

Calibrating and validating probabilistic discretionary lane change models

04-07-14

Victor L. Knoop

Discretionary LC models

- Lane changes are essential in motorway simulation
- Cause disturbances
- Lane use determines capacity
- Many car-following models, few LC models
- Calibration and validation is an issue for CF
- *Why not being done for LC models?*
- *Should we?*

Main difficulties

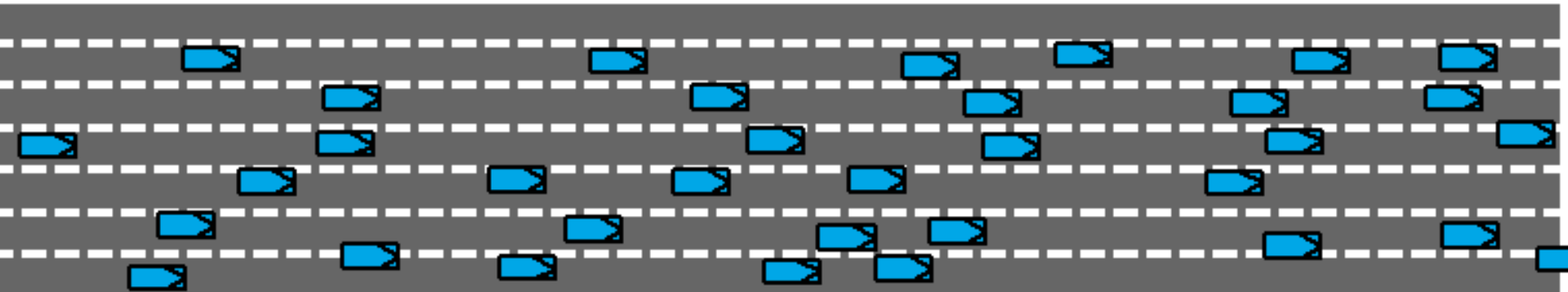
- Only observed lane changes
- Three requirements
 - Not right in current lane
 - Better in other lane
 - Possibility to change lanes
- How to validate?

Validation definitions

- 1) Values of parameters more or less right
- 2) Values of parameters equal for calibration set and validation set
- 3) Good enough in real world measures

How to calibrate

- Measure of performance
 - Number of lane changes?
 - Lane distributions?
 - Travel times?



Model

- Three base requirements
- 1) Desire for higher speed (binary, f_1)
- 2) Higher speed in other lane (linear with speed difference, f_2)
- 3) Availability of gap (speed dependent, f_3)
- All need to be fulfilled, so multiply for probability
- Besides: rest probability (α)

$$P(\text{lane change}) = \alpha (f_1 * f_2 * f_3) + (1 - \alpha)$$

Probabilistic model

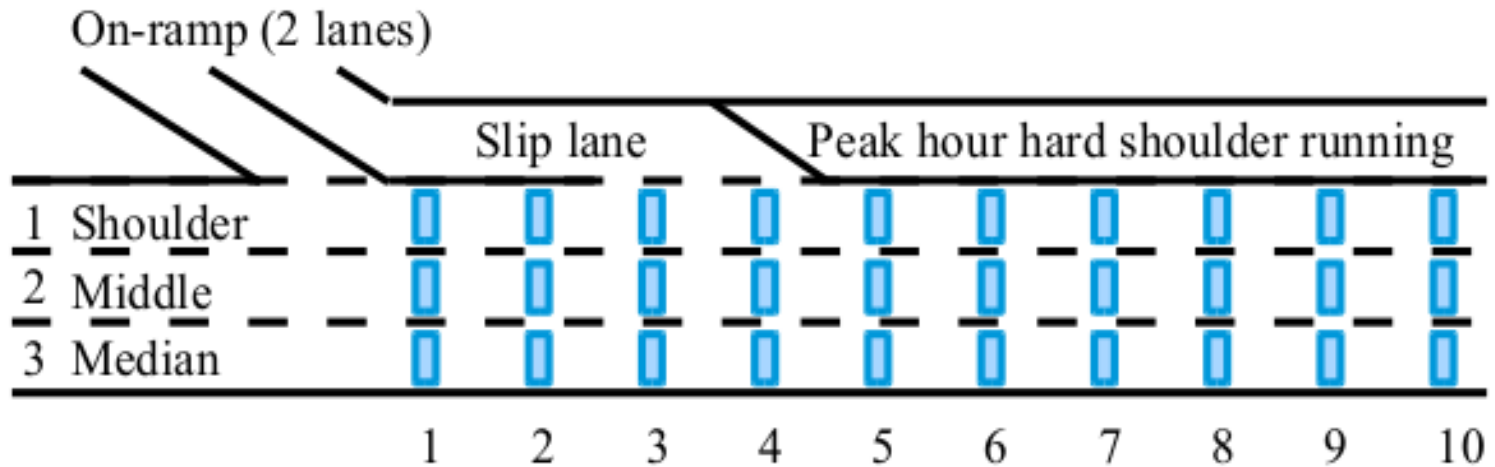
- Probability for a lane change given conditions
- Count the number of occasions where the model is right
- Likelihood: how likely is the observed result given the model prediction?
- $L = P_1 \times P_2 \times \dots \times P_n$
- Optimize parameters of the model to observe likelihood (or log-likelihood for simplicity)

