Driver Model Calibration Research

ANTIGONES Cooperation Project Kick-off
(ETHz – Huawei)

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HUAWEI

Fuzzy Modeling and Inference for Physics-aware Road Vehicle Driver Behavior Model Calibration

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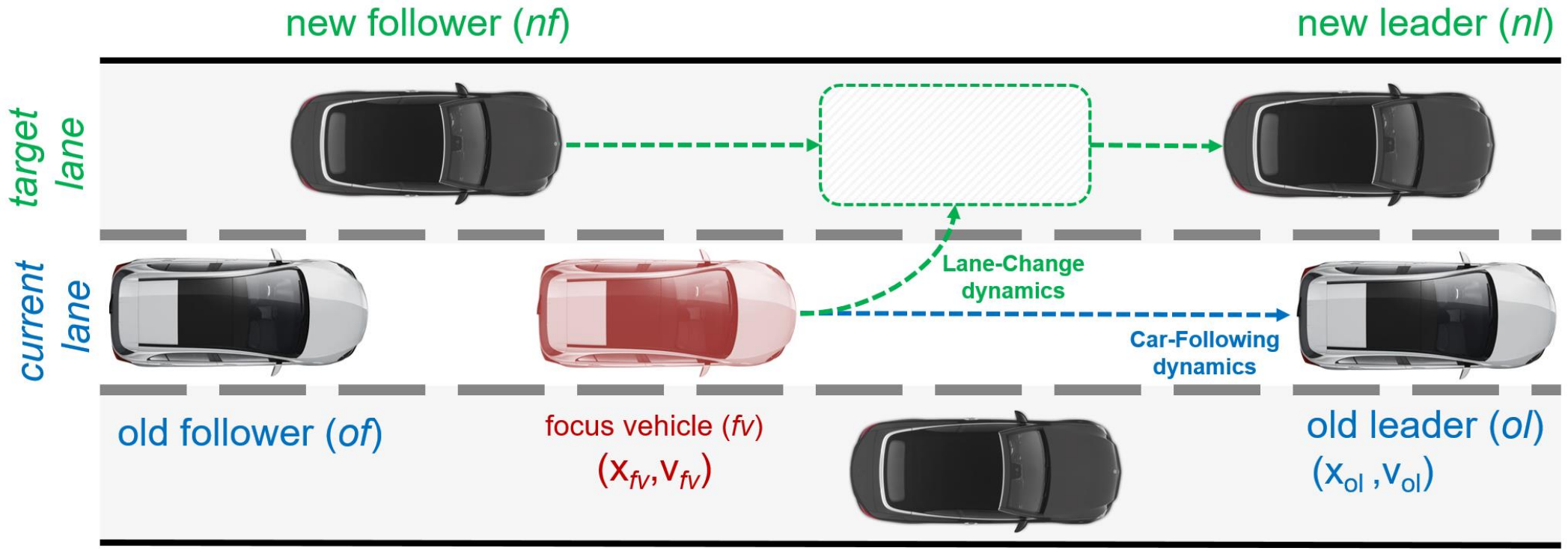
Outline

- Driver model calibration
- Alternatives to optimization-based calibration
- Preliminary results
- Conclusions & next steps

