A Study on ACC(Adaptive Cruise Control) Impacts on Sag Section under Mix Traffic Environment

混在交通下のサグ区間におけるACCの影響

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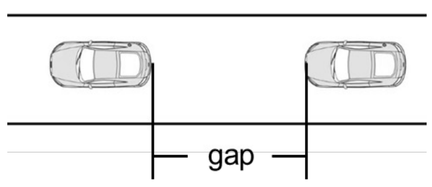
1.Introduction

- **ACC (Adaptive Cruise Control)** could automatically adjust speed to maintain a constant time gap to the leading vehicle based on the sensor information.

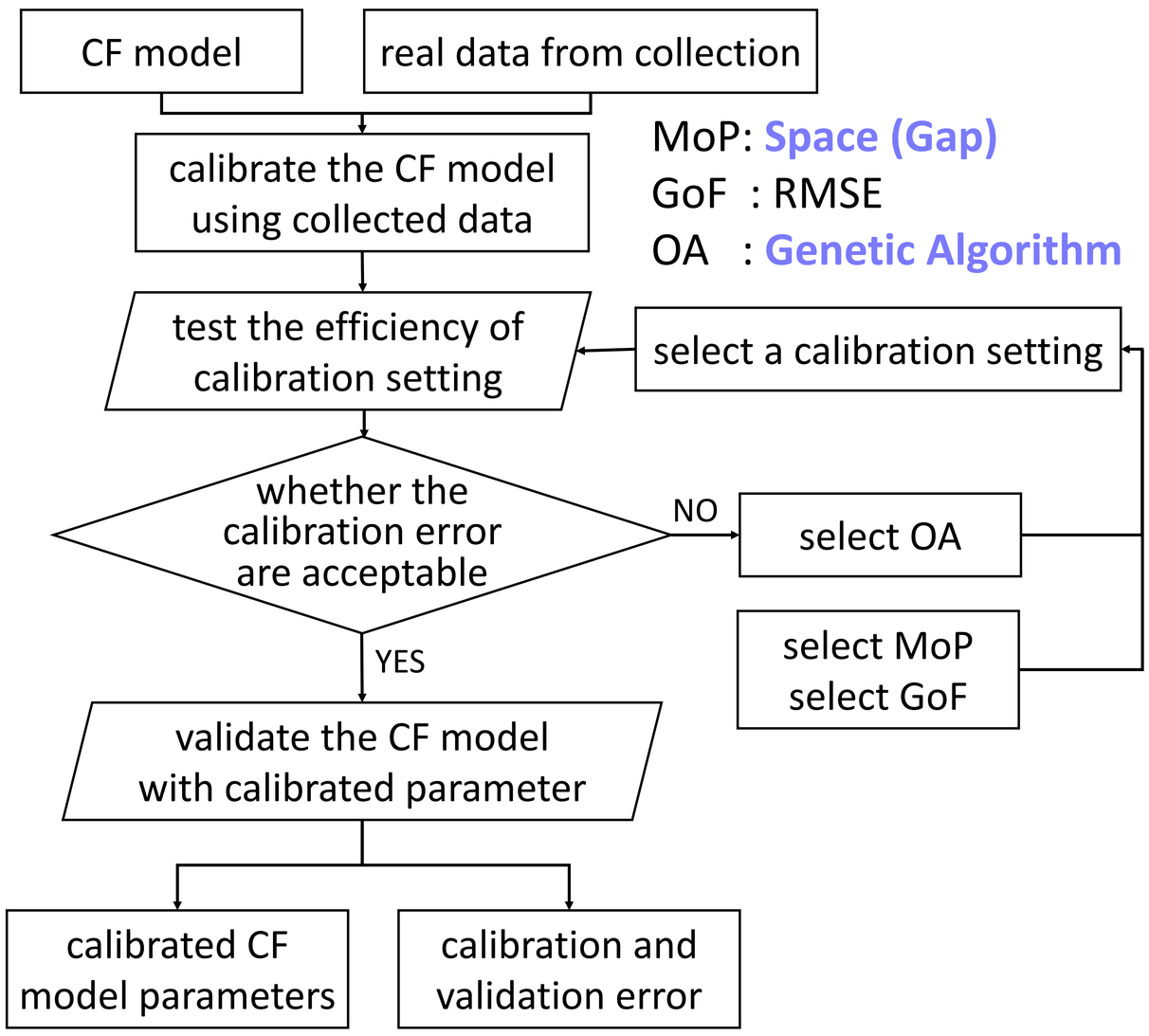
$$time\ gap = \frac{gap}{speed\ of\ follower\ vehicle}$$



- Congestion of **sag sections** (gradient changes into larger value along travel direction; typical bottleneck) may also be improved by ACC.
- Objective:
  - Evaluation of the impacts of ACC under the mixed traffic (different penetration rates of ACC) on sag sections.