Validation definitions

- $L = P_1 \times P_2 \times \dots \times P_n$

- 1) Values of parameters more or less right
- 2) Values of parameters equal for calibration set and validation set
- 3) Good enough for purpose

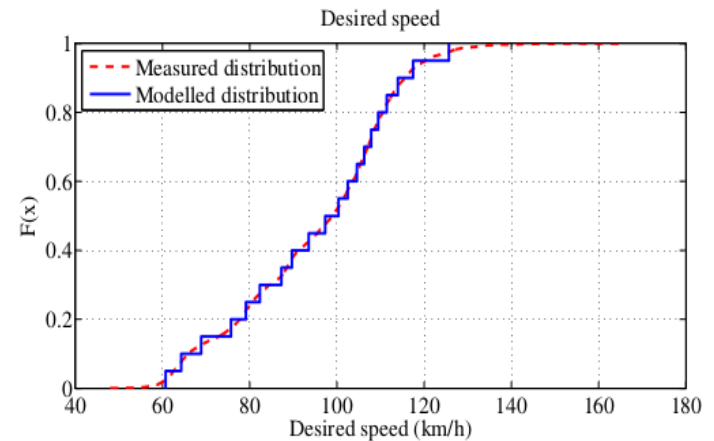
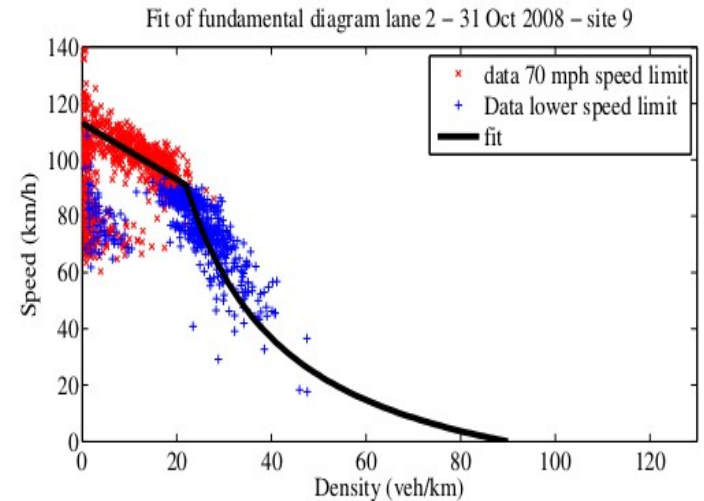
Data



- Individual loop detector data
- 100 meter spacing
- => trajectories

Information from data (micro)

