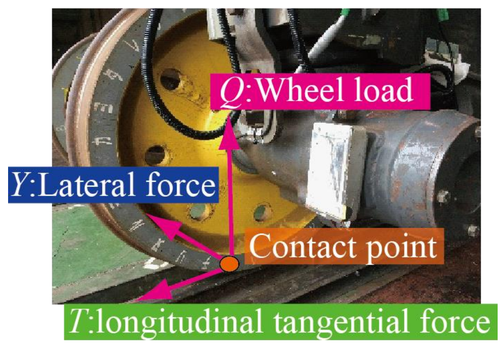
Estimation of Contact Condition between Wheel and Rail Using Instrumented Wheelset

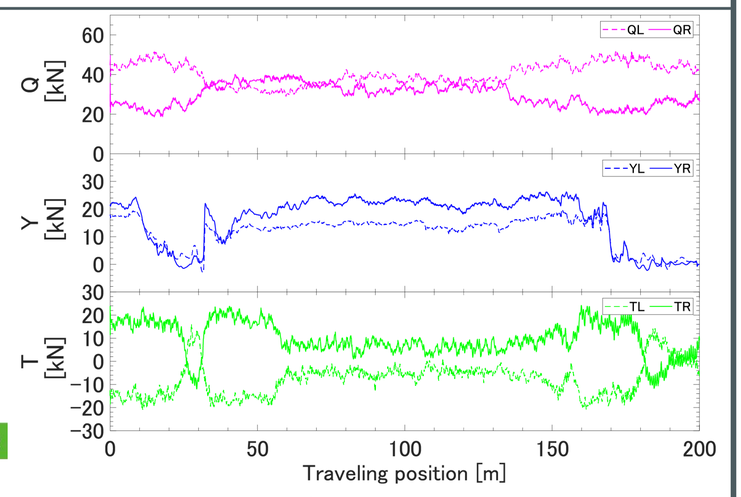
Partner: Railway Technical Research Institute

Introduction

Generally, running safety of railroad vehicles is evaluated by running tests with an instrumented wheelset called a PQ-wheel axle, which can measure vertical load P, lateral load Q, and front-rear tangential force T acting between the wheel and rail by a new continuous method. Aiming to improve the accuracy of running safety evaluation when passing through curves, a method to determine the contact condition between wheels and rails, which is difficult to measure, using the measured values of the instrumented wheelset is examined.