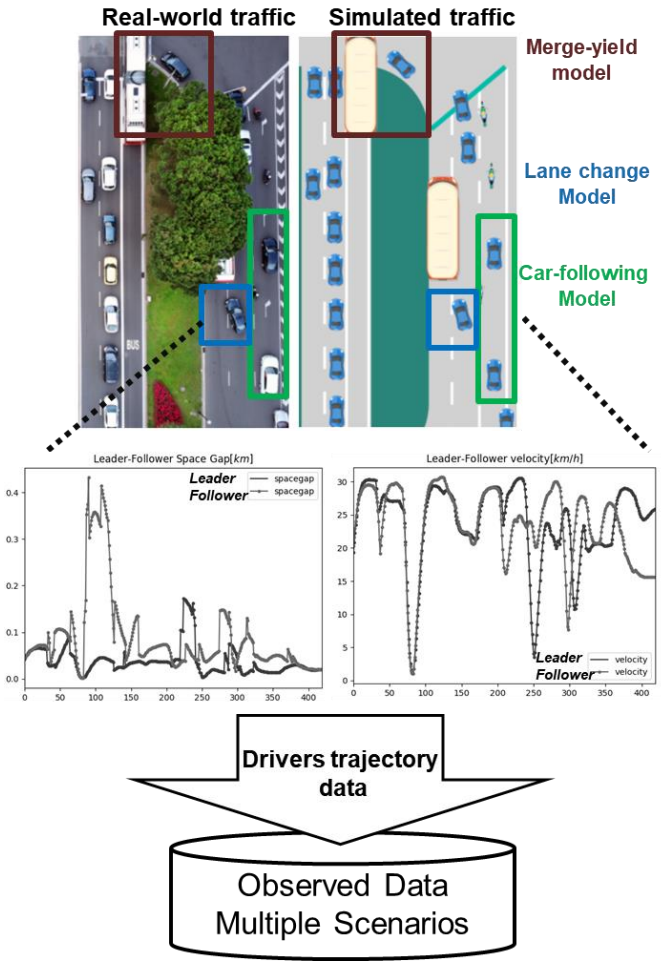
Driver model calibration

Problem analysis

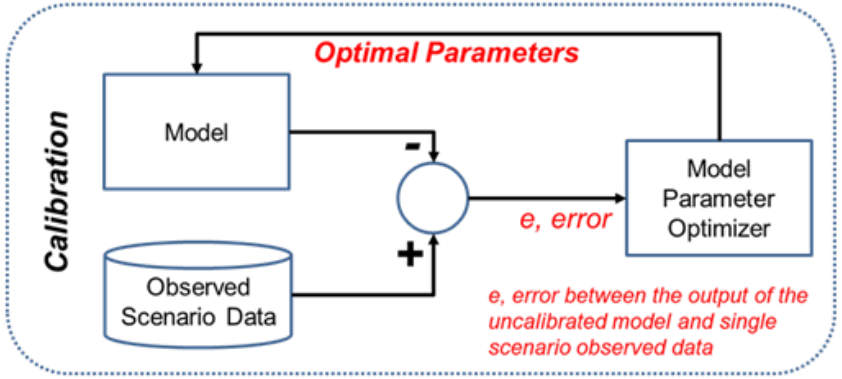


Driver model calibration

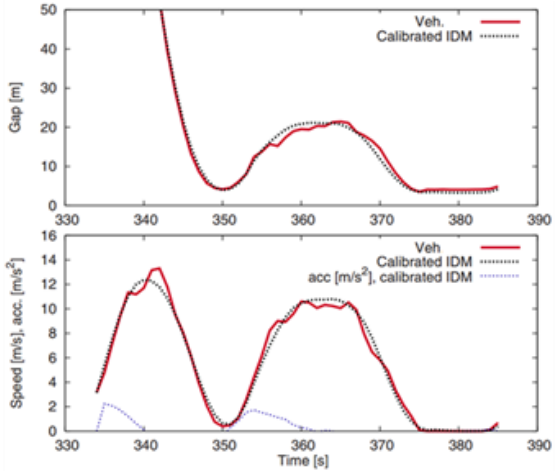
Problem statement



Typical calibration pipeline

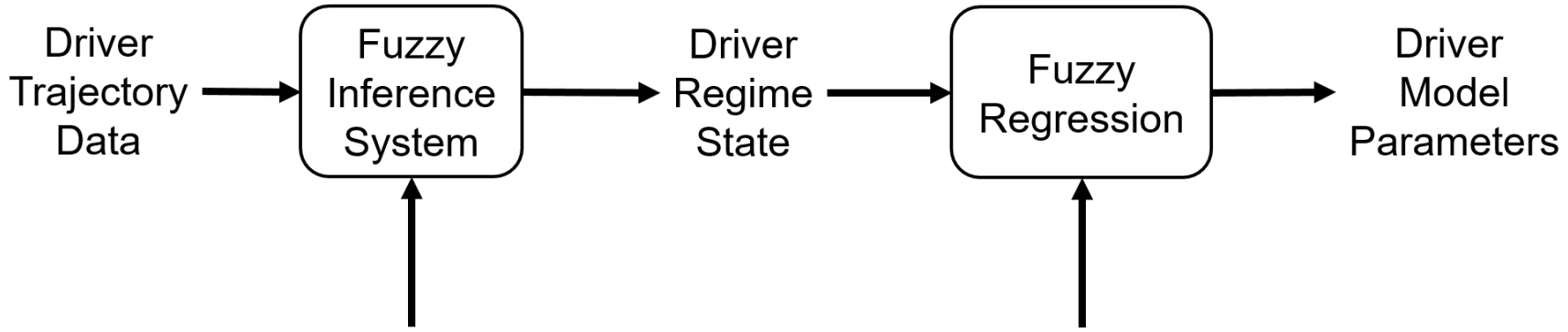


Example calibrated parameters



Alternatives to optimization-based calibration

Fuzzy Modelling, Inference and Regression

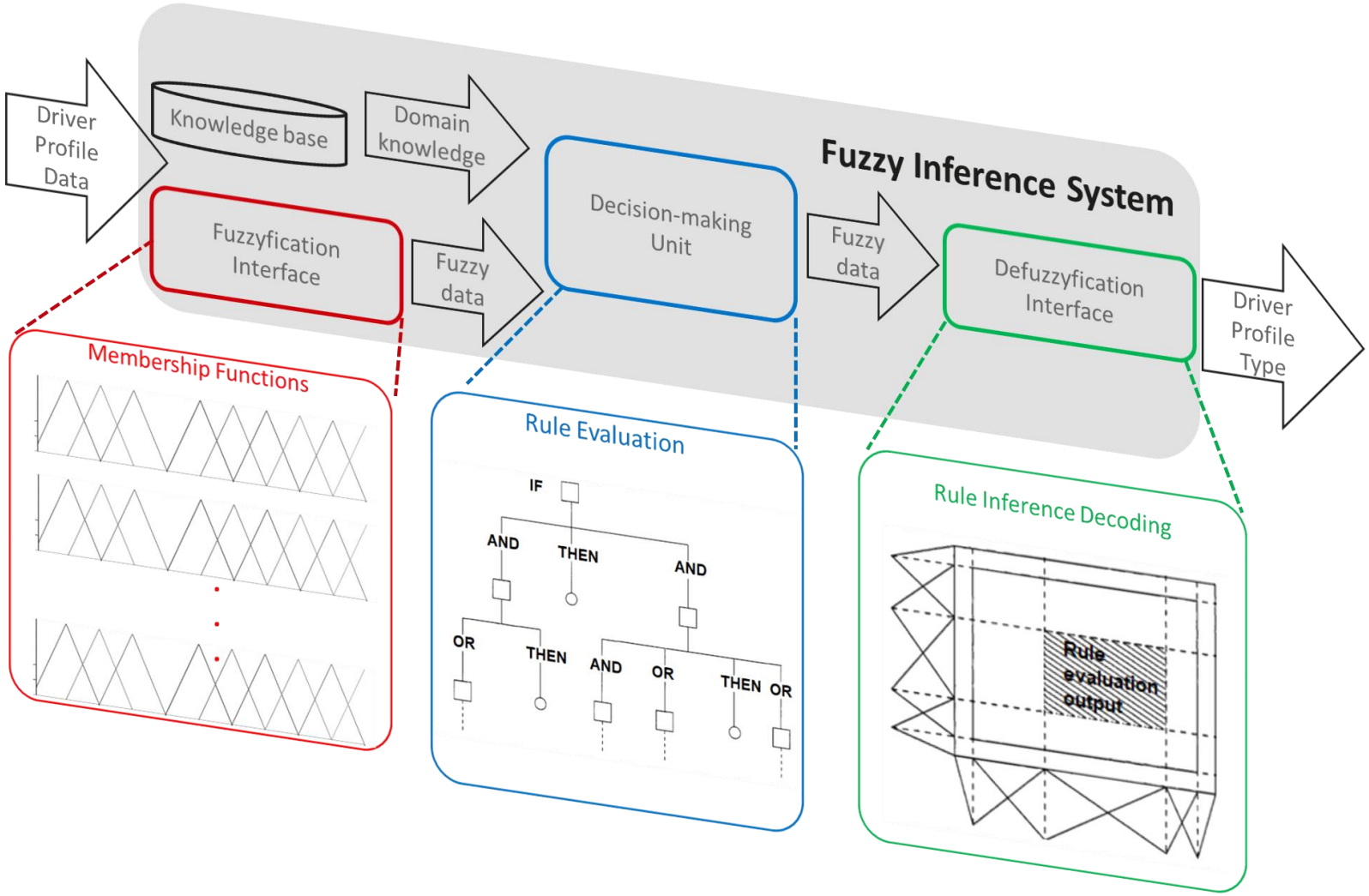



```
if velocity is verysmall and acceleration is mild and spacegap is verysmall and timegap is veryshort then creepingregime is high
if velocity is small and acceleration is negativelow and spacegap is small and timegap is short then creepingregime is moderate
if velocity is medium and acceleration is negativelow and spacegap is medium and timegap is medium then creepingregime is low
if velocity is high and acceleration is mild and spacegap is medium and timegap is medium then steadyregime is moderate
if velocity is veryhigh and acceleration is mild and spacegap is large and timegap is large then steadyregime is high
if velocity is high and acceleration is positivelow and spacegap is large and timegap is large then steadyregime is low
if velocity is high and acceleration is negativelow and spacegap is medium and timegap is medium then approachingregime is low
if velocity is high and acceleration is negativehigh and spacegap is small and timegap is medium then approachingregime is moderate
if velocity is veryhigh and acceleration is negativehigh and spacegap is medium and timegap is short then approachingregime is high
if velocity is high and acceleration is positivelow and spacegap is large and timegap is large then acceleratingregime is low
```

IDM Parameter	Driving regime/state	Identification criteria
Desired speed v_{free}	Cruising	$\tau > T_c$,$a > a_c$, $v > v_c$
Maximum acceleration a	Free-flow	$\tau > T_c$,$a > a_c$ and not cruising
Minimum space gap s_0	Braking	$s < s_c$
Maximum deceleration b	Approaching	$v > v_{ol}$, $\frac{s}{v} > T_c$, $\frac{2(v-v_{leader})}{2s} > a_c$
Desired time gap τ	Following	$\tau < T_c$ and no other regime condition

