Real-time trajectory data acquisition and evaluation for an adaptive, dynamic infrastructure measure for safer behaviour using the concept of Nudging

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• Excessive speed is a major cause of accidents
  – Inattentiveness
  – Wrong perception of the road alignment

• Limitations of existing speed reduction measures
  – acceptance
  – fixed cross sections
  – fixed speed limit
SAFETY IN MOTORWAY EXITS

- Small curve radius after long straight road
- Deceleration necessary
- Safe speed decreases along the exit lane
- Longitudinal and lateral acceleration

→ Risk of unintentional speeding
Nudging
- a gentle push to guide human behaviour into the right direction
- no enforcement or punishment

Technical implementation
- Lights along the road markings
- Real-time trajectories from thermal cameras and computer vision methods
Driver’s perspective
Top view

Real-time trajectory data acquisition and evaluation for an adaptive, dynamic infrastructure measure for safer behaviour using the concept of Nudging.
• Field test location: Exit lane in Eindhoven, NL
• Speed limit: 80 km/h -> 70 km/h -> 50 km/h
From Image Coordinates to World Coordinates

- Intrinsic Calibration (Distortion)

- Extrinsic Calibration (Translation and Rotation)
TRAJECTORY ACQUISITION

- Detection: Chamfer Matching using a 3D model of a passenger car
- Tracking: Sequential Monte Carlo Simulation

- Speed estimation: \( v(t) = \frac{x(t) - x(t-\Delta t)}{\Delta t} \) with \( \Delta t = 1 \text{ sec} \)
TRAJECTORY ACQUISITION

- Gaps between cameras: extrapolate position assuming constant speed
RESULTS

Mean speed
- reduced by up to 2.1 km/h compared to baseline

but...
- Mean speed includes slow enough vehicles
- Speed varies due to weather, daylight, traffic etc.

Scenarios: different movements and spacing of lights
Scenario 0: No lights (Baseline)
~18,000 vehicles per scenario
Linear Regression Model
\[ v = b_0 + b_1 \cdot x_1 + b_2 \cdot x_2 + \cdots \]
\( x_1 \): Initial speed at the beginning of the exit lane
\( x_2 \): Day or Night
\( x_3 \): Headway
\( x_4 \): Temperature
\( x_5 \): Rain or Dry
\( x_6 \): Fog or Clear

\[ R^2 \geq 0.21 \] depending on position

Speed reduction up to 2.7 km/h

Scenarios: different movements and spacing of lights
Scenario 0: No lights (Baseline)
~18,000 vehicles per scenario
RESULTS

Ratio of speeding vehicles

- “Speeding vehicle“ = faster than 85% quantile in baseline scenario
- reduced by up to 40% compared to baseline

Scenarios: different movements and spacing of lights
Scenario 0: No lights (Baseline)
~18,000 vehicles per scenario
Speed reduction measure
• Based on the concept of nudging
• Using real-time trajectory data from thermal cameras
• Effective in reducing mean speed and ratio of speeding vehicles
• Contributing to traffic safety where other measures are not suitable

Further Research
• Refine trajectory acquisition
• Apply to other locations