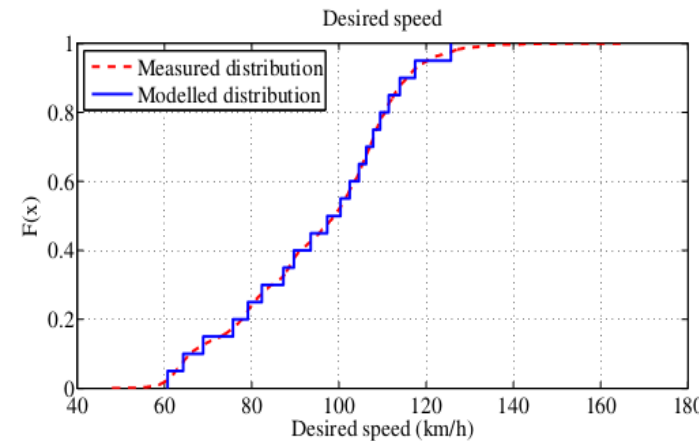
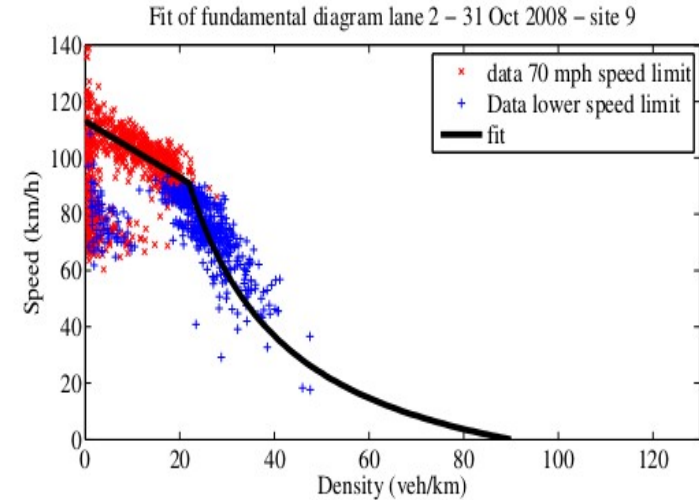
- Desired speed from free driving (correlated with gap)
=> Desire to leave lane probabilisticly from data
- Speed of neighbors
- Gap



Information from data (macro)

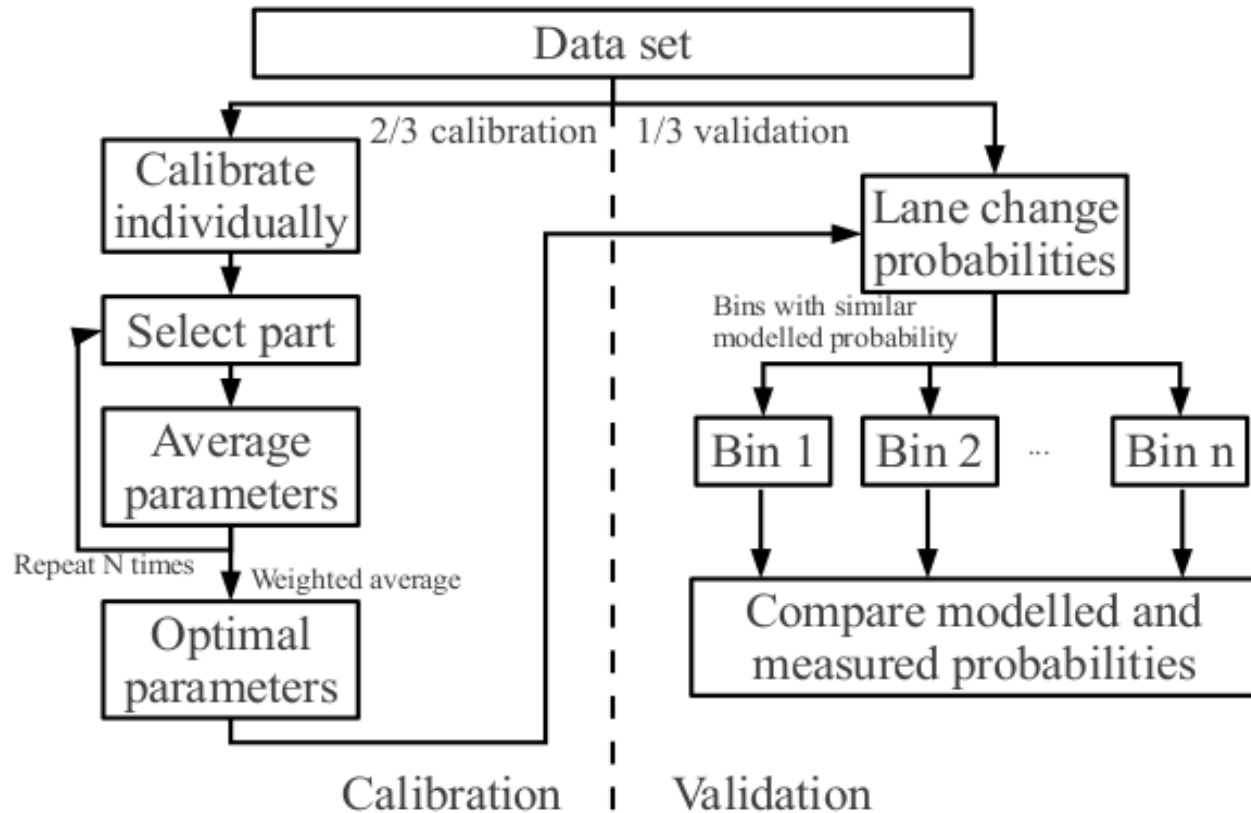
- State uniquely determined by densities (fundamental diagrams give speed and gaps)
- Density gives probability that one wants to leave lanes
- Speed of neighboring lane
- Gap from density