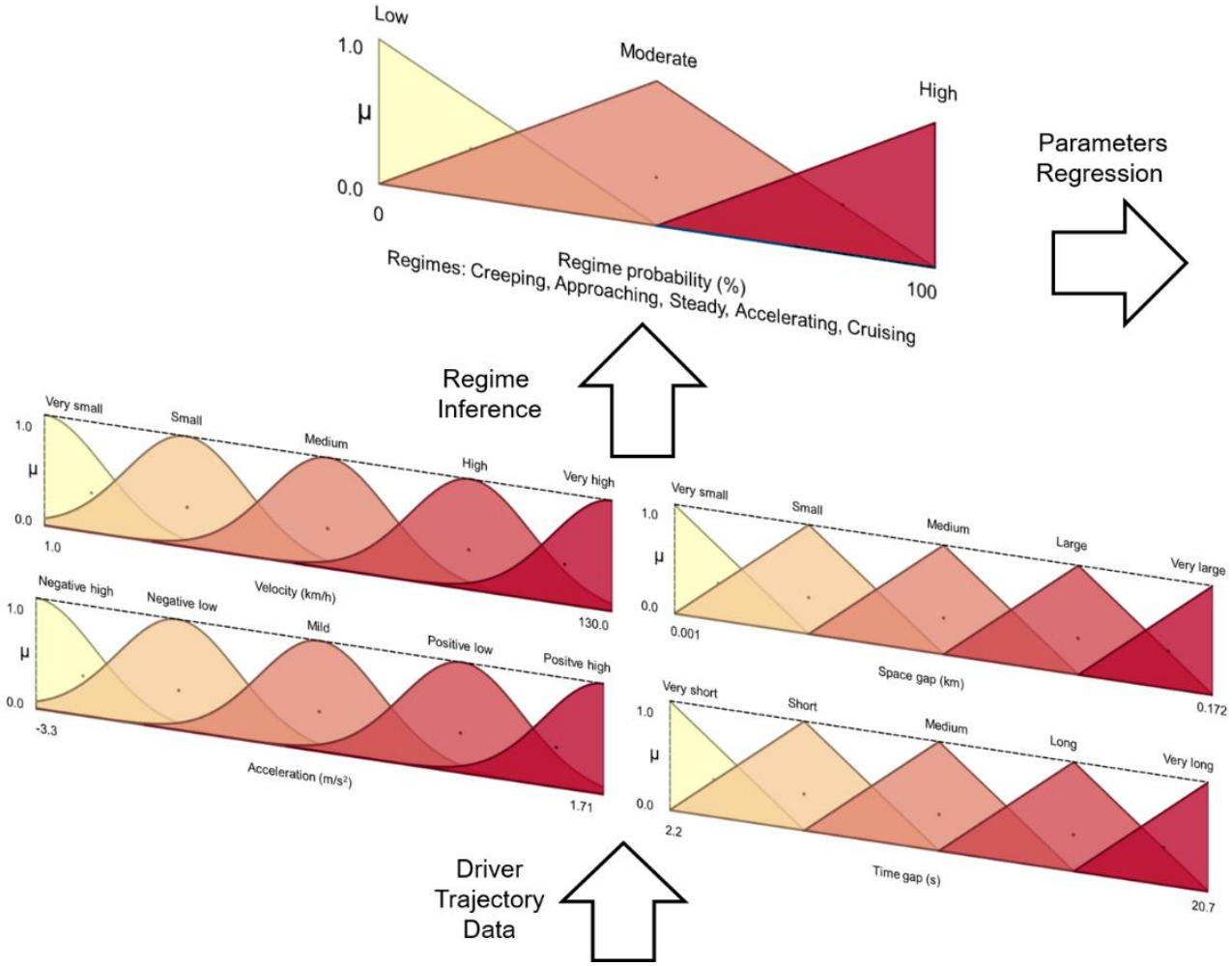
Alternatives to optimization-based calibration