Instrumented wheelset



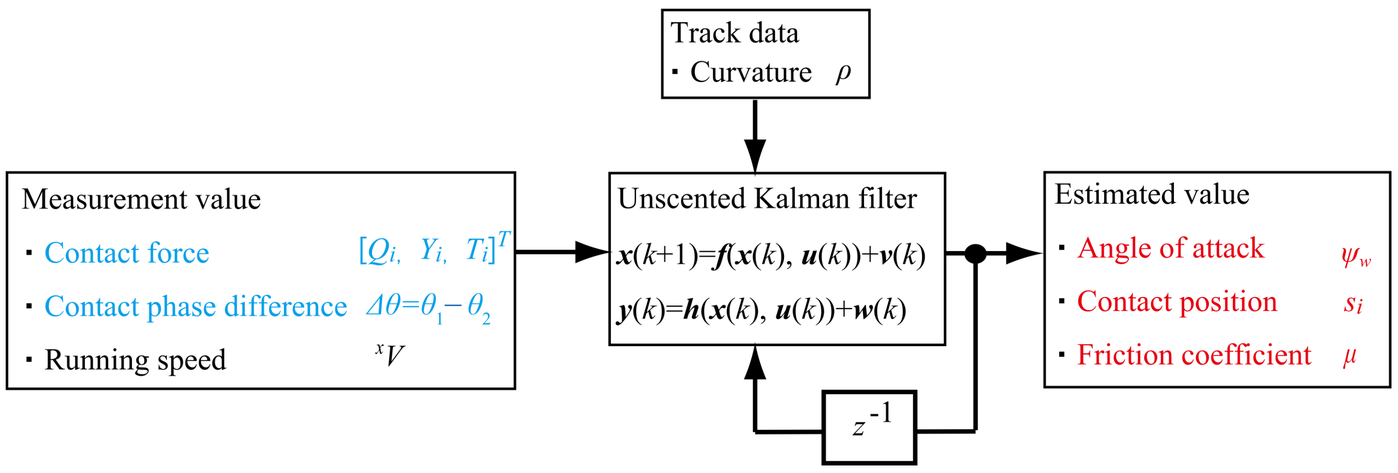
Example of measurement data

Method

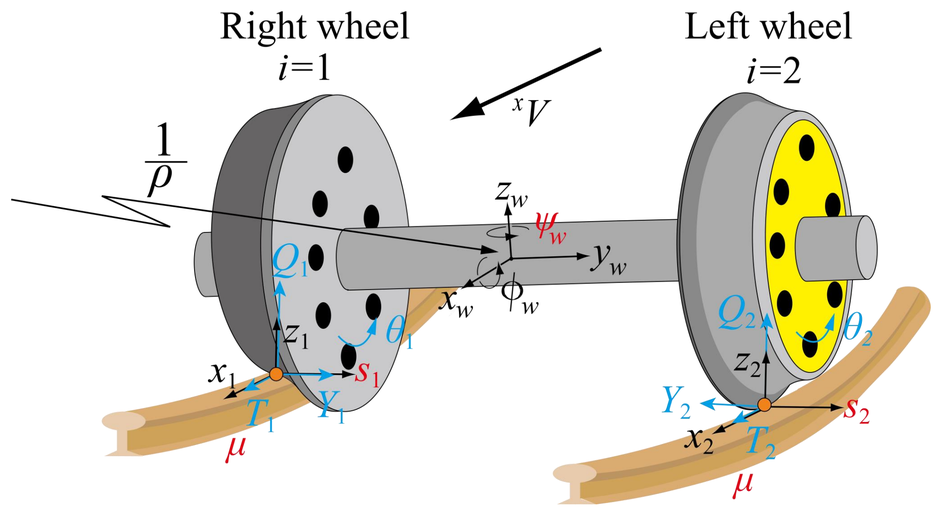
・Design observer based on state estimation theory using a nonlinear single wheelset model.

・Estimate the friction coefficient μ, the wheelset angle of attack ψ_w and the contact position s_i, which are related to climb derailment, using the contact forces (Q, Y, T), the contact phase difference $\Delta\theta$, the running speed ${}^{x}V$ and the track curvature ρ.

・These can be estimated using the date only measured on the single wheelset.