- Macro =>
n tries, probability of k Lcs

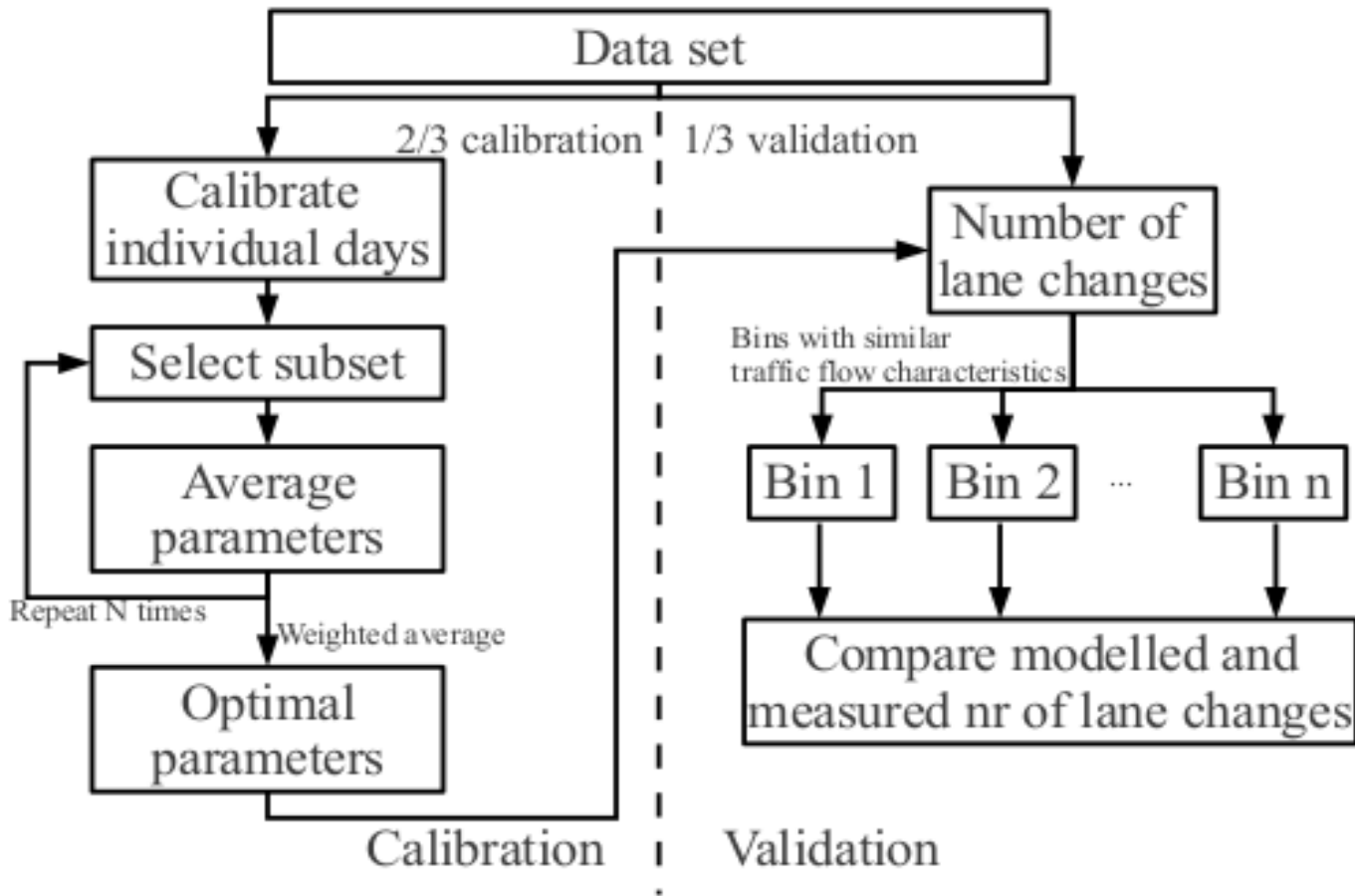


Methodology for validation (micro)

