Management of uncertainties for the computation of resilient trips

LASTIG Workshop on Uncertainty and Risk
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Outline

- Computation of resilient trips for waste collection after a flood (SIGOPT project)

- Computation of resilient hiking routes in a mountain area (IntForOut Project)

Computation of resilient trips for waste collection after a flood

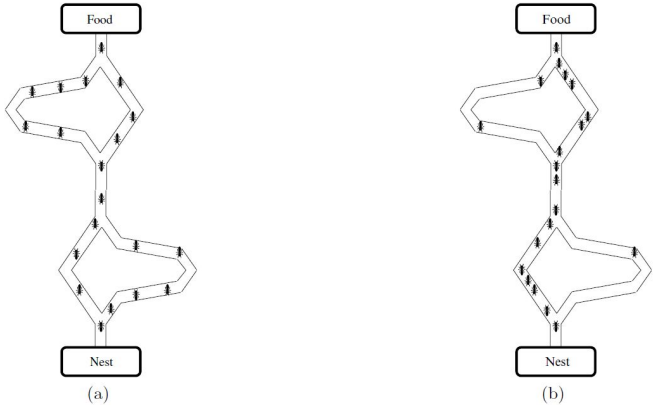
Lab'URBA

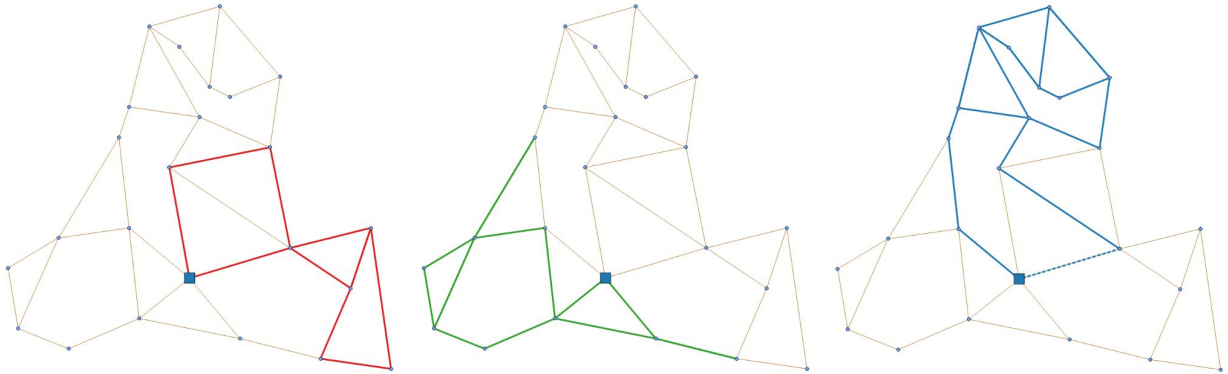
Sous la co-tutelle de :
UNIVERSITÉ GUSTAVE EIFFEL
UPEC · UNIVERSITÉ PARIS-EST CRÉTEIL

- SIGOPT project (LASTIG, Lab'Urba)
- Goals
  - Estimate household waste quantities after a flood
  - Compute efficient waste collection trips
  - Manage high levels of uncertainties
    - Waste quantities
    - Road availability
- Provide GIS tools for local deciders

Vehicle routing problem

- A routing problem that models the main operational constraints
- Capacitated Arc Routing (CARP)
  - Arcs are served by a fleet of vehicles with bounded capacity
- Solutions computed with an ant-colony algorithm





Management of the uncertainties

- Uncertain variables : waste quantities on the edges (q_E), and road practicability for each edge (pr_E)
- Uncertainties treated with a filtration-like model :
  - Long before the flood : no specific information
  - Before and at the beginning of the flood : global average water level and first observations of waste quantities
  - During the waste collection : precise knowledge of quantities and road availability

