Railway Track Vibration Analysis and Complexity Assesment Based on H-ranks

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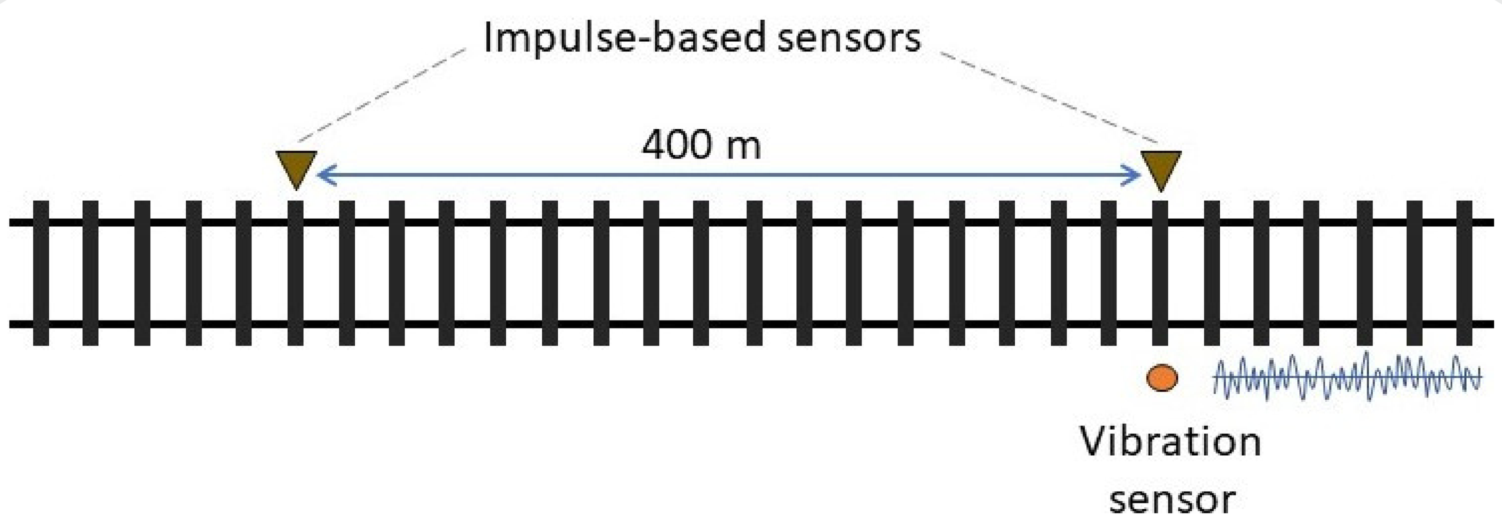
This study presents a method for early train prediction using track vibration signals and H-rank-based algorithms. It outperforms standard train detection systems, providing advanced warning of approaching trains. Experimental data from diverse train types and speeds is used, and the algorithms are robust against noise and challenging environmental conditions.

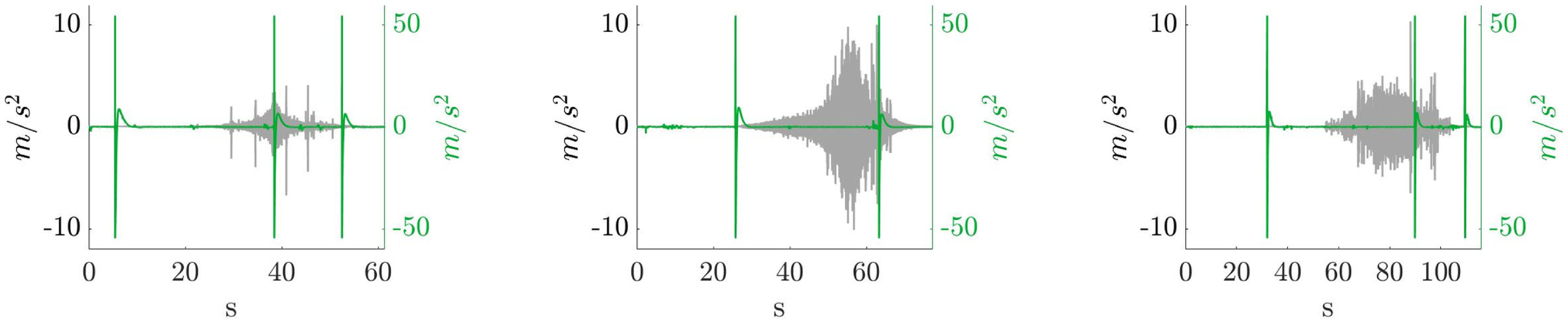


H-rank computation

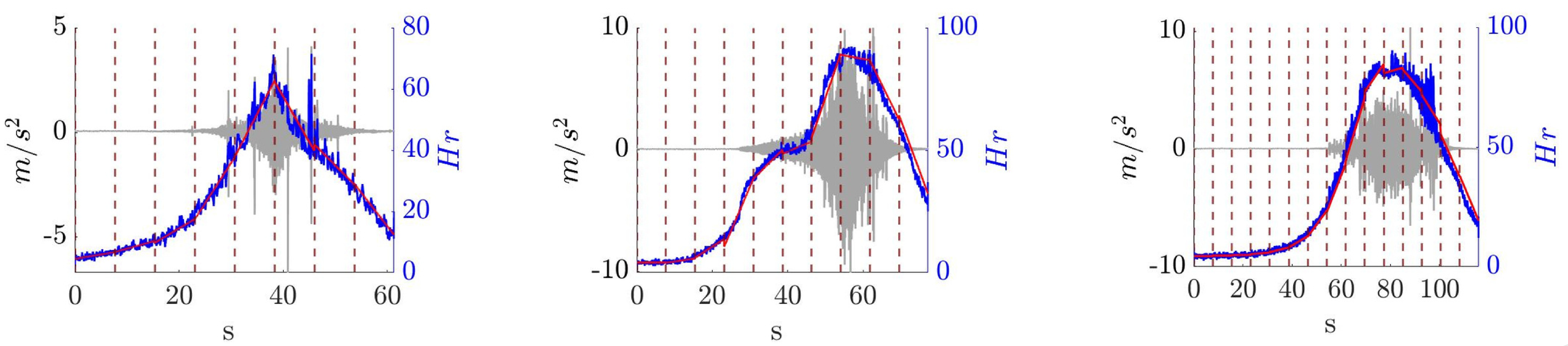
$$(x_k)_{k=1}^{+\infty} \longrightarrow H_k = \begin{bmatrix} x_1 & x_2 & \cdots & x_k \\ x_2 & x_3 & \cdots & x_{(k+1)} \\ \vdots & \vdots & \ddots & \vdots \\ x_k & x_{(k+1)} & \cdots & x_{(2k-1)} \end{bmatrix}$$

$$\text{H-rank}(H_k) = \sum_{l=1}^{k} 1(\sigma_l^2 \geq \varepsilon)$$

Track vibration data



Reconstruction of slope coefficients of H-ranks from track vibration signals



The developed approach for train prediction through advanced vibration signal processing excels in its extended detection range and independence from existing rail traffic control systems, increasing the reliability of railway safety and control systems and offering significant implementation potential