Fuzzy Modelling, Inference and Regression



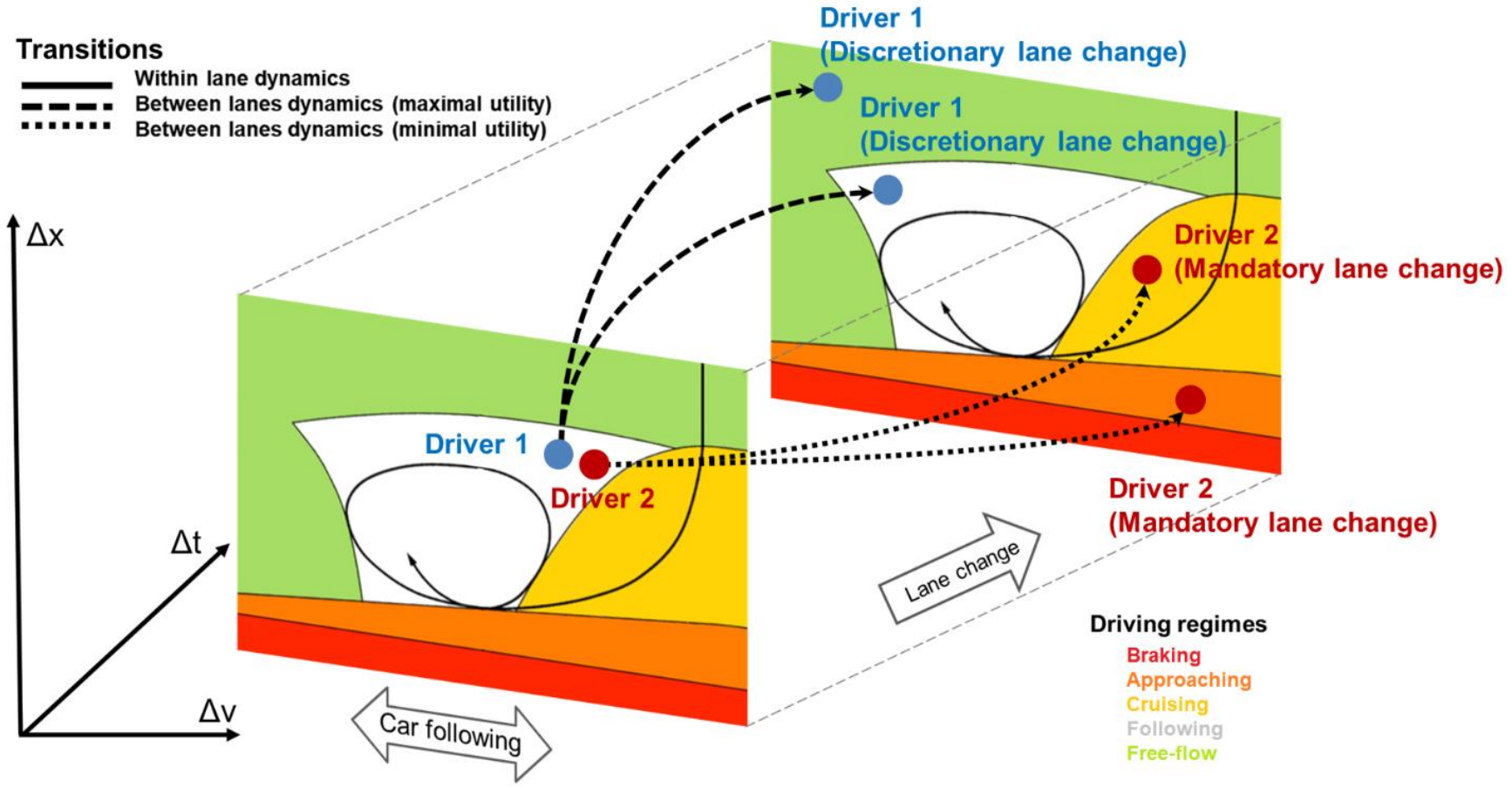
Alternatives to optimization-based calibration