Estimation System

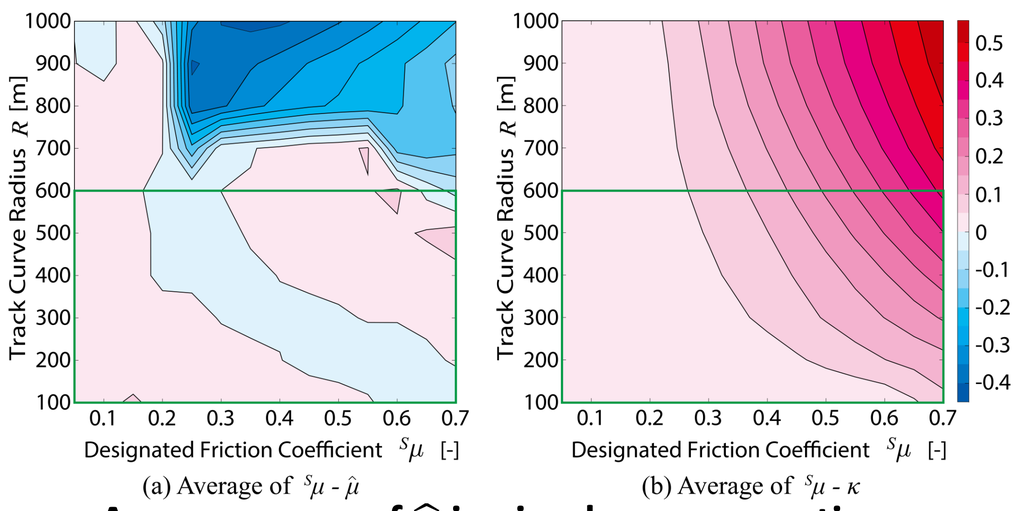


Model

Evaluation of estimation performance

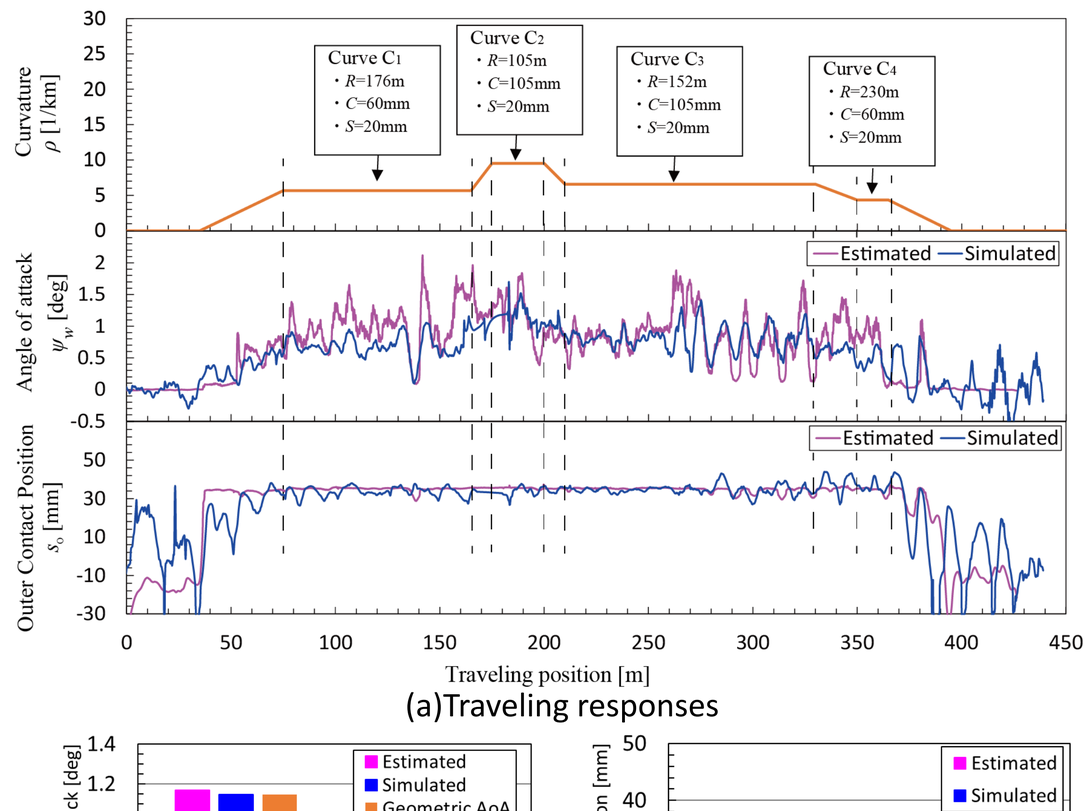
・Friction coefficient μ

The validity of the proposed method is examined through the numerical simulation where the vehicle travels in the several curved sections whose radius are 100-1000m, and the friction coefficient is 0.05-0.7. It is confirmed the error between the estimated friction coefficient $\hat{\mu}$ and the set value ${}^{S}\mu$ is smaller than that of the ratio of lateral force to the vertical load κ, in the curve section whose radius is 600m or less.



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

and $\hat{s}_O$ by the proposed method are close to the set values on average, indicating that the estimation is valid.



Comparison between estimated and simulated results

・Angle of attack ψ_w and outer contact position s_O

In order to compare the estimation results, contact conditions were calculated from numerical simulations. In the two circular curves (C_2 and C_3), where the measured data and simulation results were well matched, the estimated values $\hat{\psi}_w$

Publications

S. Kuniyuki, T. Hondo, and 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), 31.22, 2022.

S. Kuniyuki, T. Hondo, and M. Suzuki, T. Miyamoto and K. Nakano:“Method for estimating motion state of wheelset and wheel/rail friction coefficient by a single-wheel creep-force model in railway vehicle equipped with instrumented wheelset,” Transactions of the Japan Society of Mechanical Engineers (in press), 2024 (in Japanese).