New Concepts for Urban Highways Control

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University of Zagreb, Croatia
  – Established in 1669.
  – 29 faculties and 3 academies
  – 4,850 research staff members and 50,000 students

Faculty of Transport and Traffic Sciences
  – 15 departments
    • Cover all transport modes, logistics, ITS, aeronautics
  – 100 research staff members / 2200 students
  – Publisher of the journal
    PROMET – Traffic&Transportation
    • Cited in SCIE, TRIS, Geobase, FLUIDEX, and Scopus
Outline

• Introduction
• Ramp metering traffic control approach
• Learning based ramp metering
• Cooperation between ramp metering, VSLC and vehicles
• Simulator CTMSIM and augmentation
• Simulation results
• Conclusion & Future work
• Today’s highways cannot fulfil desired level of service (LoS) due to congestions

• Especially the case of urban highways
  – Many on- and off-ramps
  – Lack of space for infrastructural build-up
  – Serve transit and local urban traffic

• Solution in ITS based highway control systems
  – Ramp metering
  – Variable Speed Limit Control (VSLC)
  – Prohibiting lane changes system

• Cooperation between several highway control systems
• Uncontrolled platooned vehicle entry from on-ramps into mainstream induce
  – Slowdowns in mainstream traffic
  – Queues at on-ramps
  – Higher risk of incidents
Ramp metering traffic control approach

- Highway control approach **ramp metering**
  - Special road signals (traffic lights) at on-ramps
  - Measured traffic data in real time
  - Ramp metering control algorithm
    - **Local**
      - ALINEA
      - Demand-Capacity
    - **Cooperative**
      - Competitive
        » SWARM
        » Bottleneck
      - Comparative
        » HELPER
        » LINKED
      - Integrated
        » *Fuzzy* logic based
        » MATALINE, etc.
• Variable traffic demand has to be managed
  – Adaptive neural-fuzzy inference system (ANFIS)
    • Neural Network (ANN)
    • Fuzzy Inference System (FIS)
  – ANFIS algorithm learned using several different ramp metering algorithms
    • ALINEA
    • SWARM
    • HELPER
• Standalone urban highway control strategy not efficient enough to resolve congestions

• Cooperation between ramp metering and
  – VSLC, Selectively prohibiting lane changes, Vehicle On-Board-Unit (OBU) and Driver information systems
Cooperation between vehicle OBU and on-ramp control computer (RMS-r2v) provide semi-automatic support to driver

– Oriented to the inexperienced drivers

• Problem with hesitation in merging and failed engine starts
• Matlab based macroscopic highway traffic simulator
  – Based on the Asymmetric Cell Transmission Model
• Original version contains local ramp metering only
• Augmentation for cooperative ramp metering and VSLC
• Zagreb bypass urban highway,
  – Section between nodes Lučko and Jankomir as use case
• Congestion created near Lučko node
• Quality measures
  – Travel time (TT)
  – Delay

<table>
<thead>
<tr>
<th>Traffic control algorithm</th>
<th>TT (min)</th>
<th>Delay (vehicle-hour)</th>
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<tbody>
<tr>
<td>None</td>
<td>7.06</td>
<td>15.87</td>
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<tr>
<td>ALINEA</td>
<td>3.90</td>
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<tr>
<td>HELPER</td>
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<td>VSLC</td>
<td>5.59</td>
<td>12.24</td>
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<td>HELPER + VSLC</td>
<td>3.30</td>
<td>21.50</td>
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<tr>
<td>ANFIS</td>
<td>4.10</td>
<td>19.75</td>
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</table>
• Cooperation between HELPER ramp metering algorithm and VSLC produces smallest TT
• ANFIS delay values are lower than other ramp metering algorithms
• Cooperation between standalone traffic control systems proposed
  – Ramp metering, VSLC and vehicles
• Cooperative control concept between ramp metering and VSLC is presented and tested
  – Best ratio between TT and delay
• ANFIS based learning approach for ramp metering developed
  – New platform for cooperation between different ramp metering algorithms
  – First results promising
• Developed algorithms tested in simulations with Zagreb bypass (nodes between Lučko and Jankomir) as use case
• Future work - adjustment of learning criterion function for ANFIS based ramp metering
  – Augmentation with VSLC cooperation
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