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Algorithm development for out-of-roundness detection in railway vehicles

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INTRODUCTION

The increasing demand for rail transportation has resulted in elevated axle loads, thereby subjecting train wheels to adverse conditions. This presents numerous challenges, including operational interruptions, escalated expenses, infrastructure deterioration, and, in severe cases, the potential for derailments. To address these concerns, railway operators have proposed advanced maintenance programs to swiftly detect defects. Their objective is to minimize long-term expenses, guarantee safety, and uphold overall stability in rail operations.

OBJECTIVES

The objective of this research is to identify wheel flats and polygonal shapes on railway vehicle wheels by employing envelope spectrum analysis [1-3], with wayside monitoring system. The investigation involves conducting simulations to evaluate various types of wheel flat profiles and periodic out-of-roundness harmonic orders for polygonal wheels. These simulations are compared to reference simulations conducted on undamaged wheels. The simulation incorporates different track irregularity profiles and uses the in-house software VSI—Vehicle-Structure Interaction Analysis [4,5] to simulate the dynamic interaction between the train and the tracks. Numerical calculations are performed to assess the dynamic responses of strain gauges and accelerometer sensors positioned on the rail between sleepers. In order to analyze the methodology, the defective wheel under consideration is the right wheel of the first wheelset.

RESULTS AND DISCUSSION

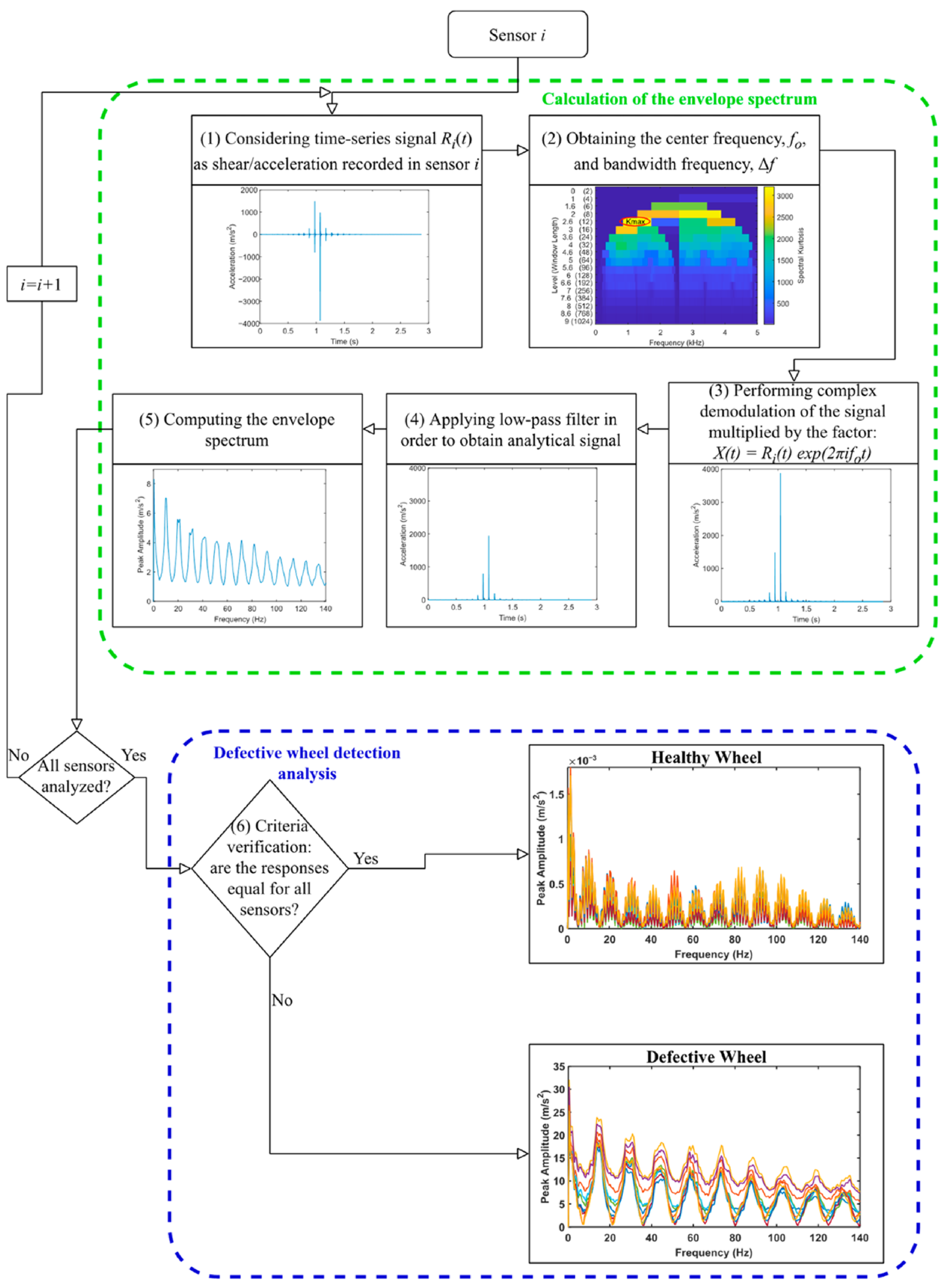
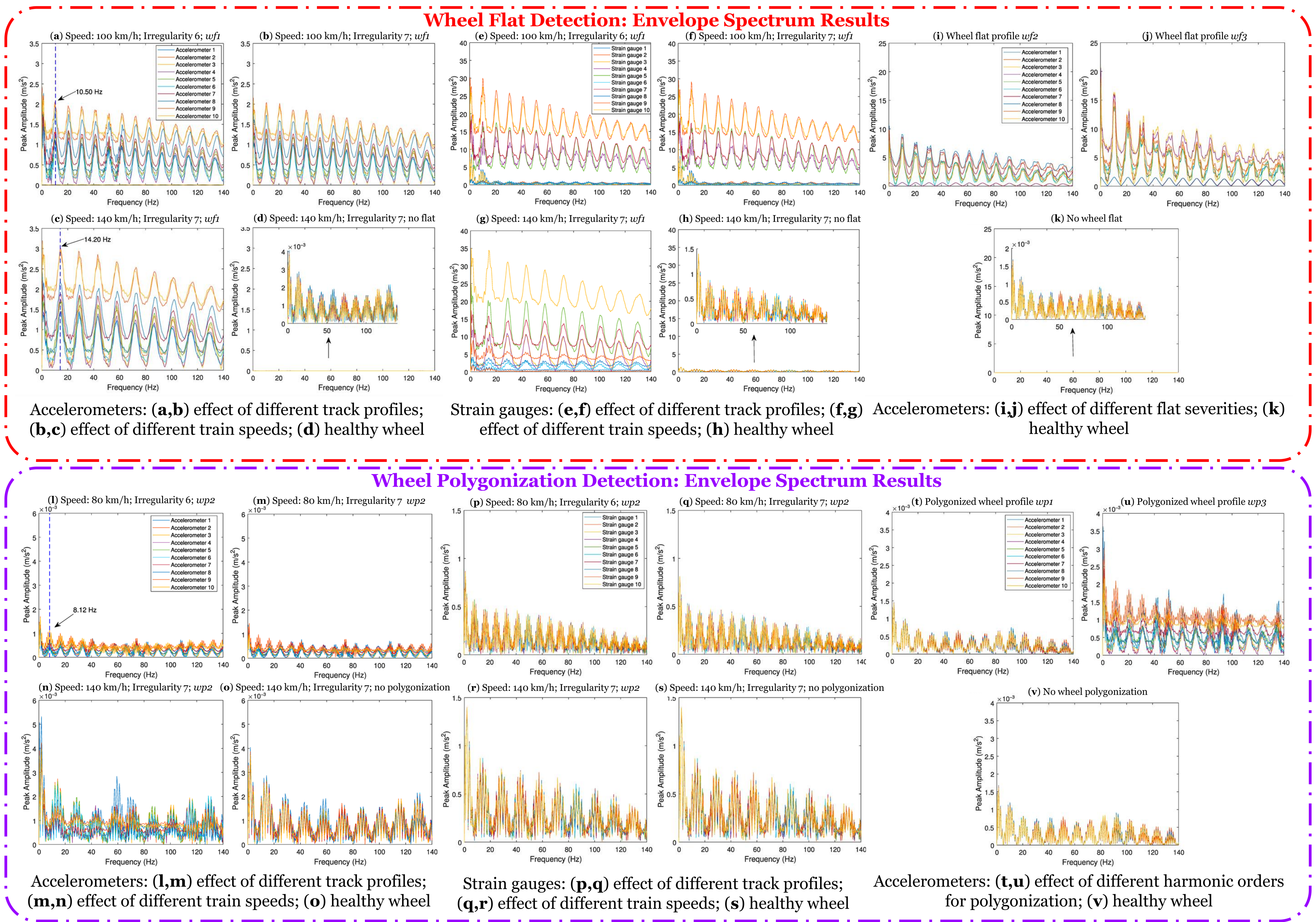


Diagram of the methodology for out-of-roundness wheel defect detection



The presented methodology demonstrates the capacity to detect wheel flats across various track unevenness profiles, train speeds, and flat severities by utilizing both accelerometers and strain gauges. The presence of a flat is indicated by signal response lag and higher peak amplitude values. In the case of polygonized wheels, only accelerometers are capable of detecting this specific type of wheel defect. This detection is achieved by considering different track irregularity profiles, train speeds, and harmonic orders for polygonization. Signal response lag serves as the sole indicator for detecting wheel polygonization using this methodology. The detection of wheel defects remains unaffected by track irregularity, while higher train speeds and more severe wheel defect profiles enhance the detection capabilities of the methodology.

CONCLUSION

The findings obtained by implementing the methodology demonstrate the successful differentiation between a healthy wheel and a defective one using envelope spectrum analysis. To further refine the proposed approach, the utilization of deep learning algorithms presents an effective means of detecting wheel defects with the sensing data or envelope spectrum, as well as validating the methodology in an actual real-world scenario.

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