5



Methodology for validation (macro)



Validation results (1)

Values of parameters more or less right

		microscopic		macroscopic	
	Var	avg	stdev	avg	stdev
Reconsider time	τ	16s	1.2s	12.1s	0.4s
Explanation by variables	α	0.915	0.006	0.927	0.004
Critical TTC	κ_0	4.0s	0.4s		
Critical gap	g_0	4.0s	0.2s		

Validation results (2)

Values of parameters equal for calibration set and validation set

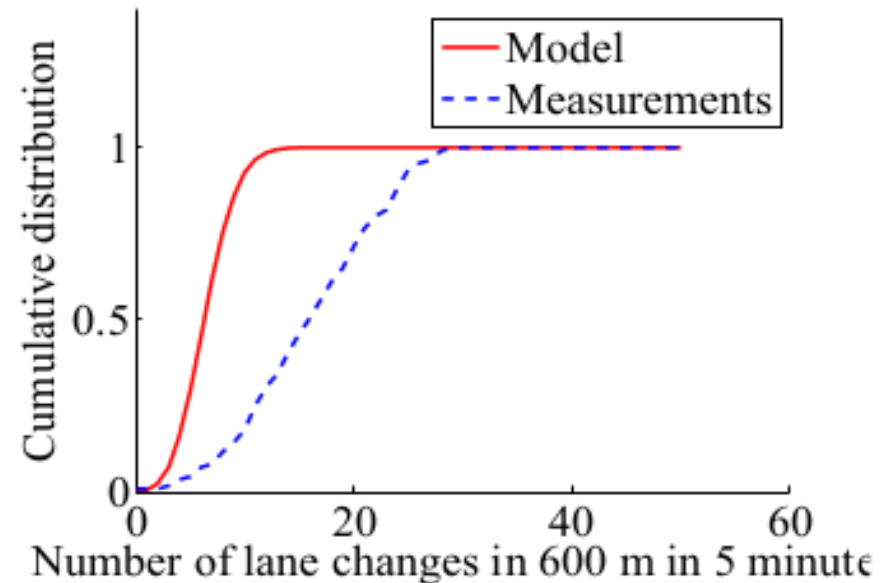
TABLE 11.1: SUMMARY OF RESULTS

Level	Calibration			Validation		
	\mathcal{L}	Nr	Norm.	\mathcal{L}	Nr	Norm.
Micro	9.7E4	2.1E5	3.1E4	1.8E6	3.6E-2	
Macro	2277	1802	1.46	1214	1.48	

They are

Validation result (3)

Good enough for purpose



(a) Distribution of lane changes in bin $4 < k_i < 6$ (density in the origin lane) veh/km/lane and $4 < k_j < 6$ (density in the target lane) veh/km/lane

Interpretation of likelihood

Log-likelihood → likelihood → mean probability

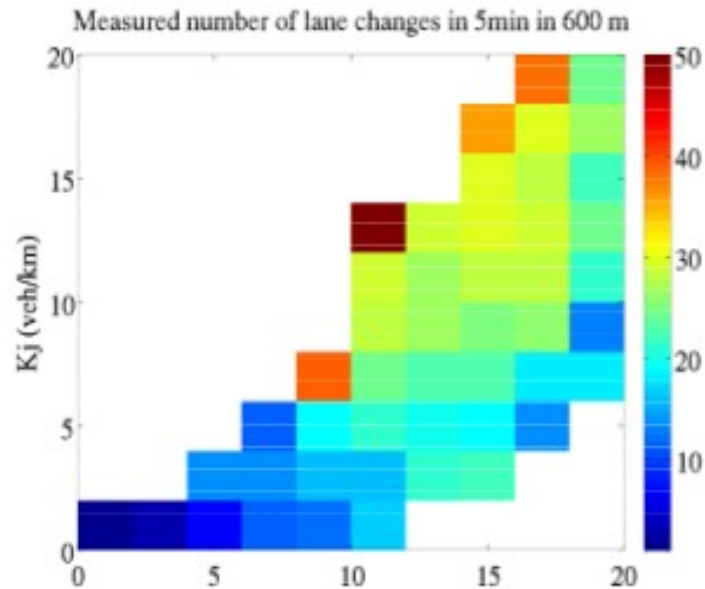
$$L = P_1 \times P_2 \times \dots \times P_n$$