A simple model for uncertainty management

- Waste quantities :

$$q_E = \sum_{i=1}^{n} \alpha_i(E)\xi_i$$

- Road availability :

$$pr_E = H(h_{min}(E) - h + r_E)$$

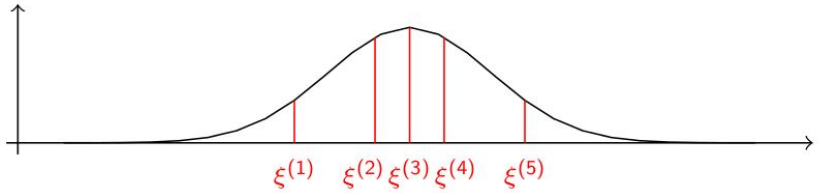
where H is the Heaviside function, h an average of water height, and r_E an uncertain quantity specific to edge E :

$$r_E = \sum_{k=n+1}^{m} \beta_k(E)\xi_k$$

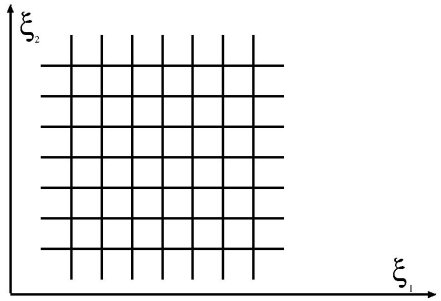
- A first model with few free parameters

Computation of solutions with uncertain parameters

- Regular discretization of the random parameters

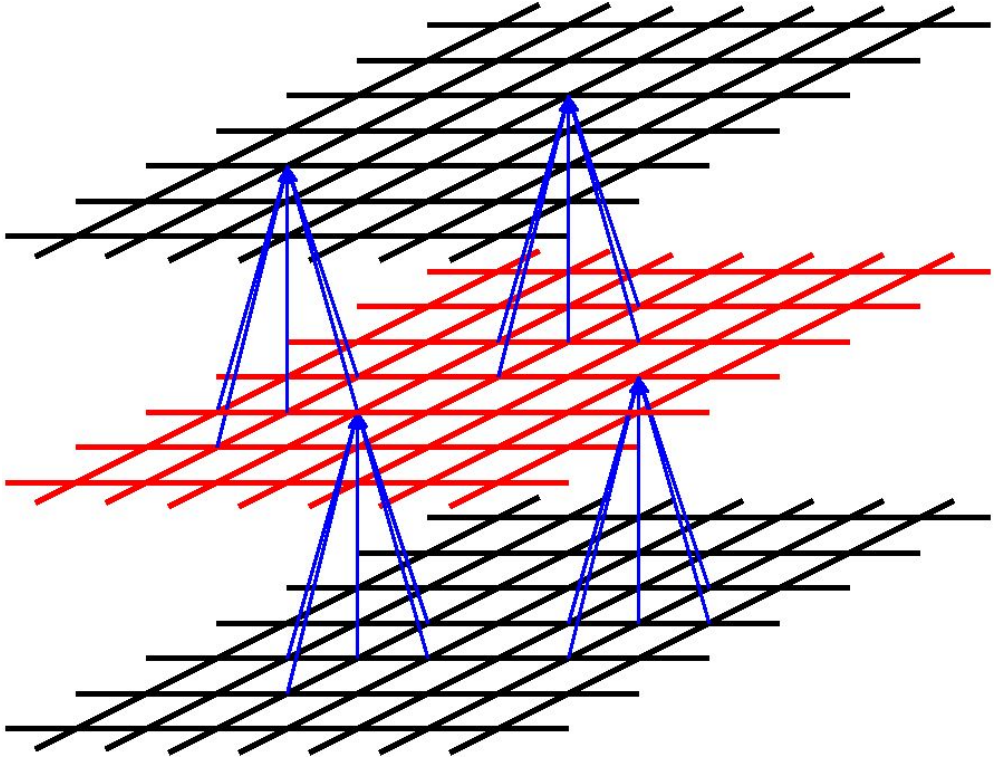


- Constitution of a grid in the space of random parameters



- Computation of a solution on each point of the grid

Simultaneous computation of solutions with information transfers



At the (*n*+*1*)th iteration on a node, information (here pheromone quantities) from neighbouring nodes at iteration *n* are used

