Master's Thesis

Modeling and Simulation of the Defects on Rail Wheels for Analyzing Vibration Signals

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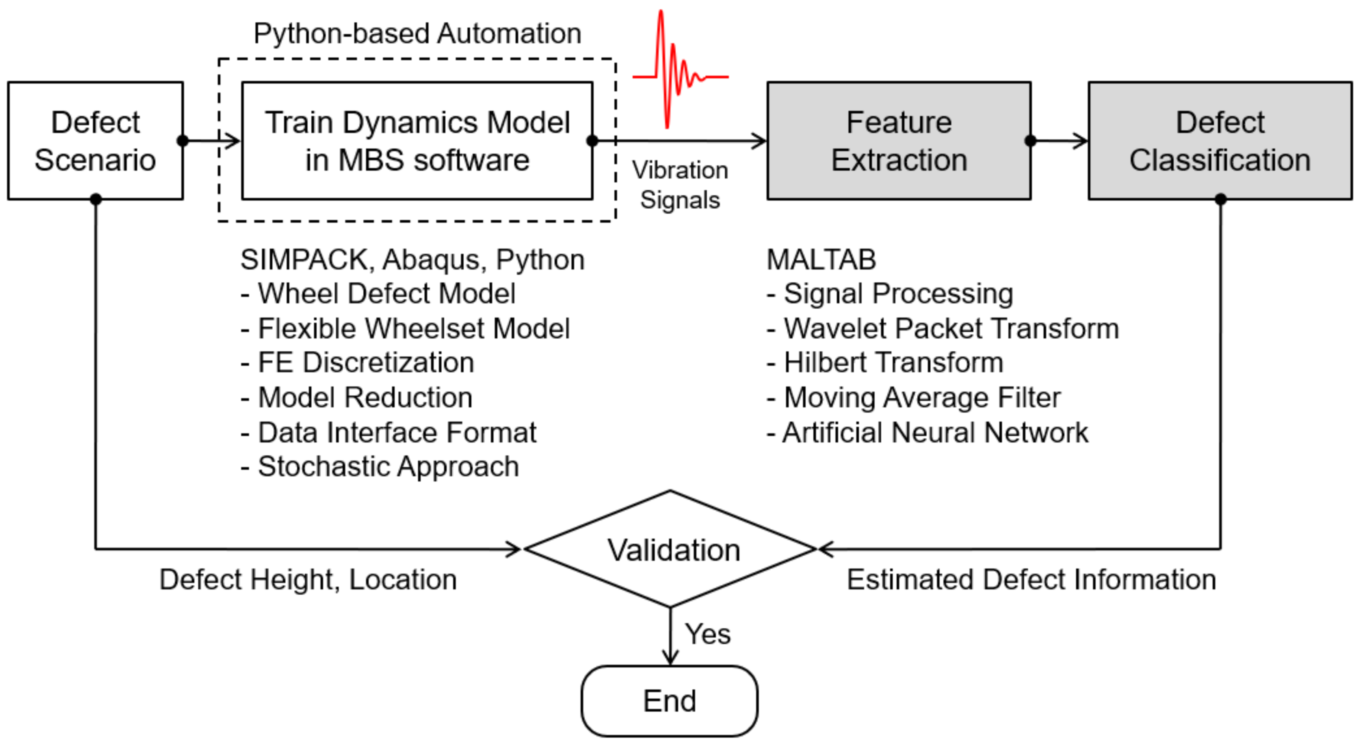
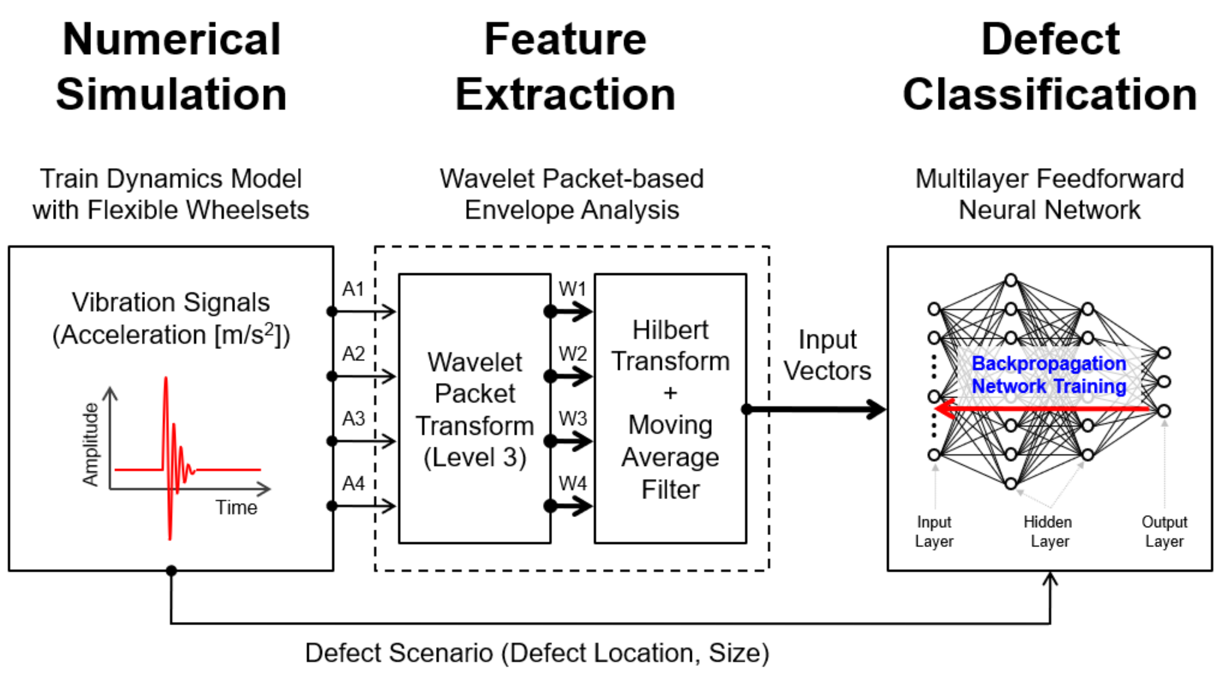
Abstract

