Estimation of Contact Condition between Wheel and Rail Using Instrumented Wheelset

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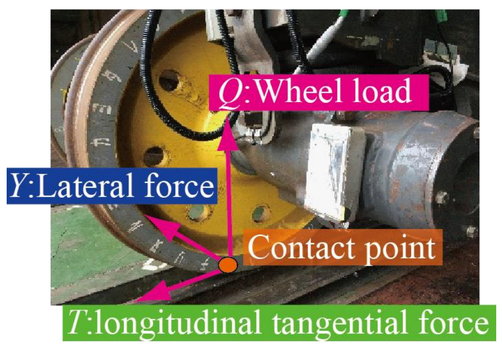
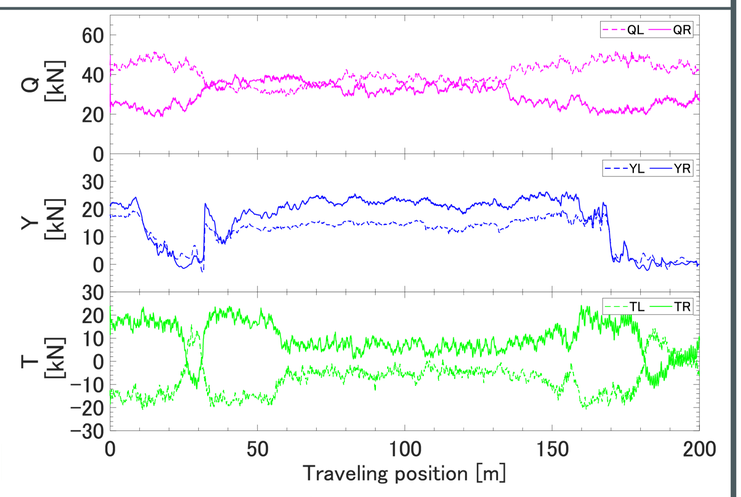
Introduction

An instrumented wheelset is widely used to evaluate running safety in railway vehicle. The instrumented wheelset can measure the contact forces acting on contact point between the wheel and the rail, namely wheel load Q, lateral force Y and longitudinal tangential force T. Using data measured by the instrumented wheelset, the method to estimate the contact condition is proposed for the evaluation of the running safety of the railway vehicle in passing the curve.