Fuzzy Modelling, Inference and Regression

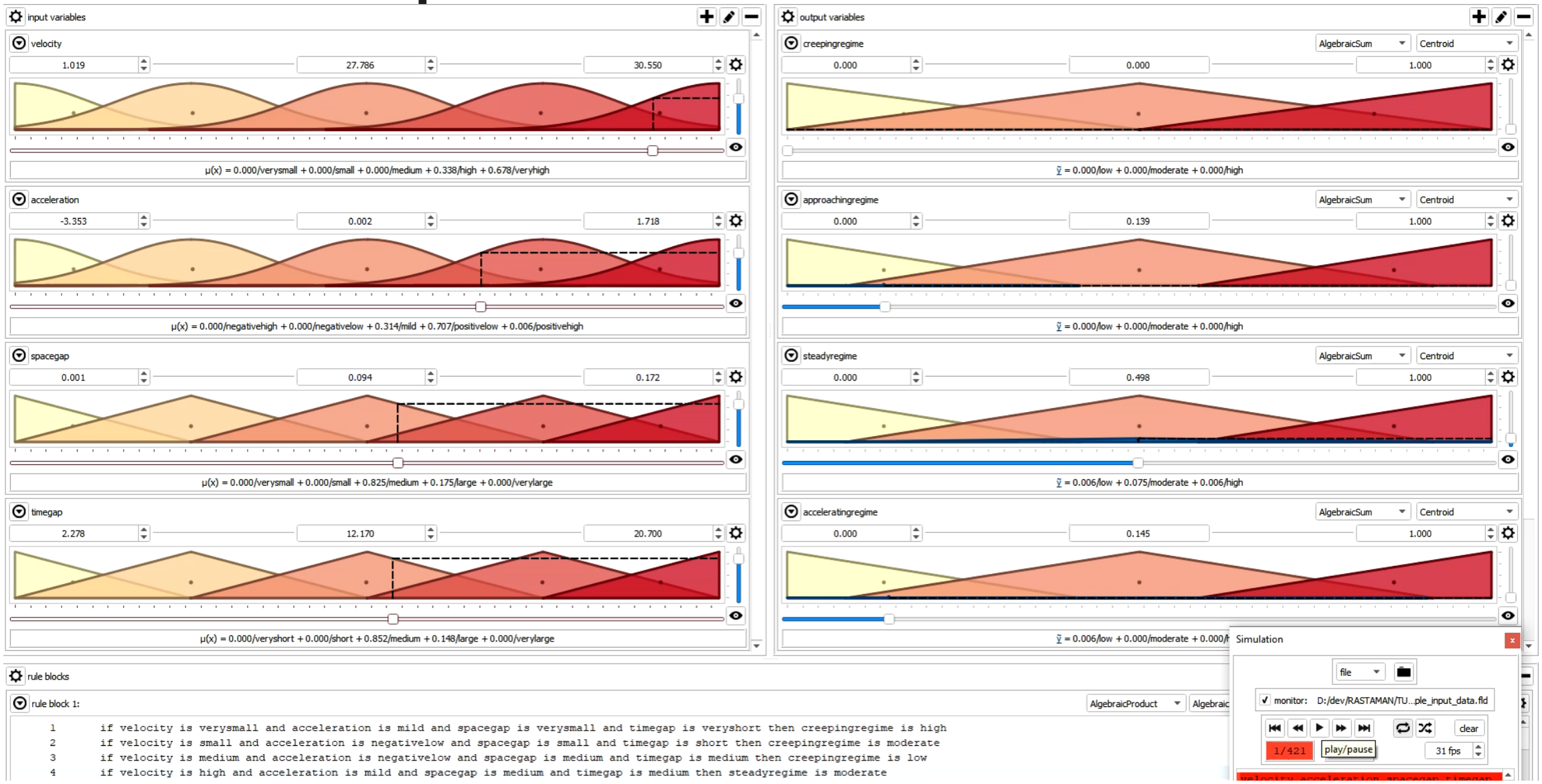


Alternatives to optimization-based calibration

Fuzzy Modelling, Inference and Regression



Alternatives to optimization-based calibration

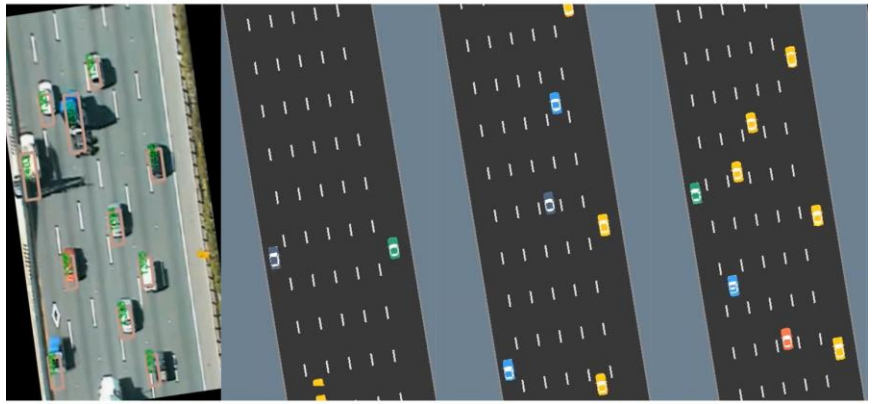


Preliminary results

Preliminary results

Qualitative realism

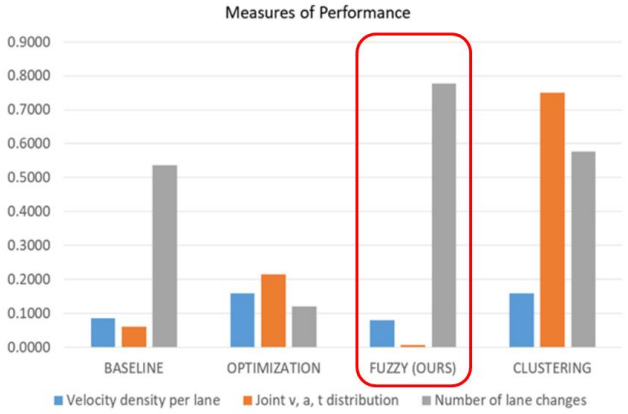
Tested and evaluated on NGSIM (I80)

