Department of Transportation Planning and Engineering
School of Civil Engineering
National Technical University of Athens

Modeling Powered Two Wheelers' overtaking maneuvers using Game Theory

Emmanouil Barmpounakis, PhD, Eleni Vlahogianni, Ph.D.
and John Golias, PhD

8ο ΔΙΕΘΝΕΣ ΣΥΝΕΔΡΙΟ για την ΕΡΕΥΝΑ ΣΤΙΣ ΜΕΤΑΦΟΡΕΣ στην ΕΛΛΑΔΑ
Οι Μεταφορές το έτος 2030: Τάσεις και Προοπτικές

8th INTERNATIONAL CONGRESS on TRANSPORTATION RESEARCH IN GREECE
Transportation by 2030: Trends and Perspectives

Introduction

- The modern urban environment is changing rapidly.
- Citizens are looking new ways for everyday commuting.
- European registrations of Powered Two Wheelers (PTW) continued increasing in 2016: +9.1% on a year-on-year basis
- An increasing trend is also reported in various Asian cities and Australia

Introduction

- Research on PTW traffic characteristics is growing fast.
- Previous studies aimed to describe PTW kinematic characteristics and model interactions between different types of vehicles
  - Important variables during overtaking have been identified
  - Significance in acquiring naturalistic vehicle trajectory data
  - Limitations in using stationary cameras

Scope of the current work

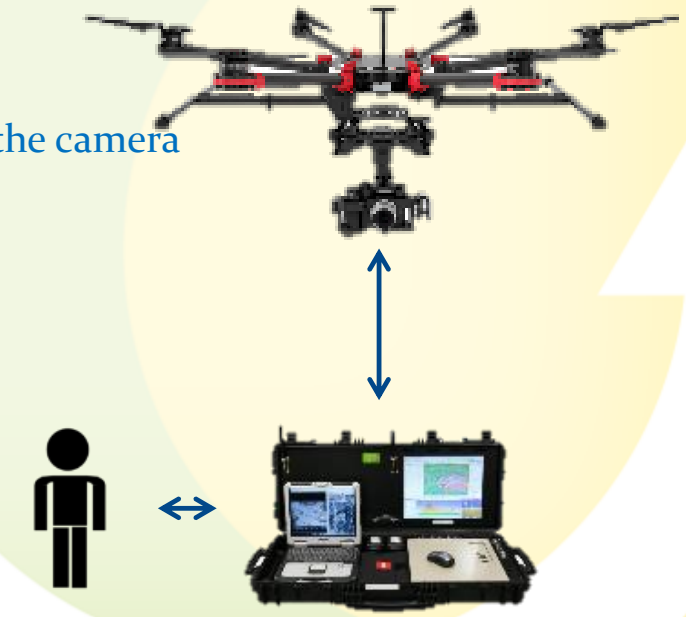
- Unmanned Aerial Systems (UAS) are used for data acquisition
- Three lane arterial to study overtaking phenomena
- Dynamic approach using Sequential Games from Game Theory

Using Unmanned Aerial Vehicles for Data Acquisition

Advantages of UAS over stationary cameras

- Extended length of arterial recorded
- Hovering Capabilities and small size
- No hidden points in video

- The limitations relate either to the length of the arterial recorded, or to the height of the camera