Assuming equal P
(probability to have the right number of LC)

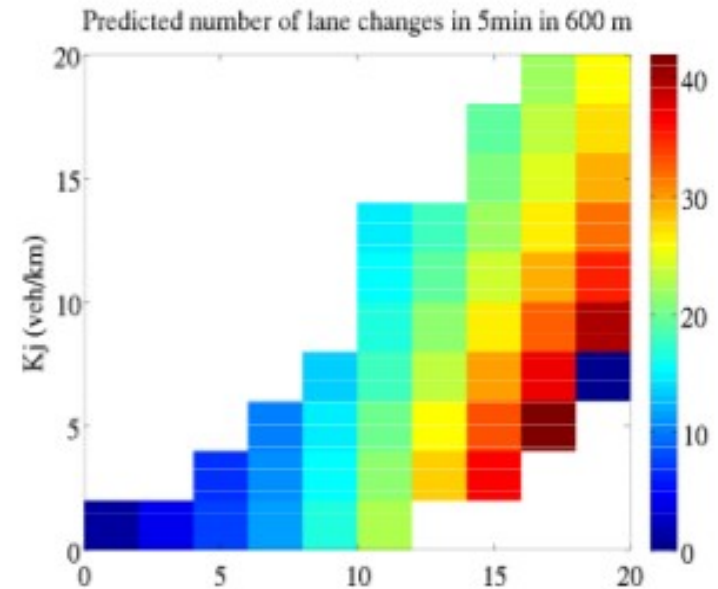
$P = 0,035 \Rightarrow 3,5\%$ right to be correct

Zero order model (no lane changes): 5,8 %!

RMSE of nr of LCs

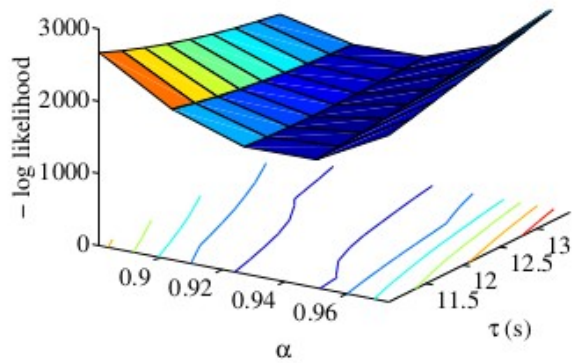


(b) Measured number of lane changes

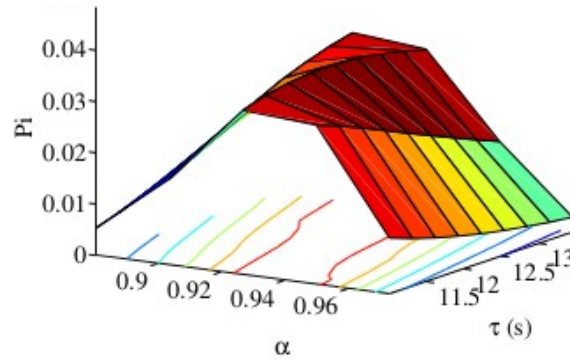


(c) Predicted number of lane changes

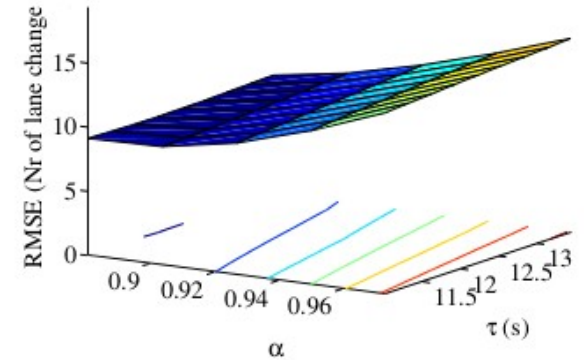
Sensitivities



(a) loglikelihood



(b) Probability



(c) Root mean square error of the number of lane changes compared to the expected number of lane changes

Sensitivities depend on measure
(RMSE not in same minimum)

Conclusions

- Probabilistic models are difficult to cal/val
- Likelihoods make most sense
- No proper interpretation for likelihood
- RMSE sensible alternative to check where the model is wrong
- **Validation needed according to proposed purpose**

Questions

v.i.knoop@tudelft.nl

This research is sponsored by COST action Multitude and NWO project:

There is plenty of room in the other lane