Algorithmic Game Theory: from Multi-agent Optimization to On-line Learning

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Motivation & Outline

You are planning your commute route for tomorrow.

Not sure about your departure time, nor who might be on the road.

A game with a random set of players !

In US alone, congestion cost US$305 billion in 2017

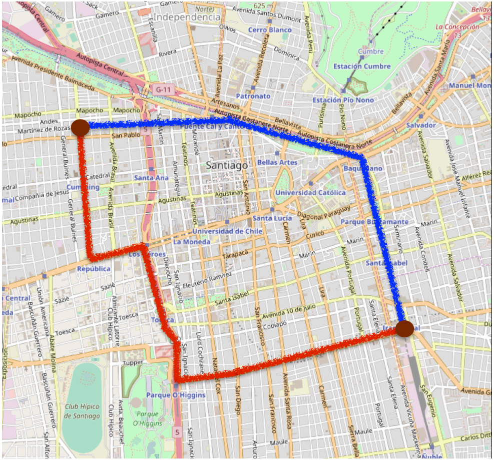
$\approx$ 1.6% of GNP... 3% increase from previous year !

(source: INRIX)

Lost productivity of workers sitting in traffic, wasted fuel...

...before accounting for environmental impacts, accidents, quality of life.

Urban traffic under congestion



2266 nodes / 7636 arcs

SANTIAGO
6.000.000 people
11.000.000 daily trips
1.750.000 car trips

Morning peak
500.000 car trips
29.000 OD pairs

Many Questions

1. How should we model traffic and congestion ?
    - Urban traffic / transit systems / telecom / logistic networks
    - Selfish routing / routing apps / autonomous vehicles
2. Equilibrium models vs adaptive dynamics ?
    - Can players *"learn"* how to play an equilibrium ?
    - Informational constraints and bounded rationality
3. Deterministic or stochastic models ?
    - What are the impacts of uncertainty and risk-aversion ?
4. Static vs dynamic routing ?
5. Asymptotics for large games ?
6. How inefficient is selfish routing ?
    - How (much) can we reduce congestion ?

...and more !

Outline of the Mini-course

Part I (Cominetti)

- **Lecture 1:** Basic concepts in game theory
- **Lecture 2:** Non-atomic routing games – Wardrop equilibrium
- **Lecture 3:** Large routing games – Wardrop or Poisson?

Part II (Mertikopoulos)

- **Lecture 4:** Game dynamics and evolutionary biology
- **Lecture 5:** Learning in finite games and multi-armed bandits
- **Lecture 6:** Learning in continuous games and online convex optimization