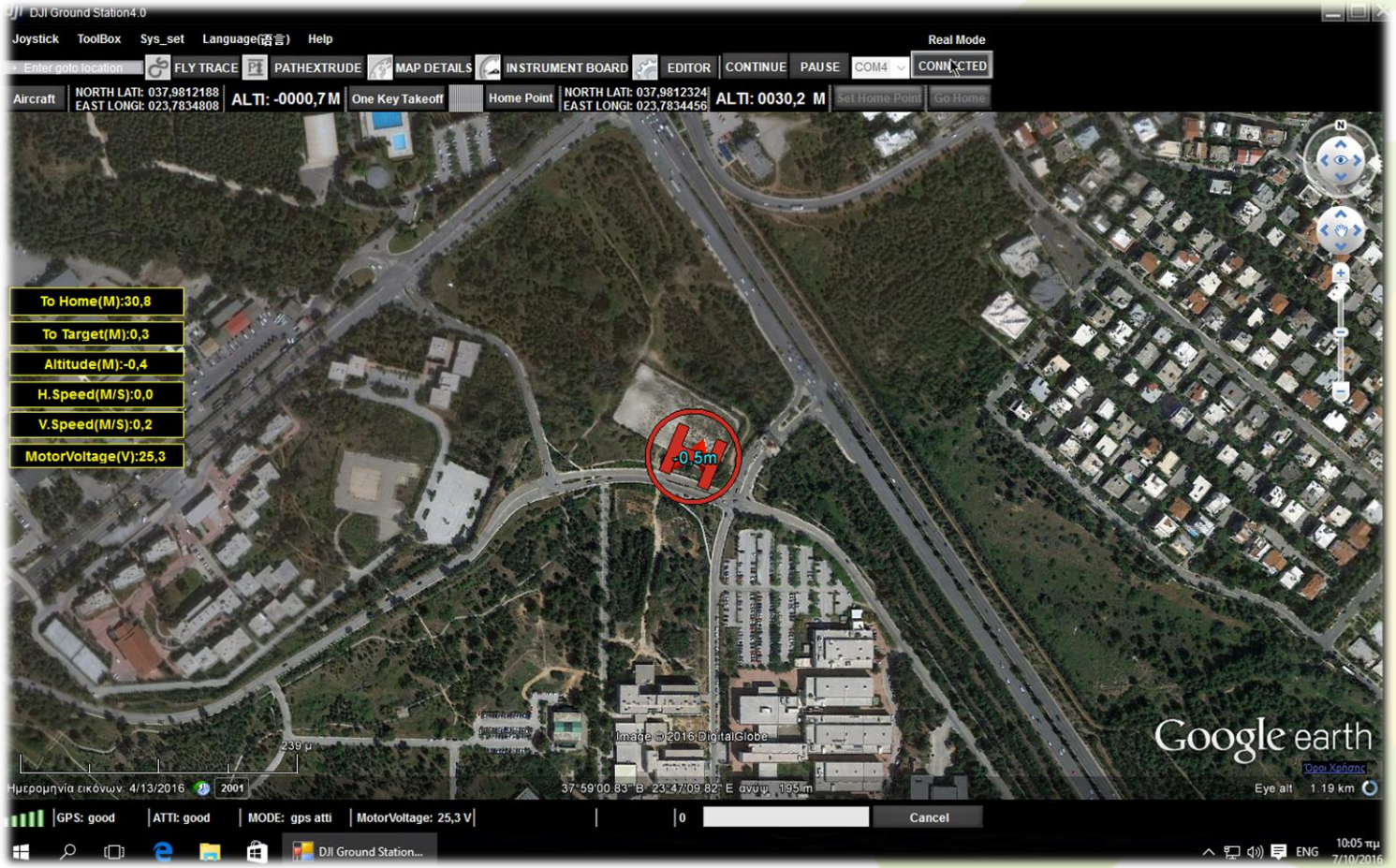


Using Unmanned Aerial Vehicles for Data Acquisition

The Study Area

Using Unmanned Aerial Vehicles for Data Acquisition

The Study Area (Telemetry View)