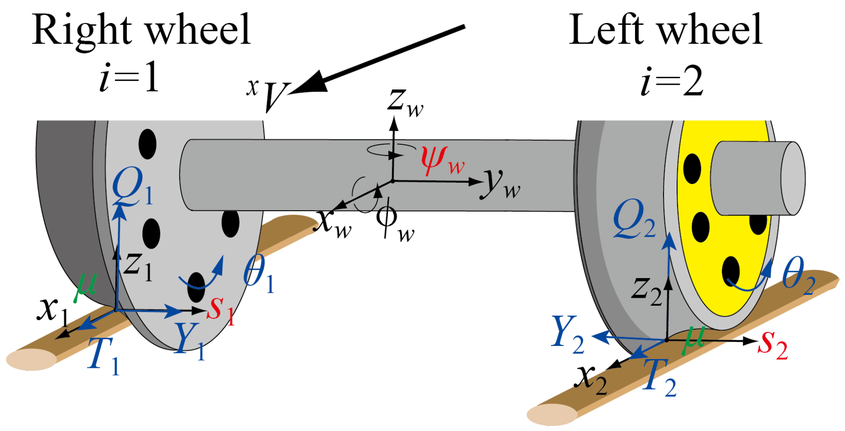
Instrumented wheelset

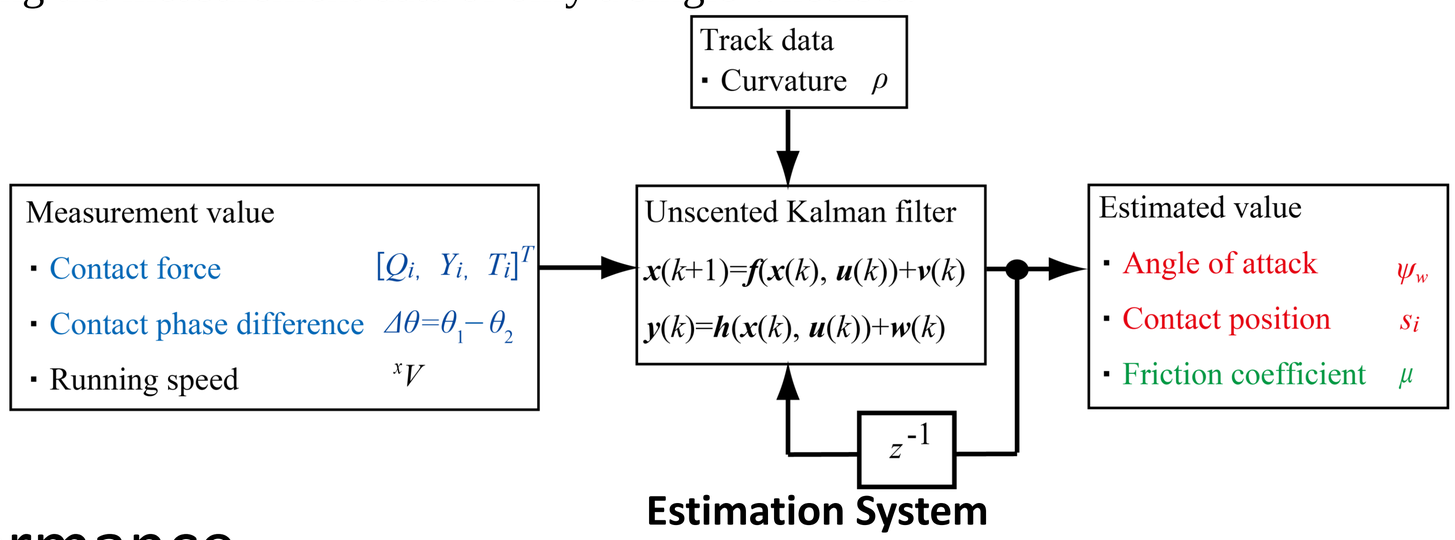


Example of measurement data

Method

- Observer is based on state estimation theory using a nonlinear single wheelset model.
- Input data: the contact forces (Q, Y, T), the contact phase difference $\Delta\theta$, the running speed ${}^{x}V$ and the track curvature ρ.
- Estimated values: the friction coefficient μ, the wheelset angle of attack ψ_w and the contact position s_i.
- This system can estimate the state values by using the measurement data of only a single wheelset.





Estimation System

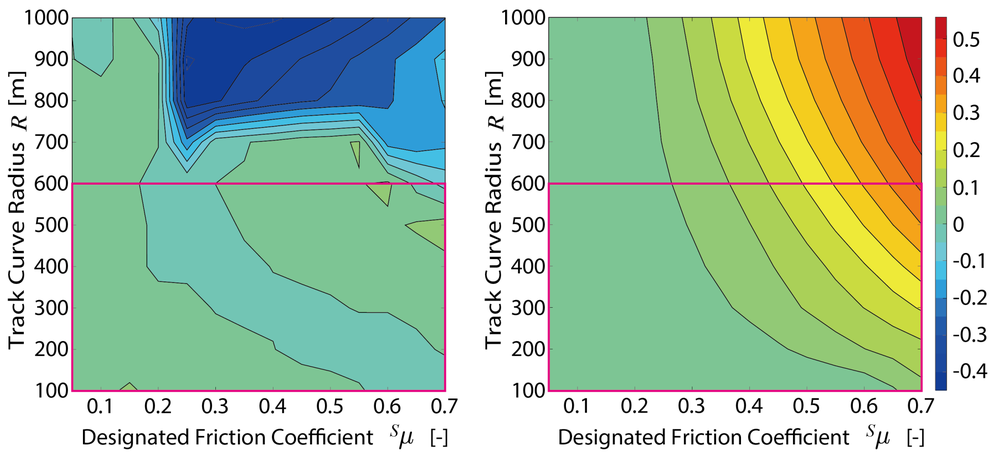
Evaluation of estimation performance

- Friction coefficient μ

To evaluate the proposed method, we conducted multitype simulation in passing the curve and generated mimicked measurement data under the following conditions:

- Track curve radius R varies from 100m to 1000m.
- μ varies from 0.05 to 0.70.

