COMBINING ITS SOLUTIONS FOR TRAFFIC IMPACT MITIGATIONS:
AN APPLICATION TO A CASE STUDY IN NAPLES

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Background

- ITS solutions to alleviate traffic congestion
- Traffic Control
- Route guidance
- Unified Framework
  - Bi-level vs Simultaneous approaches
2. Research objectives
Research objectives

- **Traffic Control**
  - to propose a solution method suitable for traffic responsive applications (dynamic traffic conditions)

- **Route guidance**
  - 1) to use real time information
  - 2) to respond to route enquires (requirement of real time reaction)

- **Unified (simultaneous) Traffic Management Framework (TMF)**
Main contributions

- **Methodological**
  - DTA models
  - Analytical based vs Simulation based
    - On-line implementation

- **Operational**
  - The unified TMF is tested on the platform of Simulation of Urban MObility (SUMO)
TMF overview

2.3

✓ rerouting
✓ route guidance

traffic signal controllers

gating controllers
3. Methodological Framework

3.1 Dynamic Traffic Management
   - Network Traffic Control
   - Traffic Flow Modelling
   - Rolling Horizon prediction model

3.2 Feedback based gating (perimeter) control

3.3 Route guidance
3.1.1 Network Traffic Control

Synchronisation
Flow based strategies

- Fixed timing plans
- Timing plans selection
- Timing plans computation
On-line Traffic Control

3.1.1
Synchronisation

- Stage matrix
- Decision variables
- Green timings
- Offsets

- Objectives function
  - Mono-criterion: TD minimisation (TFM)

- Solution Algorithm
  - Simulated Annealing
3.1.2 Traffic Flow Modelling

CT&PDM
Traffic Flow Model: PDM

3.1.2

\[ q_{sh}(i+\Delta i) = Fq_{li}(i) + (1-F)q_{sh}(i+\Delta i-i) \]

\[ \Delta i = 0.8 \cdot t_{lh} \]

\[ F = 1/(1+0.4 \cdot t_{lh}) \]
Traffic Flow Model: CTM/CT&PDM

i : cell index
n_i : is the number of vehicles on the cell i
Q_i : is the maximum flow rate in cell i
d_i : is the wave speed coefficient of cell i
N_i : is the maximum number of vehicles present in the cell i
t : time slot index (clock tick)

\[
S_i(t) = \min\{Q_i, n_i\} - R_i(t) = \min\{Q_i, d_i[N_i - n_i]\}
\]

\[
Y_i(t) = \min\{S_i(t), R_{i+1}(t)\}
\]

*speed-density relationship (Underwood):

\[
X_i(t) = k_i(t) v_0 \exp[-0.5(k_i(t)/\text{km})^2]
\]

\[
Y_i(t) = \min\{S_i(t), R_{i+1}(t), X_i(t)\}
\]
3.1.3 Rolling Horizon Prediction Model
Kalman filter methodology

3.1.3

- rolling horizon
3.2 Gating Control
Gating (Perimeter) Control

- Gating task
  - to hold vehicles back upstream of a “protected network (PN)” such that the accumulation does not exceed the critical value in order to maximize the outflow (input flow metering)

- Feedback controller
  - Occupancy desired set-point
4. Route guidance
Route guidance

- Congested roads prediction $\rightarrow$ alternative paths identification
  (vehicle rerouting, route guidance)

- Forecast traffic congestion

- Drivers’ reaction to the information
  - All vehicles report the information to the central ITS server
    (current position, destination and route to destination)
  - Constrained to TF composition (connected vehicles)

- Simulation based approach
Drivers’ reaction to the information

- Compliance modelling (Accuracy of Information)
- Holding model (MMNL-error components)

5. Numerical Results
Case study

City centre of Naples

via Francesco Caracciolo and via Riviera di Chiaia

The most used connection is the Vittoria urban tunnel

SUMO:
calibrated (macro) and validated
- two kinds of point measures collected through loop detectors and manual existing traffic flows (link flows), traffic counts;
- travel times and queue location and lengths.
Scenarios

- (Scenario 1) Traffic control:
  - 1.1 Single junction
  - 1.2 Synchronisation
  - 1.3 Synchronisation (Synchr) + Gating control (GC)

- (Scenario 2) Traffic control + Information:
  - 2.1 Synchr + GC + with rerouting (Vittoria tunnel closed)
  - 2.2 Synchr + GC + with ‘explicit’ compliance (rates)
  - 2.3 Synchr + GC + with ‘implicit’ compliance
Results analysis (1)

Performance indicators (for each section):
- PTTs [min]
- QLs [m]

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4: rerouting scenario
Results analysis (2)

Performance indicators (for each section):
PTTs [min]
QLs [m]

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4: rerouting scenario
Concluding Remarks & Future Perspectives
Concluding Remarks & Future Perspectives

6.1

- the combined analysis of ITS strategies
- the application to a real context
- the consideration of an enhanced traffic control method (on-line)
- the ‘implicit’ simulation of travellers’ reaction to the information

- enhanced feedback based gating control
- the integration with connected vehicles
- hybrid control (centralised + decentralised)
Thank you for your attention

- Questions?
- Suggestions?
- Comments?