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HILS System with Time Series Forecasting by Machine Learning Technique

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Abstract

HILS can be regarded as a kind of co-simulation technique that controls hardware components by real-time simulation based on measured data, and is widely used in automobile development. HILS needs to use the values from one step earlier when simulating with the data measured in the hardware section. In addition, delays occur during measurement due to communication between hardware and filtering of measurement signals. These factors reduce the accuracy and stability of HILS analysis. In this study, HILS based on time series forecasting using Long Short-Term Memory networks was investigated to reduce the effect of this delay. Experiments were conducted to evaluate the accuracy of the proposed method.

The experimental setup used in this study is shown in Figure 1. This experimental apparatus is a simplified version of an automobile suspension, consisting of an air damper, a spring, and a tire. The damper has nonlinear dynamic characteristics, and the measurement data of the damper force is used for a quarter car model simulation. The actuator for the road input is controlled according to the simulation result.

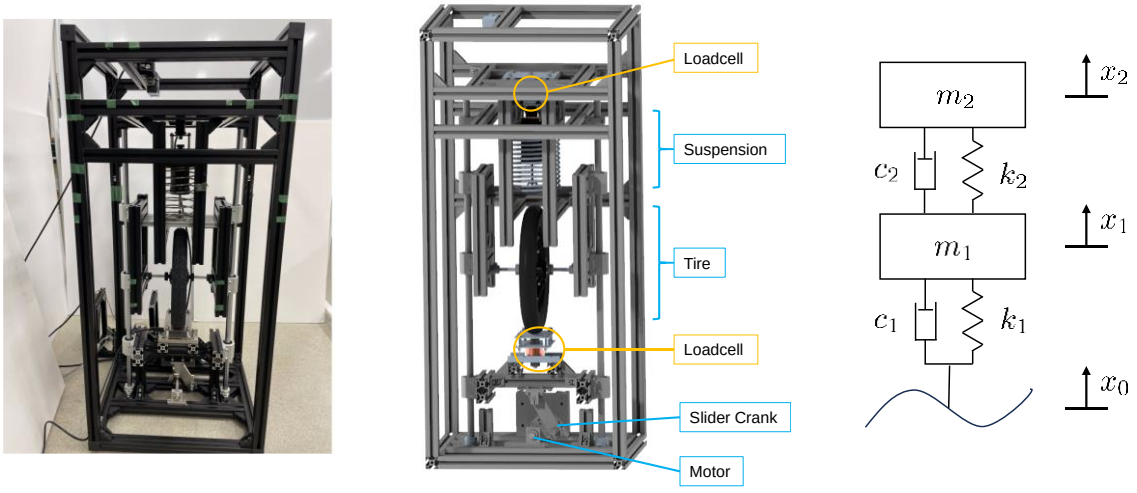
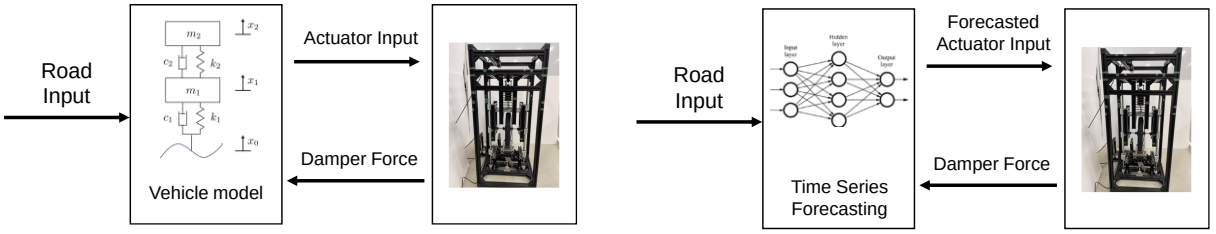


Figure 1: Experimental setup and quarter car model for HILS.

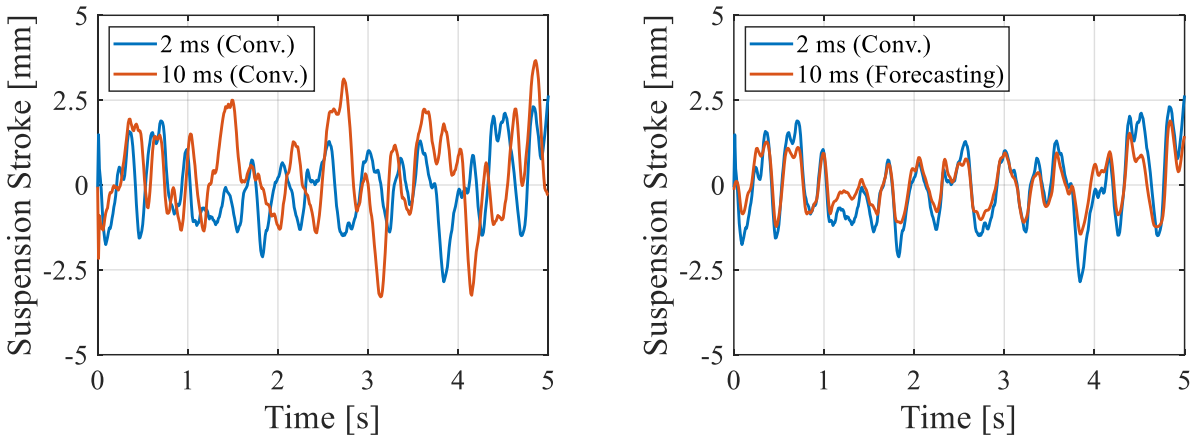
This HILS was originally operated with a step time of 2 ms. In this study, we attempted to extend the step time by generating a time series forecasting model for a quarter car model using Long Short-Term Memory networks. By using the time series forecasting model, it is possible to obtain future simulation result one step ahead. To compensate for the one-step time delay during simulation, the forecasting values are used to control the actuator for the road input (Figure 2).



(i) Conventional HILS (ii) HILS with time series forecasting

Figure 2: Concept of HILS system with time series forecasting.

Figure 3 shows the results. In conventional HILS, the analysis was performed using the measured value one step before. When the step time is extended up to 10 ms, the result differed from the result when the step size was set to 2 ms in conventional HILS. On the other hand, almost similar result was obtained by using of the time series forecasting even when the step time was set to 10 ms.



(i) Conventional HILS (ii) HILS with time series forecasting

Figure 3: Test results.

References

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