



KEYNOTE LECTURE:

Onboard monitoring for intelligent assessment of railway tracks

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Dr. Abdollah Malekjafarian is an Associate Professor in the School of Civil Engineering at University College Dublin (UCD), where he leads the Structural Dynamics & Assessment Laboratory (SDA-Lab). His research focuses on vibration-based structural health monitoring, with particular expertise in onboard/drive-by monitoring for railway track inspection, drive-by methods for bridge monitoring, and the application of artificial intelligence and machine learning to large-scale transport infrastructure systems.

Dr. Malekjafarian has published over 82 peer-reviewed journal articles in leading international journals and more than 90 conference papers. He has an h-index of 30, reflecting the strong impact of his research in structural dynamics and intelligent infrastructure monitoring. His work has been supported by over €3 million in competitive funding from European and national research agencies. He is also a member of Young Academy Ireland and serves on the Bridge Structural Health Monitoring Committee of IABMAS. He is currently a member of the editorial boards of several international journals, including *Engineering Applications of Artificial Intelligence*, *Shock and Vibration*, *Discover Energy*, and the *Journal of Vibroengineering*.

Abstract: Track geometry is one of the critical indicators of railway tracks' condition which requires continuous monitoring and maintenance over time. Onboard monitoring has emerged as a scalable and cost-effective alternative to conventional railway track inspection methods. By leveraging vibration responses collected from sensors installed on in-service trains, it enables continuous and network-wide assessment without the need for dedicated track recording vehicles. However, practical implementation remains challenging due to noise contamination, environmental and operational variability, class imbalance, and distribution shifts between different railway lines.



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This keynote presents a synthesis of our recent research on data-driven frameworks for railway track geometry monitoring using onboard acceleration data. The talk will discuss the development of unsupervised anomaly detection models based on feature engineering and one-class learning for geometrical defect identification, hierarchical classification strategies designed to mitigate bias introduced by imbalanced datasets, and supervised approaches for detecting track maintenance needs. Particular emphasis will be placed on recent advances in unsupervised domain adaptation, which enable the transfer of diagnostic models across multiple railway lines without requiring labelled data from new tracks. The results demonstrate that AI-enabled onboard monitoring systems can achieve high defect detection accuracy while maintaining robustness and transferability under varying operational conditions. These advances highlight the potential of intelligent drive-by monitoring to support scalable, data-driven railway asset management at the network level.