2. Methodology

- Non-linear State-feedback Control Model :
  - $a_k^{i+1} = k_1\left(l_l^i - l_k^i - t_{hw}v_k^i\right) + k_2(v_l^i - v_k^i)$
- Framework of Parameter Calibration:



- Data :
  - Resource:
    1. The field experiment data of George Gunter (2019)
    2. Designed speed profiles: Oscillatory, Speed dips, Low speed steps, High speed steps.
  - Train data: speed dips (6 pairs)
  - Test data: Osc, Steps_Low, Steps_High (18 pairs)

3.Calibration Result and Analysis

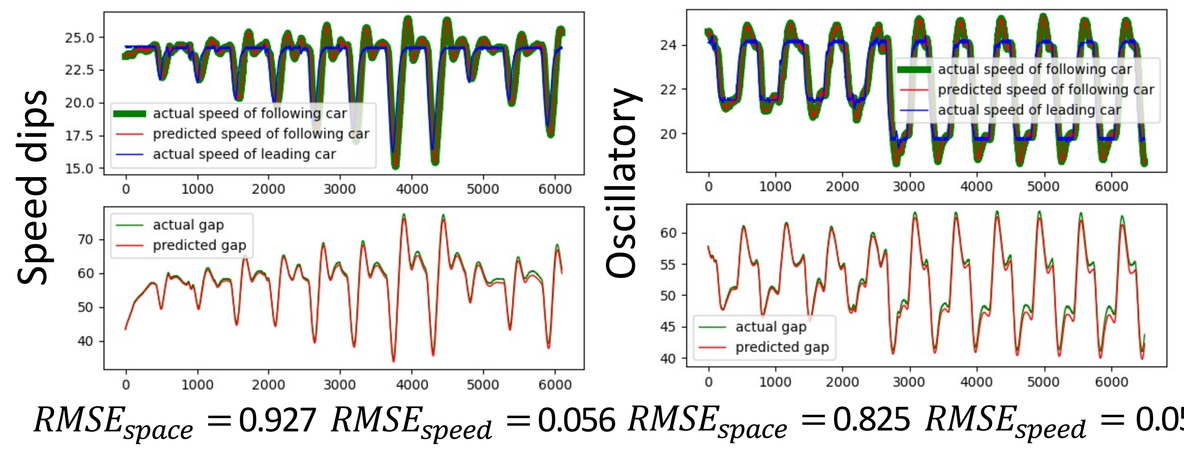
- Calibrated parameter set

	Parameters	Parameter range	Optimal values
k_1	gaining in position	[0,1]	0.00097
k_2	gaining in speed	[0,1]	0.18768
t_{hw}	desired time gap	[0,10]	2.93047

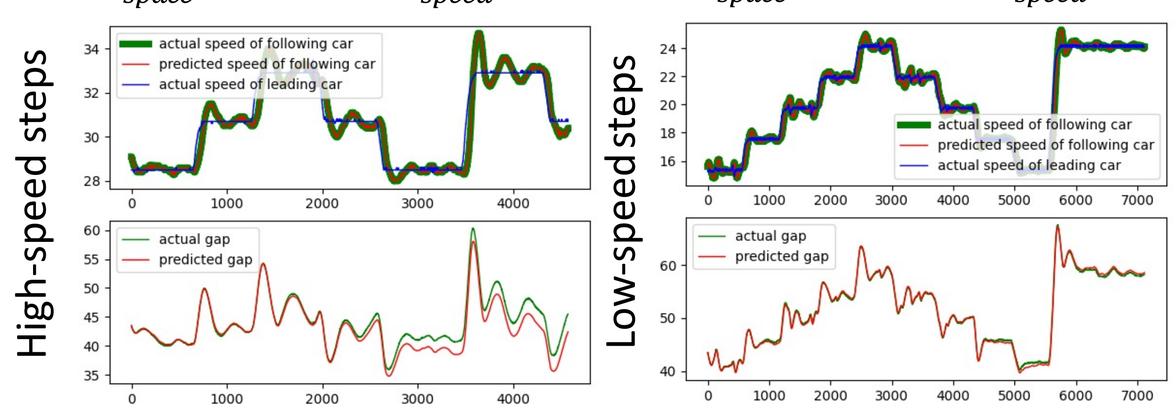
- Calibration and Validation Error
  - calibration:

$$RMSE_{space} = 0.996 \quad RMSE_{speed} = 0.056$$

  - validation:



$RMSE_{space} = 0.927$ $RMSE_{speed} = 0.056$ $RMSE_{space} = 0.825$ $RMSE_{speed} = 0.052$



$RMSE_{space} = 1.462$ $RMSE_{speed} = 0.037$ $RMSE_{space} = 0.329$ $RMSE_{speed} = 0.047$

- Cross-Validation
  - Repeat the experiment with Oscillatory case data as the training set.
  - The minimum RMSE of space (0.775) was obtained for $k_1 = 0.00097$, $k_2 = 0.36265$ and $t_{hw} = 2.89751$.

4. Summary and Future work

- The non-linear state-feedback control model with calibrated parameter set can effectively reproduce the real trajectory of ACC vehicle, which is **in accordance with the characteristics of the sag section**.
- It is acceptable and reasonable to choose the **speed dips data** as the training data to calibrate model.
- Future Work
  - Development of traffic simulator.
  - Proposal of the modified car-following parameter.
  - Verify the effectiveness of the improvement of congestion mitigation using the developed traffic simulator.