Using Unmanned Aerial Vehicles for Data Acquisition

The Equipment

Using Unmanned Aerial Vehicles for Data Acquisition

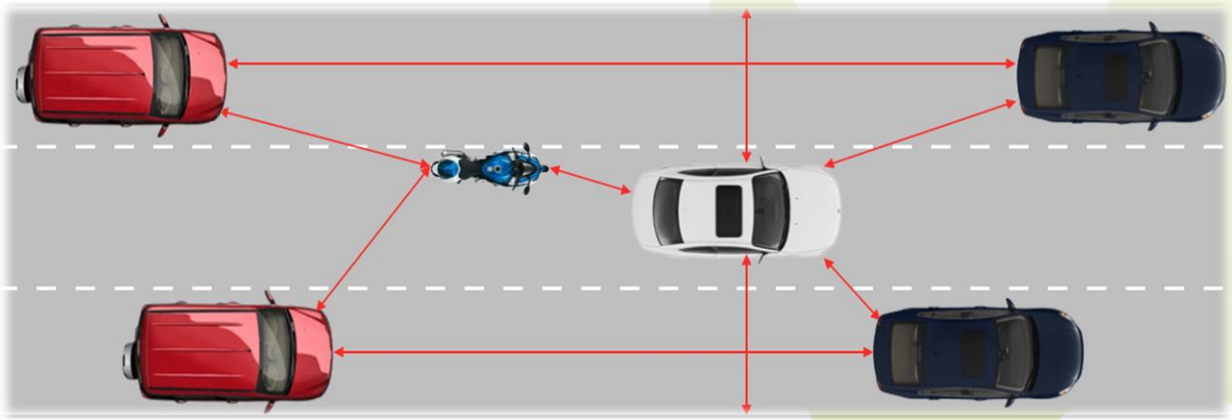
Managing distortion from lenses in the study area

A detailed dataset of 433 overtaking attempts is created using UAS.

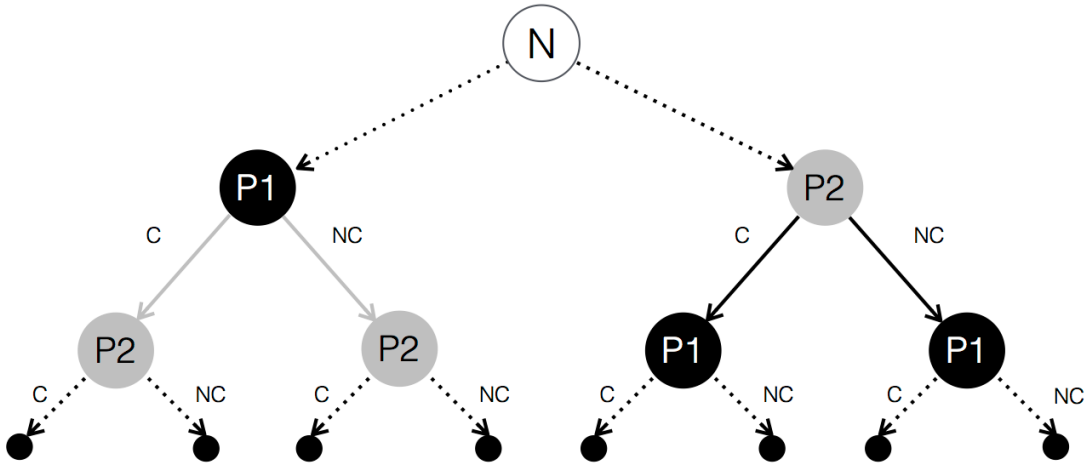
Database Description

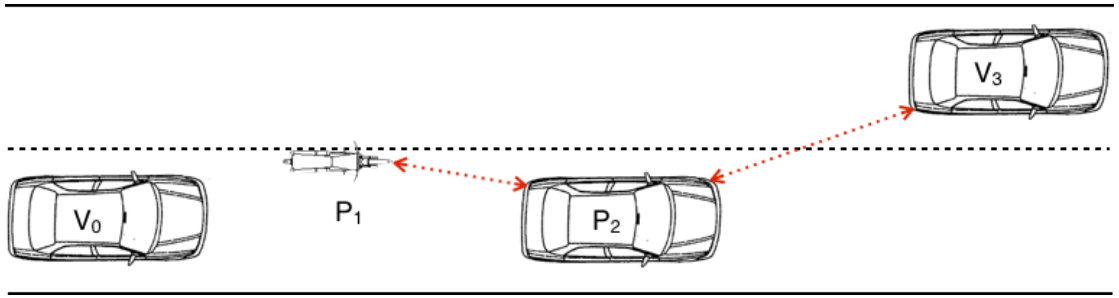
A total of 65 variables are measured for each overtaking attempt.