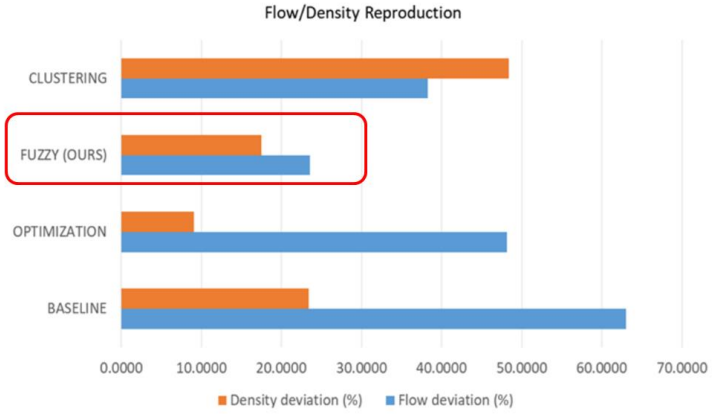


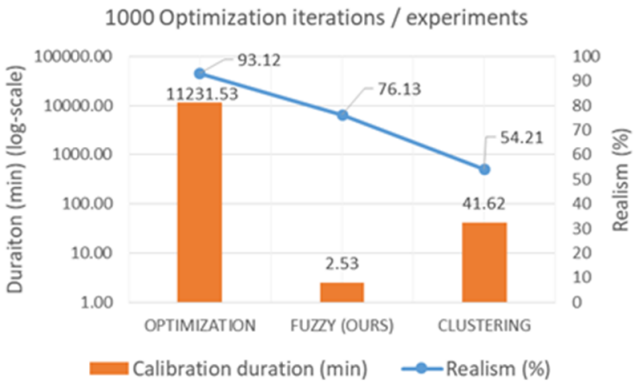
Ground truth No calibration Opt. calib. Fuzzy calib.

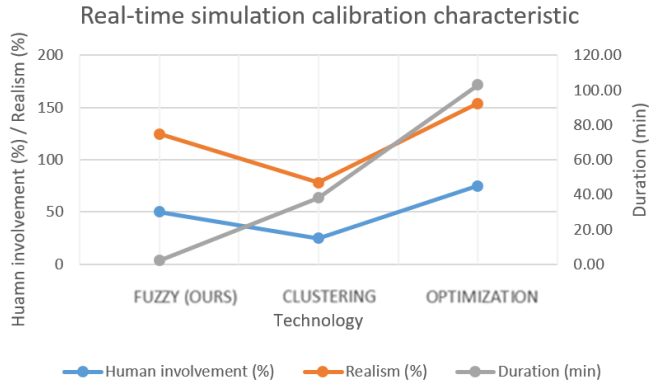
	Driver model calibration approach			
Metric	Baseline	Optimization	**Fuzzy(ours)**	Clustering
Velocity-density characteristic, M_1	0.085	0.159	**0.080**	0.158
Joint velocity-acceleration-headway distribution, M_2	0.061	0.214	**0.006**	0.751
Number of lane changes, M_3	0.536	0.120	**0.777**	0.576
Flow percent deviation, M_4	0.637	0.481	**0.235**	0.382
Density percent deviation, M_5	0.233	0.090	**0.175**	0.483

