Electric Vehicle Drivetrain Diagnosis Using Operational Transfer Path Analysis of Remotely Sensing Signals

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For the reliable operation of electric vehicles, fault detection in electric motors and gear systems is highly desirable. This can be achieved through the monitoring of vibration signals by using accelerometers placed on the rigid components of drivetrains. However, a challenge is that the drivetrains lack the accelerometers in the drivetrains. To address this limitation, this study presents a new approach for fault diagnosis of electric vehicle drivetrains, that employs remotely-sensing signals from accelerometers beneath the driver's seat. An operational transfer path analysis (OTPA) is conducted to determine the critical transmission routes originating from the vibration source (i.e., drivetrain) to the vibration receiver (i.e., driver's seat). In this study, OTPA accounts for transition points including the shock absorber mount, subframe mount, and motor/reducer mount. A denoising deep learning model is used to convert the vibration signal recorded at the driver's seat, through these transition points, into a representation of the vibration from the source. Then, a diagnostic deep learning model is used to classify the faults using the converted synthetic vibration signals that mirror the real-world vibration signals captured at the source location (i.e., drivetrain). A comprehensive case study is conducted to evaluate the validity of the proposed approach. The experimental results show that the proposed approach that incorporates OTPA of remotely sensing signals is effective in the fault diagnosis of electric vehicle drivetrains.