- the type of each vehicle (Motorcycle, Scooter, Car and Heavy Vehicle)
- the lane each vehicle is moving (Right, Center or Left)
- speeds of all vehicles present
- accelerations of all vehicles present
- spatial distances between vehicles
- duration between each State
- general information for the PTW driver, for example if the PTW driver wears a helmet, if there is a passenger on the PTW or if a platoon of PTW is formed.



Game Theory Model





Stackelberg Game

3 players

- Nature
- Player 1 (PTW)
- Player 2 (Preceding Vehicle)

2 strategies for each player

- NC (Non-cooperative)
- C (Cooperative)

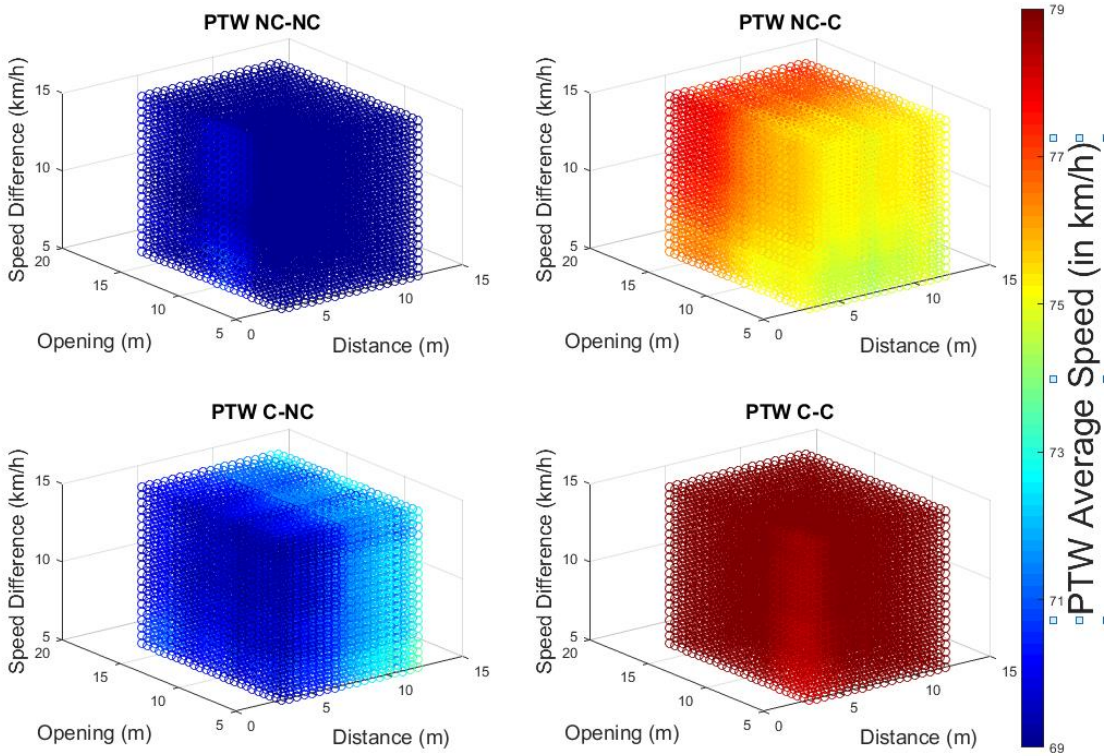
PTW Cooperation based on:

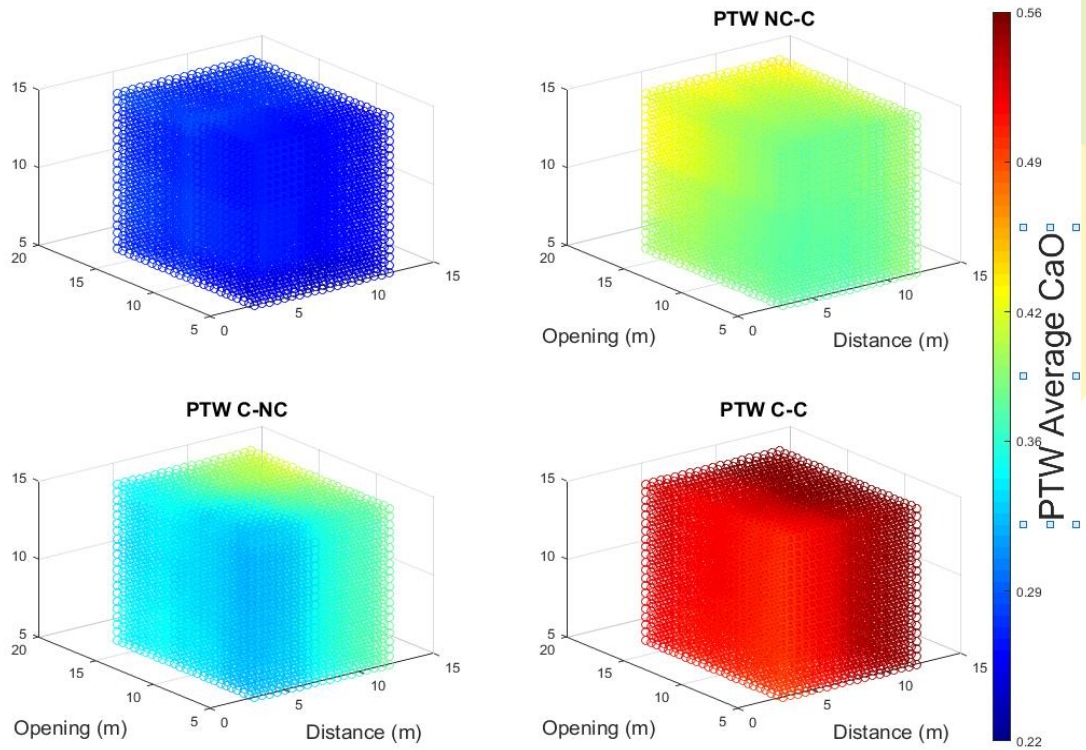
- distances (no tailgating)
- Positioning (adjacent lane)

Vehicle Cooperation based on:

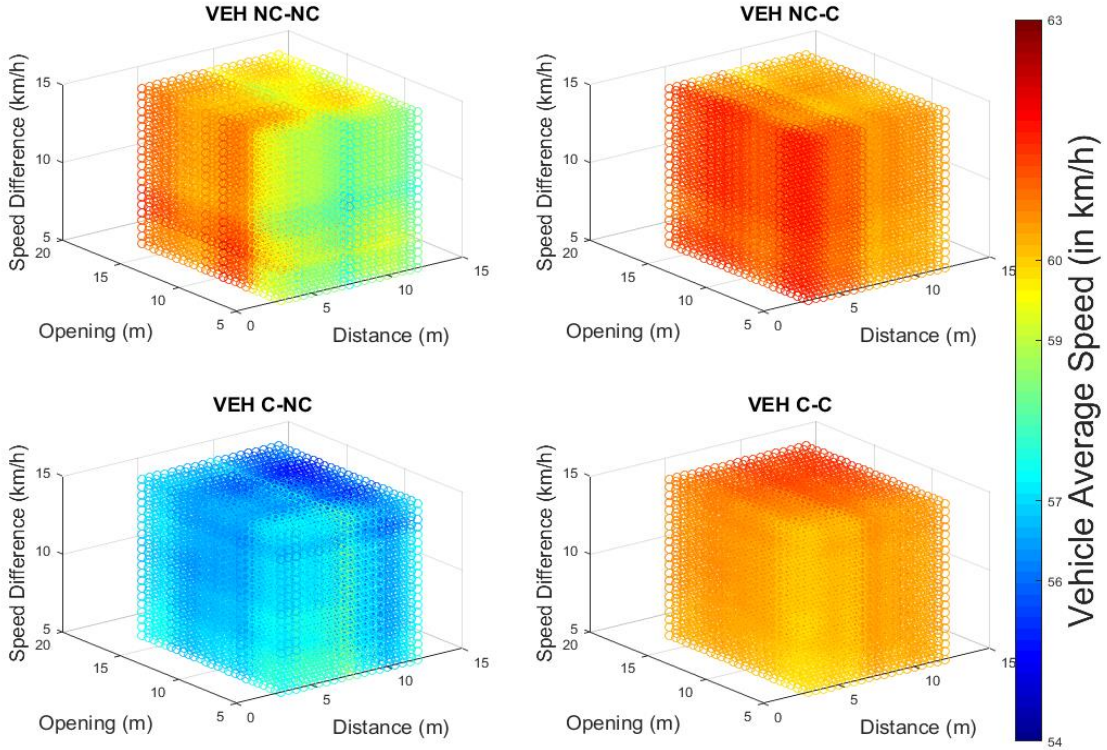
- Available opening (for the PTW to pass)
- Acceleration while overtaking