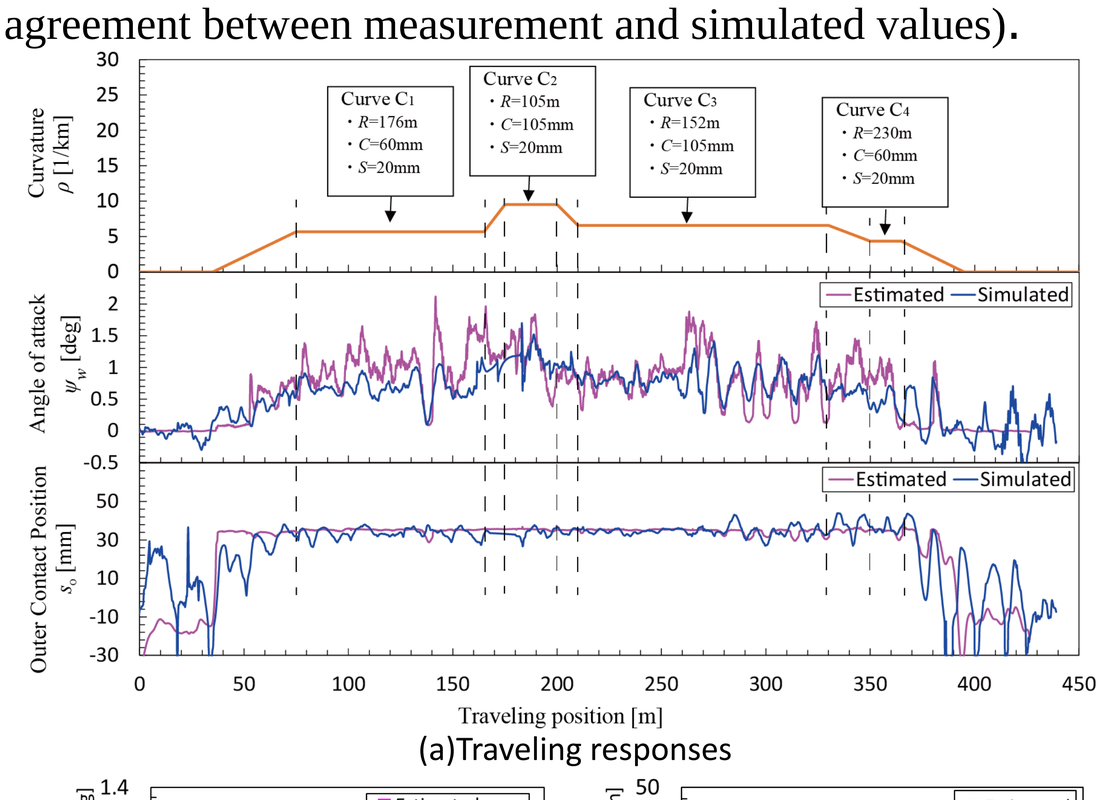
Estimated friction coefficient $\hat{\mu}$ calculated by the proposed method had good agreement for set value ${}^{S}\mu$ in simulation when R is smaller than 700m.



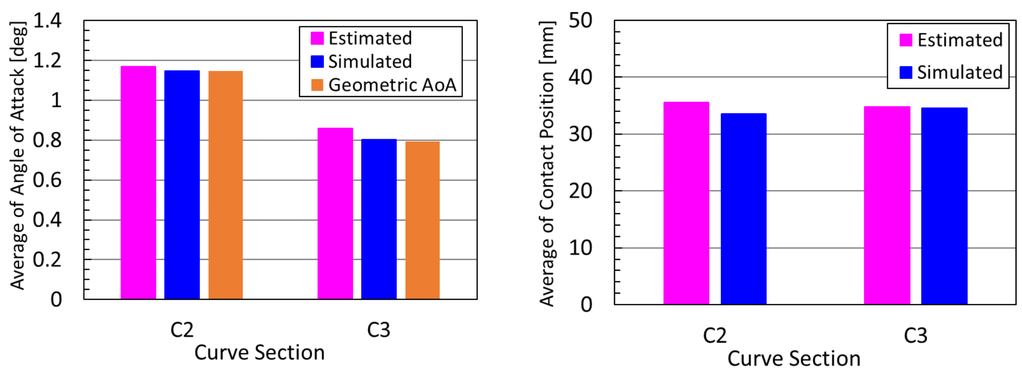
Average error of $\hat{\mu}$ in circular curve section

- Angle of attack ψ_w and outer contact position s_O

The proposed method is applied to running test data. For the comparison, the contact condition is calculated through the simulation reproducing the running state such as track irregularity. Estimated angle of attack $\hat{\psi}_w$ and outer contact position $\hat{s}_O$ are averagely similar to simulation results in the circular curve section C_2 and C_3(these sections obtained good agreement between measurement and simulated values).



(a)Traveling responses



(b) Average of ψ_w (c) Average of s_O

Comparison between estimated and simulated results

Publications

S. Kuniyuki, T. Hondo, M. Suzuki, T. Miyamoto and K. Nakano:“Improvement of estimation accuracy for wheelset angle of attack using a single-wheel creep-force model by taking into account contact phase difference and lateral contact position,” Proceedings of the Fifth International Conference on Railway Technology (Railways 2022), 8E.04, 2022.

S. Kuniyuki, T. Hondo, M. Suzuki, T. Miyamoto and K. Nakano:“Estimation Method for Friction Coefficient between Wheel and Rail by a Single-Wheel Creep-Force Model Using Measurement Data of Instrumented Wheelset,” Proceedings of the Dynamics and Design Conference (D&D 2022), 517, 2022 (in Japanese).

S. Kuniyuki, T. Hondo, M. Suzuki, T. Miyamoto and K. Nakano:“Performance evaluation of estimation method for wheelset motion using a single-wheel creep-force model with instrumented wheelset,” Proceedings of the 31st Conference on JSME Transportation and Logistics (TRANSLOG2022), TL1-4, 2022 (in Japanese).