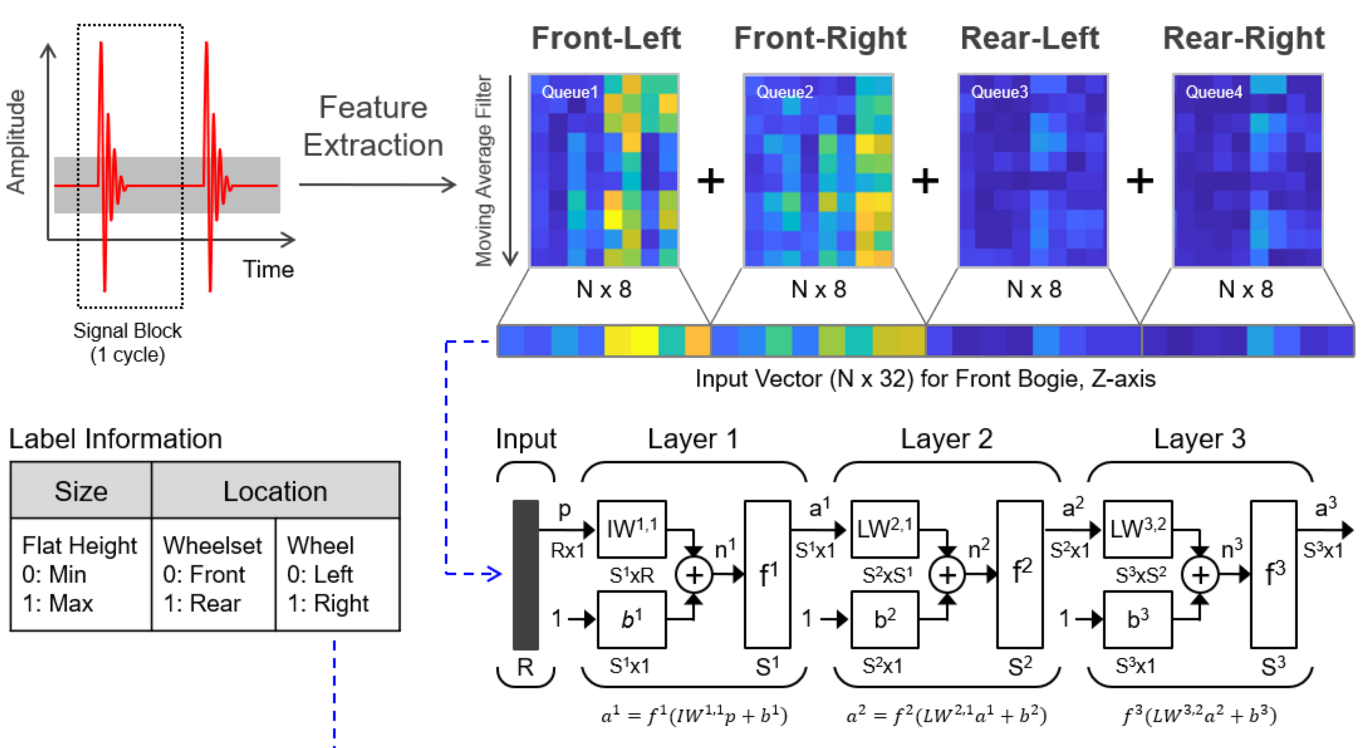
Structural health monitoring systems have been widely used in terms of safety, maintenance, cost, and performance of railway operations. This study aims to identify a single defect on wheel surfaces within the bogie by analyzing vibration signals obtained through stochastic simulation of train dynamics models and composes of two major parts: the modeling and simulation of defects on train wheels and the feature extraction and defect classification.