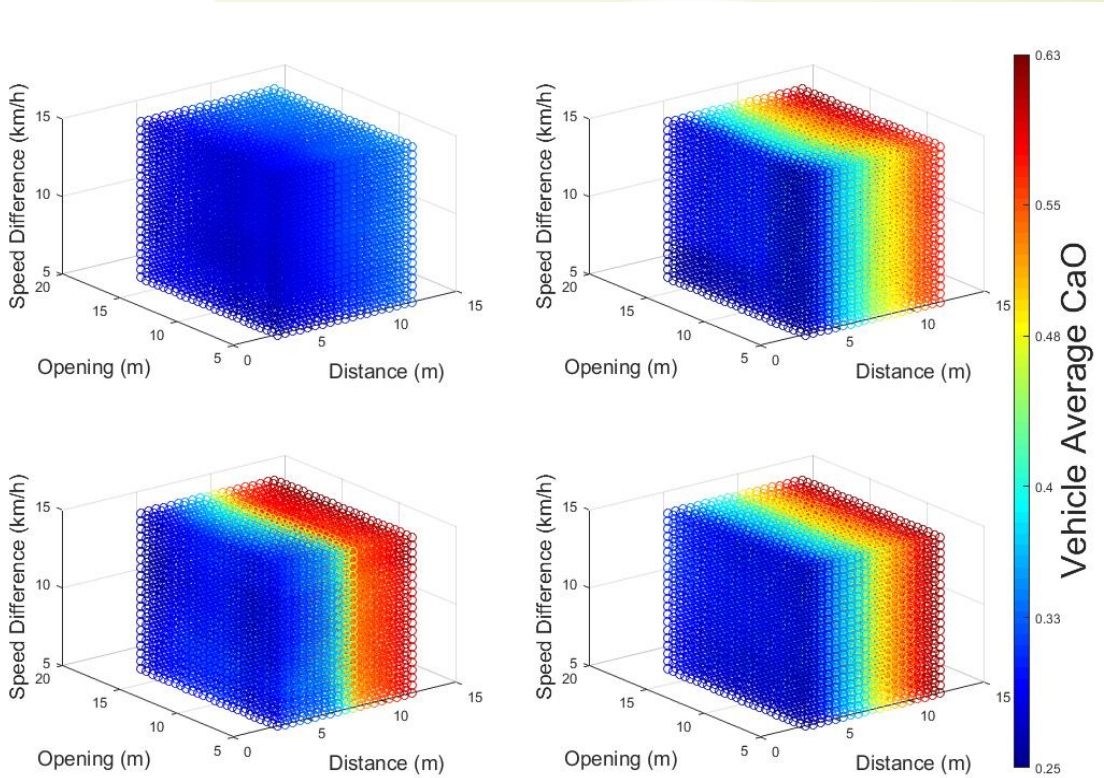
Investigating PTW Payoffs



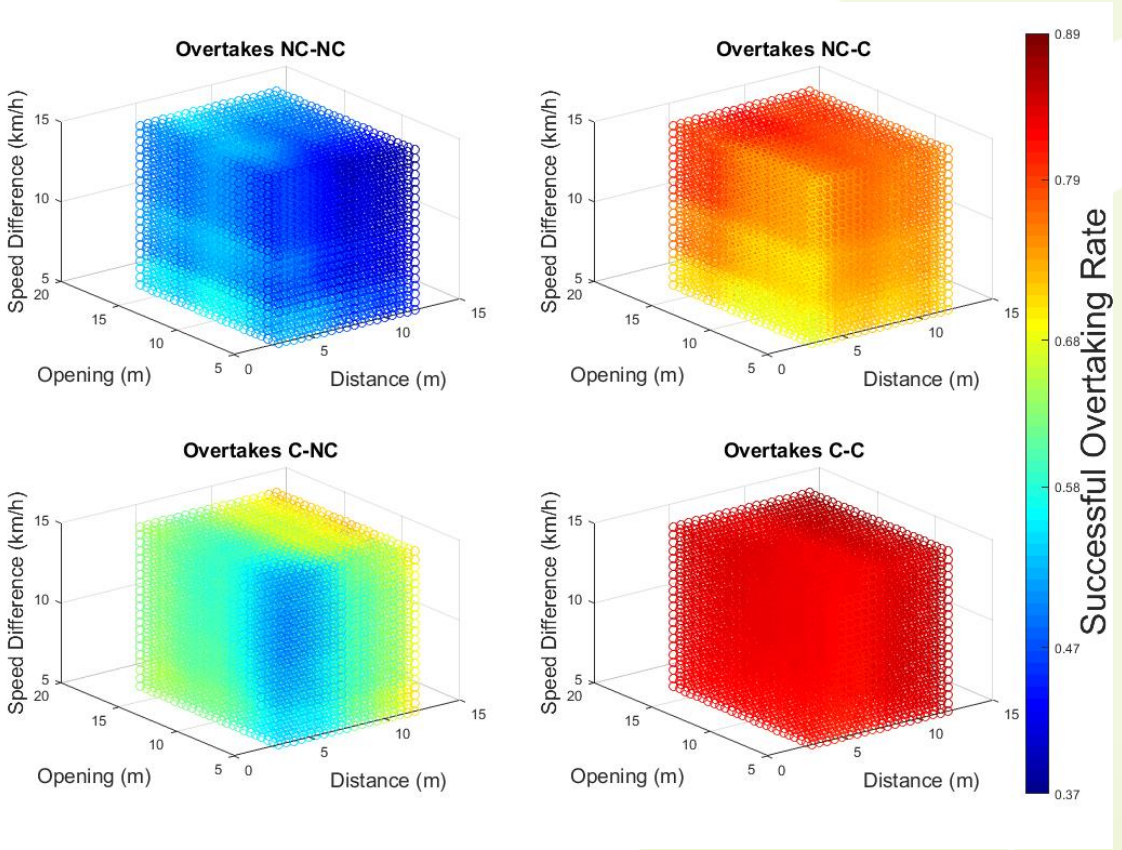


Investigating Preceding Vehicle Payoffs





Investigating Successful Overtaking Rate



Conclusions

- The extensive game theoretic model is played under different cooperation conditions in order to better identify the benefits of cooperation and the underlying factors that may affect it.

Results show that

- when drivers are cooperative, their payoff is increased both in terms of speed and CaO.
- the combination of advanced data gathering tools and advanced models is promising as a powerful mix of tools in the ITS infrastructure.
- they can be used a framework for advancing current and designing future systems that would allow cooperation to emerge more easily between drivers.
  - The administrator of a transportation system could advance safety over flow (or the opposite)
  - the overtaking rate of PTW can increase or decrease by adjusting spatial factors and speeds of bigger vehicles (traffic flow optimization)

In future works, the game can be revisited with different cooperation conditions and the interactions could be represented in a simulated environment to better identify the gains

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