A principle adaptable to many optimization methods (simulated annealing, genetic algorithms)

Computation of resilient trips for mountain hikers

- IntForOut Project (LASTIG, LIFAT, LECA, CREA Mont-Blanc)
- Goals
  - Measuring and understanding human pressure on mountain ecosystems
  - Developing solutions to alleviate this pressure, e.g. by proposing alternative hiking routes
  - Within an open data ecosystem

LECA

université de TOURS

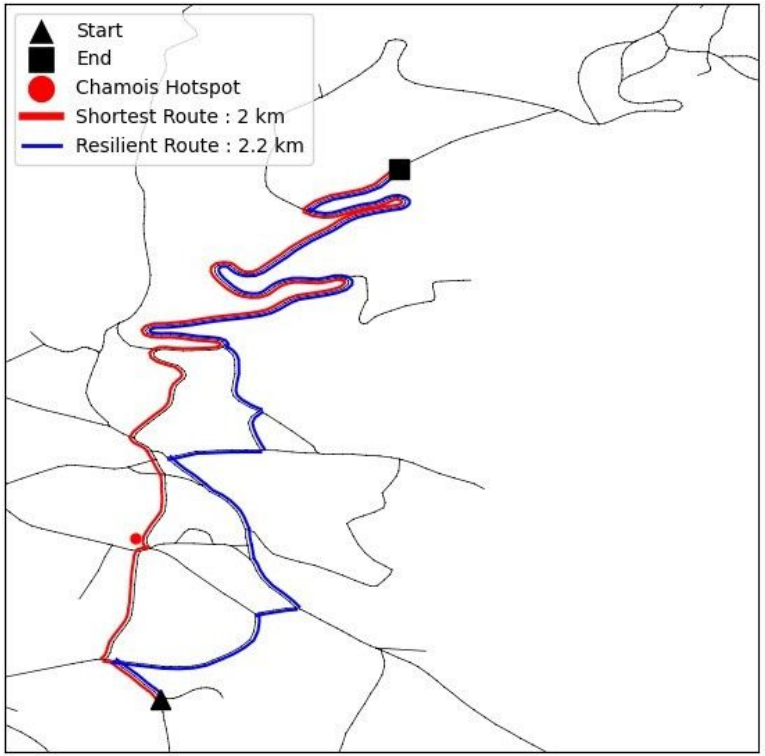
CREA
-MONT-BLANC-

LaSTIG

PROJET FINANCÉ PAR L'ANR
ANR
PROJECT FUNDED BY THE ANR

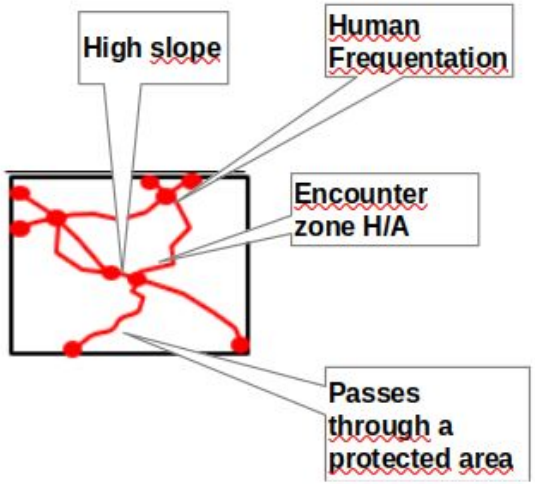
A definition of resilient routes

We define **resilient routes** as routes that reduce the impact and tourism mass effect whilst proposing tailored routes (e.g. bypass a portion of the route in May-June to avoid a nesting area, simulate an alternative trail itinerary with rich landscapes that could offload a famous route with high impact on the ecosystem)- IntForOut



