A Cooperative Overtaking Assistance System

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Current Status

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problem scenario

- Support to overtaking maneuver
- Navigation at the lane level
- Timely communications
proposal

Lane change prediction

Notification (CN)
proposal

Notification to vehicles only inside the area of interest

CN based communication is proposed. VANET is also possible but it has not been tested.
Vehicle that launched the system

Vehicle map-matched on this lane (direction) inside the area of notification

If road is ‘simpler’, map matching can reach lane level
proposal

Trajectory predictions assuming that both vehicles follow the lane shape (using the map)
Areas of uncertainty

Not only comparing predicted positions but also taking into account the uncertainties.

The risk is estimated based not only on the positions but also on its uncertainties.
what to do

1) Communicate the vehicles of the scene

2) Predict lane-changes

3) Assess whether or not a maneuver is risky
- P2P approach
- **Traffic zones** organized in **coverage areas** each one using different P2P communication groups
- Information about areas kept in **GS**
- **Roaming** between coverage areas allows moving from one P2P group to another
- Information about areas is received from GS using **TCP/IP link** over **UMTS**
- A **ES** (onboard or offboard) manages **special messages** inside the area
- Messages can be sent to a **specific vehicle** or **broadcasted** in the area
overlay vehicular network
overlay vehicular network

Histogram of distribution of latency values.

Most of values between 200 and 300 ms
overlay vehicular network

Cumulative distribution function:

Around 90% of the messages between 200 and 400 ms.

The rest grows following a quasi-logarithmic trend

Values between 400 and 500 ms come from signaling traffic when the terminal comes from low-power mode
Mobility conditions provoke continuous peaks (they affect both the uplink and the downlink)

1st stretch: building blocking the signal with base station

2nd stretch: farthest position from base station and blockages

3rd stretch: a hill decreases the channel quality
lane change prediction

No extra sensors apart from those of the navigation system: GNSS, inertial sensors, odometry, map

kinematic models oriented to 2 different maneuvering states:

KEEP LANE    CHANGE LANE

we must find out which model represents better the vehicle state
lane change prediction

1. init
2. state & covariance prediction
3. Observation & validation
4. Calculate model probabilities
5. IMM Mixing
6. Output to the user
7. update filtered estimates
8. Change lane model
9. Keep lane model

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lane change prediction

State vector

\[ \mathbf{x}_{CL/B} = (x, y, \phi, v, \omega, a, c_0, c_1) \]

CHANGE LANE

\[ \dot{\mathbf{x}}_{CL} = \]

\[ \begin{bmatrix} (v + at) \cos(\phi) & (v + at) \sin(\phi) & a & 0 & 0 & c_1 v & 0 \end{bmatrix}' + \]

\[ \begin{bmatrix} 0 & 0 & 0 & 0 & \eta_{\omega_{CL}} & \eta_{a_{CL}} & \eta_{c_{0CL}} & \eta_{c_{1CL}} \end{bmatrix}' \]

Model of ‘free moves’

KEEP LANE

\[ \dot{\mathbf{x}}_{KL} = \]

\[ \begin{bmatrix} (v + at) \cos(\phi) & (v + at) \sin(\phi) & c_0 v & a & 0 & 0 & c_1 v & 0 \end{bmatrix}' + \]

\[ \begin{bmatrix} 0 & 0 & 0 & 0 & \eta_{\omega_{KL}} & \eta_{a_{KL}} & \eta_{c_{0KL}} & \eta_{c_{1KL}} \end{bmatrix}' \]
lane change prediction

Probability of maneuvering state increases when the maneuver is predicted

Noise estimates have low values when vehicle keeps the lane

and higher values when all lane change is carried out
lane change prediction
Lane change prediction
conclusions

A cooperative system that supports collision avoidance based on:

- Navigation sensors (widely available)

- CN communications (widely available)

First tests show good results

The work is ongoing...
MANY THANKS FOR YOUR ATTENTION

QUESTIONS, COMMENTS, SUGGESTIONS?

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