Perspectives on an ALKS model in SUMO

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Short agenda

- Introduction about ALKS
- Partial reproduction of UN Reg. No. 157
- Conclusions & Outlook
Introduction
ALKS = Automated Lane Keeping System

- ALKS: essentially level 3 automated driving

- Reg. 157 lays down safety requirements

https://www.sae.org/standards/content/j3016_202104

ALKS: about to enter the market

Motivation: Can we have an ALKS model in SUMO?


Short summary of UN ECE Reg. 157

- Not a nice read!
- Operational speed up to 60 km/h
  (theoretically up to 130 km/h, if system MRM lane change capable)

- So-called “performance models“ (= cf models):
  - Regulation 157
  - CC human driver
  - FSM
Three “traffic critical scenarios”

(a) 
Cut-in:

(b) 
Cut-out:

(c) 
Deceleration:
Notation

- $V_y$: lateral speed of challenger (speed jumps from 0 to $V_y$)
- $d_{x0}$: initial distance between front of ego and back of challenger

- $d_y = 1.6m$ (fixed): lateral distance between left side of challenger and right side of ego
- $\ell_e, \ell_c$ (fixed): the lengths of the two vehicles
Most interesting: cut-in

**ego: 60 km/h**

\[ V_y = -1 \text{ m/s}, \ d_{x0} = 19\text{m}, \ V_{challanger} = 30 \text{ km/h} \]
Most interesting: cut-in

$V_y = -1 \text{ m/s}, \ d_{x0} = 19\text{ m}, \ V_{challanger} = 30 \text{ km/h}$
Partial reproduction of UN ECE R157
Two step analysis:

1. Reproduce collision classification from R157

2. Comparison of models provided by the JRC repository:
   https://github.com/ec-jrc/JRC-FSM/tree/main

see also:
Two step analysis:

1. Reproduce collision classification from R157: e.g. Figure 7, Annex 3
1. Collision classification with SUMO

Two example outputs with simple continuous lane-change model:
SUMO’s lane-change mechanism explained

- note: default lane change is instantaneous (not applicable here)
- simple continuous lane change model with lateral velocity
  - SUMO’ lane change model reserves a corridor for lane changes to ensure safe gaps
  
  → leads to immediate reaction by ego vehicle
  → deceleration to ensure safe gap is overridden by lc model
2. Model comparison

→ Delayed detection and reaction by the other models lead to curved collision pattern
Conclusions
Partial success, but…

- sublane model probably better suited for further developments (wait for next slide…)

final remarks:

1. UN ECE R157 maybe a bit feeble: seems easy to implement better / safer models

2. Further questions regarding string stability and capacity:
   - (relatively large) headway $\tau = 1.6 s$ as minimum required
   - current ACC systems prone to show string instable platoon behavior

(OpenACC JRC database: https://data.jrc.ec.europa.eu/dataset/9702c950-c80f-4d2f-982f-44d06ea0009f)
Outlook: deploying the sublane model (work in progress)
Imprint

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Credits: All Figs are “DLR (CC BY-NC-ND 3.0)“, if not stated otherwise
Delayed response by ALKS performance models

Driver model for the cut-in scenario

source: R157, Fig. 2, p.42
The red line...

- boundary between interrupt backwards and side collision under the assumption, that both vehicles keep their speeds (no reaction!);

- connects initial distance $d_{x0}$ (and speed difference $\Delta v$) determining overtaking time $t_x$ to the time needed for the challenger to move lateral the distance $d_y$ to tackle the ego from the side, $t_y$.

- May write down an equation $t_x = t_y$, where $t_x = d_y/V_y$
  and $t_x = (d_{x0} + \ell_c + \ell_e)/\Delta v$.

- And then end up with: $V_y = \frac{d_y}{d_{x0} + \ell_c + \ell_e} \Delta v$;

- if lateral speed $V_y$ is smaller than the expression on the r.h.s., then the challenger is too slow and ends up behind the ego.