The first part reviews the existing train dynamics model that was created using SIMPACK Rail. Model improvements are realized in the following three aspects: FE discretization, model reduction and integration, and initial equilibrium problem, which help to reduce numerical errors and to reinforce theoretical basis for the reliability of train dynamics models.

The second part consists of the feature extraction technique and defect classification. The amplitude modulation in the envelope of vibration signals is assumed to have a close relationship with the dynamic behavior of wheels. Among various techniques, the combination of wavelet packet transform and Hilbert transform is chosen because it shows orthogonal changes of amplitude modulation on the binary tree structure while keeping the computational costs at the low level. The artificial neural network is used to model the nonlinear input-output relation between extracted features and defect information. It is shown in the application example that the flat height and location of a single defect on wheel surfaces within the bogie can be identified even though the operating condition is limited to a fixed speed condition.

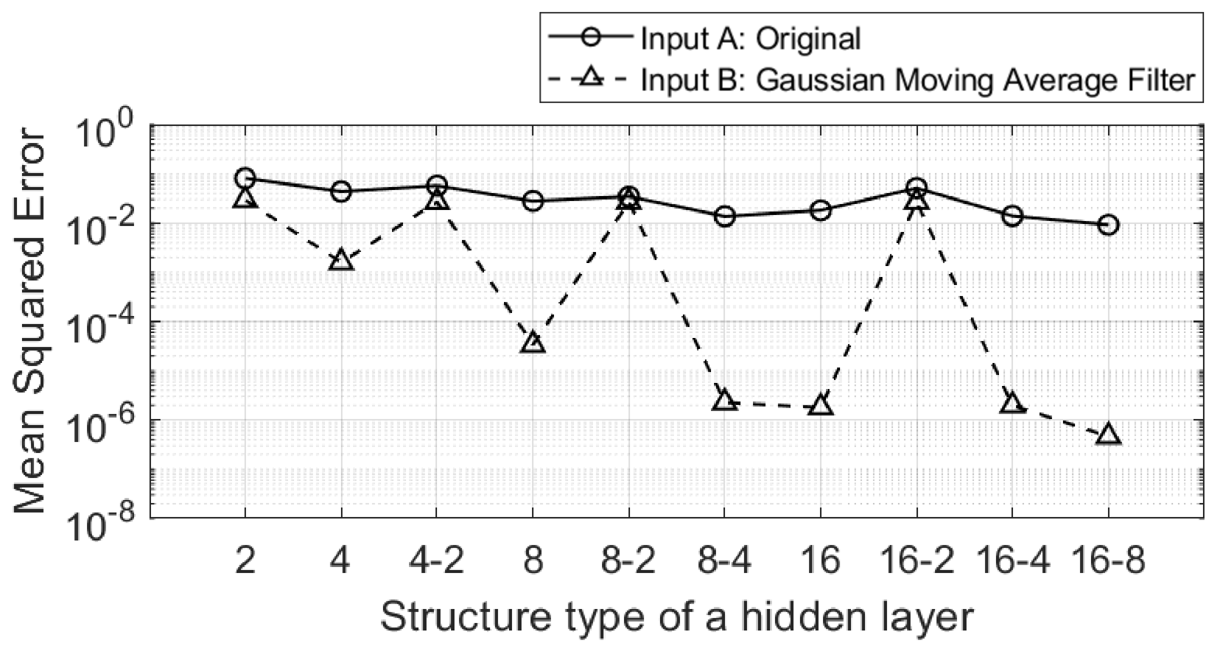






Size	Location	
Flat Height 0: Min 1: Max	Wheelset 0: Front 1: Rear	Wheel 0: Left 1: Right

$$y = a^3 = f^3(LW^{3,2} f^2(LW^{2,1} f^1(IW^{1,1} p + b^1) + b^2) + b^3)$$



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E-2019/09