Example of a resilient route avoiding a chamois encounter hotspot

A semantically enriched network to compute resilient trips

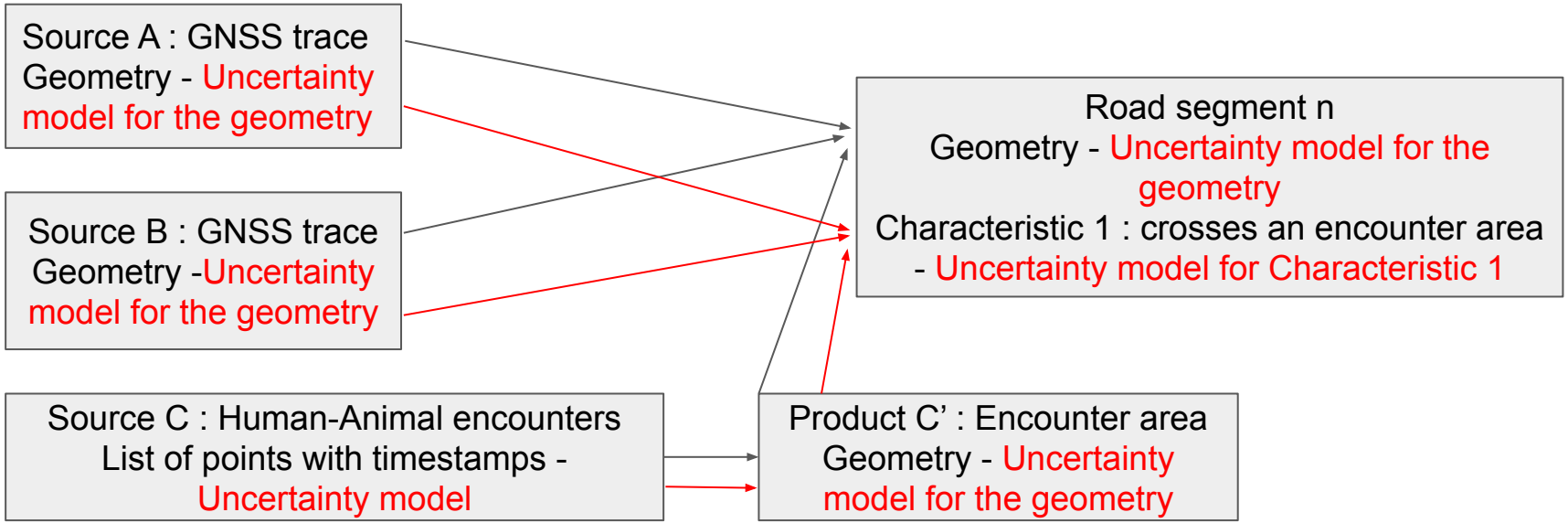


- An enriched network computed from human activities GNSS traces
- For each road segment :
  - Geometry
  - Characteristics (e.g. slope, human frequentation figures, crosses an encounter zone…)
- Enables the computation of resilient routes with similar characteristics for hikers

Management of uncertainties

- Sources of uncertainties:
  - GNSS traces (geometry and representativity)
  - Spatial extension of characteristic areas (encounter zone, forest, area with a view on a given landmark)
  - Numerical uncertainties on quantitative characteristics (frequentation figures, slope)
- Uncertainty models : probabilistic, others?
- Propagation of uncertainties
  - From sources to the enriched network
  - From the enriched network to the computed resilient routes
- Methods for the propagation of uncertainties
  - Monte-Carlo simulation
  - Polynomial chaos-like solutions

Propagation of uncertainties (1/2)



Propagation of uncertainties (1/2)