Quantitative realism







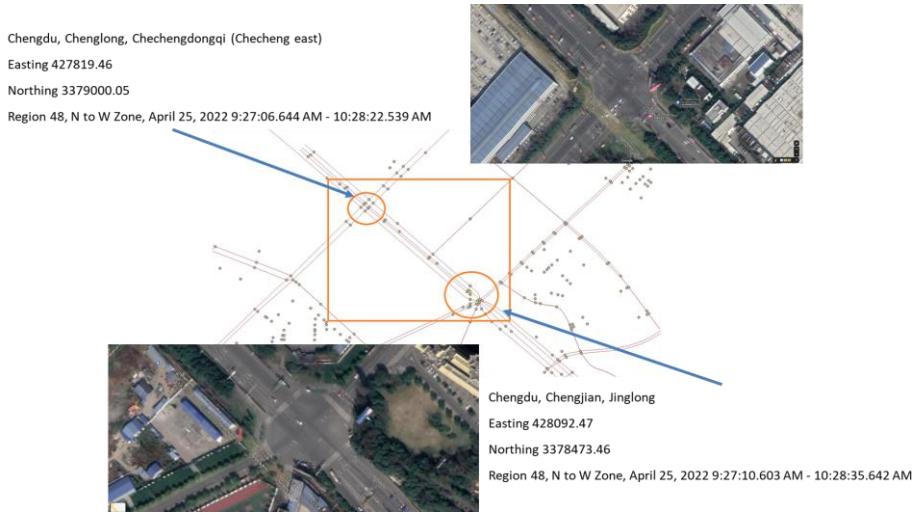


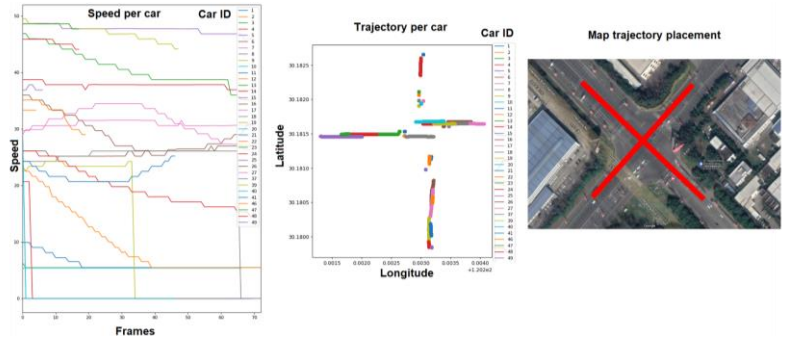
Preliminary results

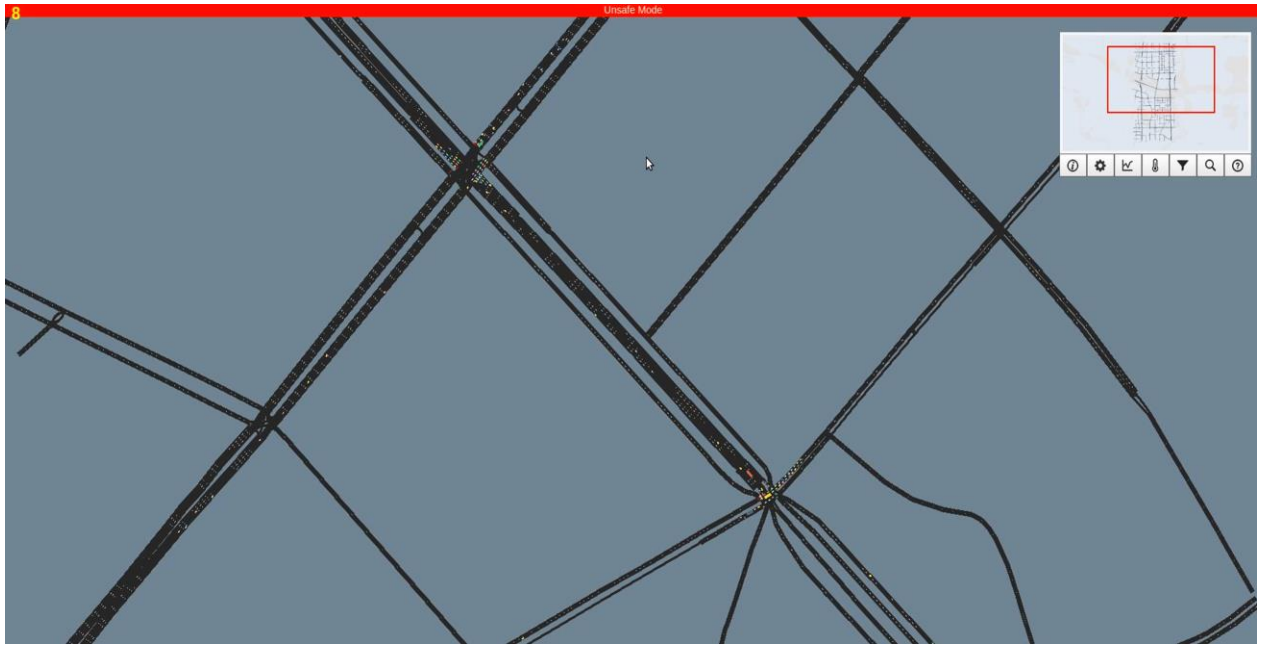
Preliminary results

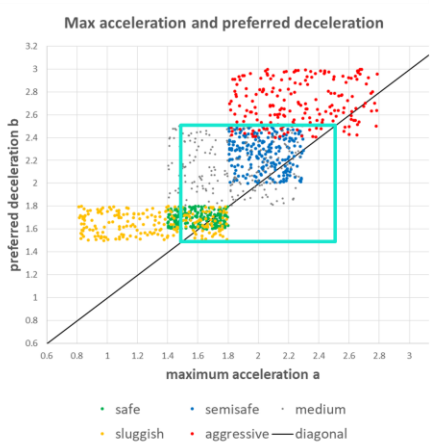
Qualitative realism

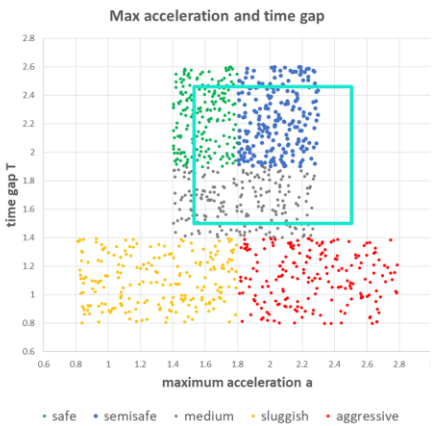
Tested and evaluate on Chinese Drivers

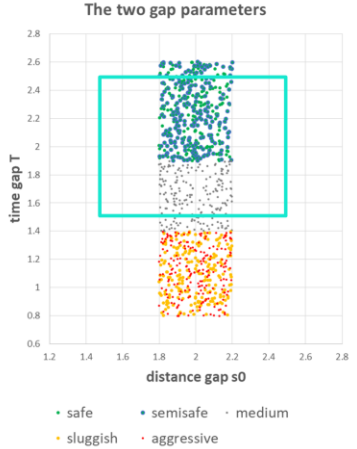












Conclusions & next steps

- Driver model calibration can go **beyond optimization-based** methods and follow **plausible** configurations.
- **Expert knowledge** is very important to **assess calibration outcomes** (micro-/macro-quantities).
- Opening the way to **online calibration/re-calibration without** time-consuming **optimization** and a plausible **trade-off in accuracy**.
- **Fusing** physics, expert knowledge, machine learning in and **end-to-end system**.