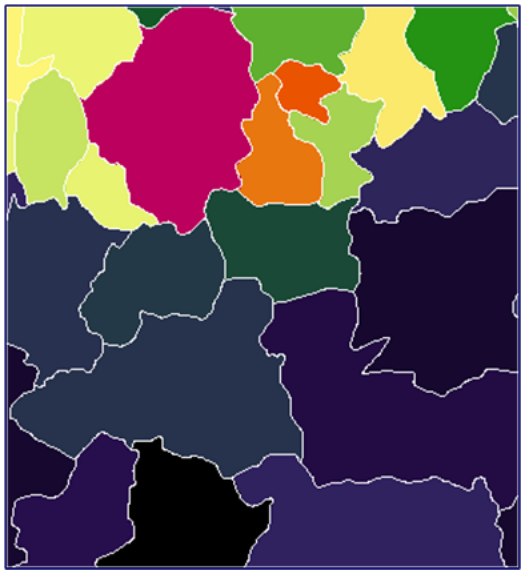
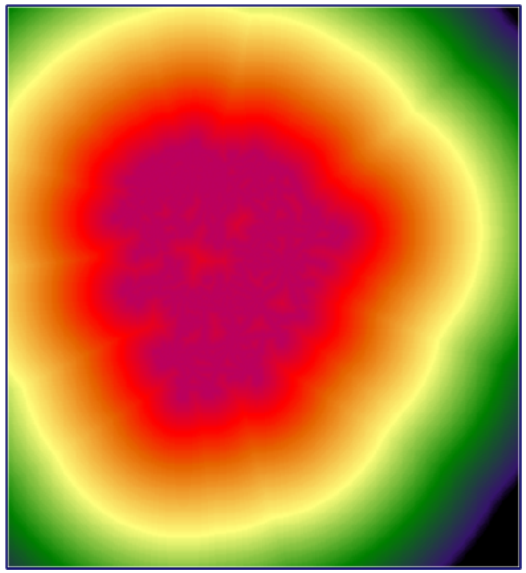
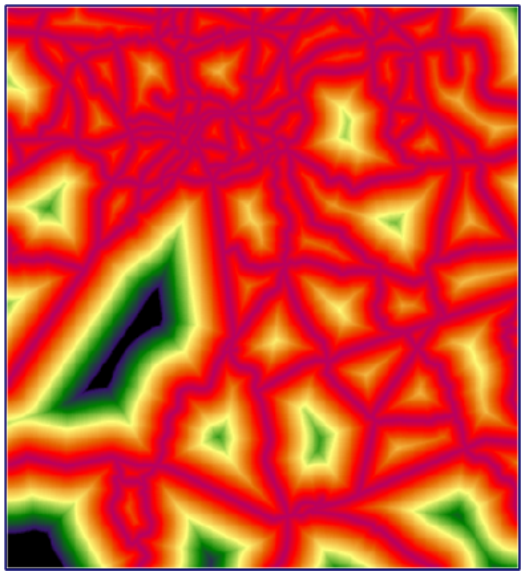
- **Constraint** : Withdrawal area inside a built-up area (Binary mask)
- **Factor 1** : Rural commune (via PCA) 0.1
- **Factor 2** : Proximity to the main road 0.2
- **Factor 3** : Distance to road segments determined by the previous operations 0.7

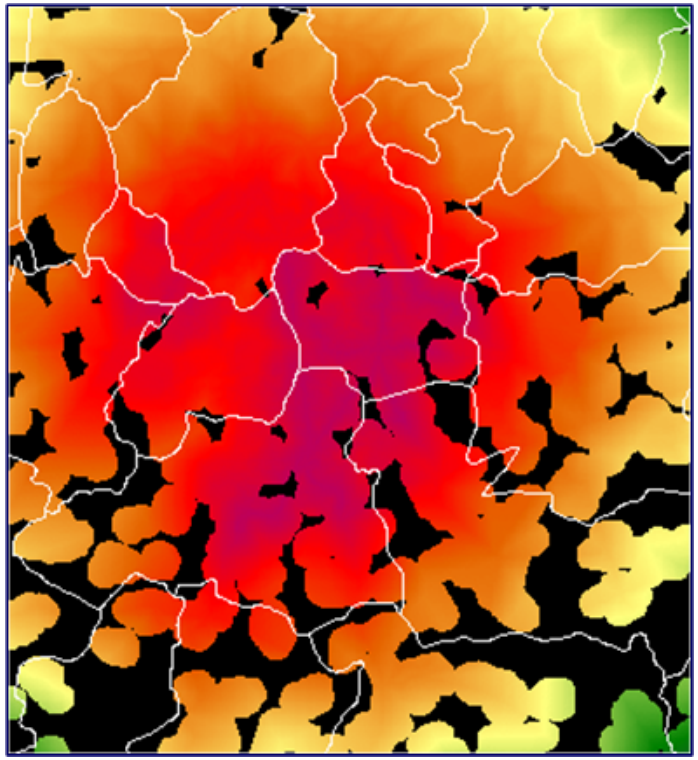
$$\left(\sum_{i=1}^{n} p_i F_i\right) \prod_{j=1}^{m} C_j$$



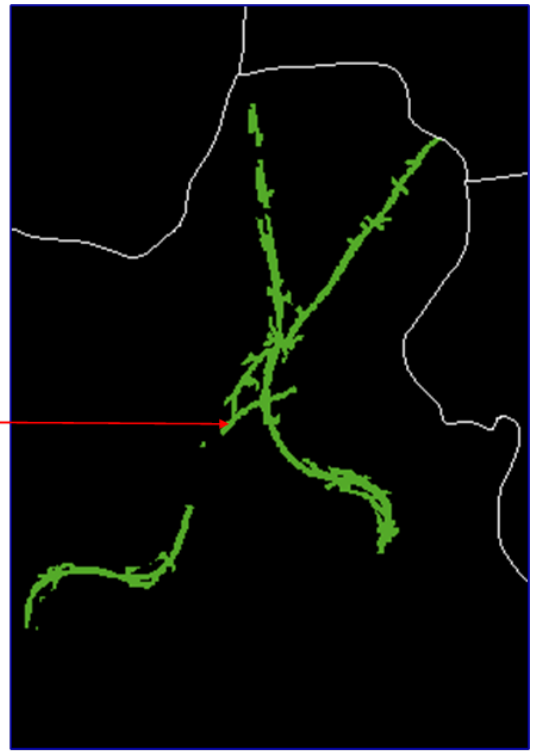






E420
N978
N5
Route de Couvin
Pont des Diables



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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