基于 Wav2vec2.0 神经网络的轨道交通钢轨损伤压电阵列超声导波定位方法*

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摘　要　鉴于普通超声波检测方法无法实现对轨道交通钢轨的长距离检测，基于超声导波的 SHM（结构健康监测）技术难以从响应信号中提取损伤特征而影响损伤定位精度，提出了一种基于 Wav2vec2.0 神经网络的压电阵列超声导波定位方法对轨道交通钢轨损伤进行定位。基于压电阵列超声导波数据的特点，对该方法进行了简要介绍。搭建了钢轨损伤的超声导波检测系统，并利用该系统进行数据集的采集。采用 ABAQUS 有限元软件建立钢轨损伤超声导波检测三维有限元模型，并利用该模型进行数据集的采集。利用小波信号处理方法对超声导波试验信号进行重构，以达到信号去噪的目的；在仿真信号中加入随机噪声，将叠加随机噪声后的超声导波仿真信号作为补充数据集；通过计算模型中钢轨损伤定位的准确率和误差对模型的性能进行评估。结果表明，当迭代轮次达到第 120 次时，训练样本的准确率达到 100%。利用基于 Wav2vec 2.0 神经网络的压电阵列超声导波定位方法可实现轨道交通钢轨损伤的准确定位。

关键词　轨道交通；钢轨损伤；压电阵列超声导波定位方法；Wav2vec2.0 神经网络

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Piezoelectric Array Ultrasonic Guided Wave Locating Method for Rail Transit Rail Damages Based on Wav2vec2.0 Neural Network

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Abstract　Given that the common ultrasonic detection method fail to carry out long-distance detection of rail transit tracks and the SHM (structural health monitoring) technology based on ultrasonic guided waves has difficulty extracting damage features from response signals, affecting the accuracy of damage locating. A locating method using piezoelectric array ultrasonic guided wave-based on Wav2vec2.0 neural network is proposed for rail transit track damages. With reference to the characteristics of piezoelectric array ultrasonic guided wave data, this method is briefly introduced. An ultrasonic guided wave detection system for track damages is established and utilized for data collection. A 3D finite element model for ultrasonic guided wave detection of track damages is built using ABAQUS finite element software, and used to collect the dataset. Wavelet signal processing is applied to reconstruct the ultrasonic guided wave test signals for signal denoising; random noise is superposed to the simulation signals and the ultrasonic guided wave simulation signals with the superposed random noise are adopted as the supplementary dataset; the performance of the model is evaluated by calculating the accuracy rate and error of rail damage locating. The results show that when the iteration reaches the 120th round, the accuracy of the training samples reaches 100%. By adopting the piezoelectric array ultrasonic guided wave locating method based on Wav2vec2.0 neural network, the accurate locating of rail transit track damages can be achieved.

Key words　rail transit; rail damage; piezoelectric array ultrasonic locating method; Wav2vec2.0 neural network

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钢轨是轨道交通列车运行的基础，其服役状态直接影响列车行车安全[1]。超声波检测方法是一种广泛应用于钢轨探伤的无损检测技术，但该方法仅能以逐点方式对钢轨进行扫查，无法实现对钢轨的长距离检测。基于超声导波的 SHM（结构健康监测）技术作为一种主动监测技术，其往往将压电陶瓷作为激发器在被监测的波导结构中激发导波，并根据接收到的损伤响应信号判断损伤情况。但

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