DEVELOPMENT OF AN INTEGRATED REAL-TIME SCOUR MONITORING SYSTEM USING AI-POWERED CAMERAS, FLOW VELOCITY SENSORS, AND GEOPHYSICAL DETECTION TECHNIQUES

ABSTRACT This research is developing an integrated real-time scour monitoring system using artificial intelligence (AI) powered cameras, flow velocity sensors, and geophysical detection techniques to continuously analyse visual and numerical data to detect sediment displacement and potential structural movement. Flow velocity sensors provide critical hydrodynamic data to assess scour potential by using measured velocities at bed level to calculate a threshold value for bed load transport using Shields Equations. Additionally, a geophysical-based detection method, such as ground penetrating radar (GPR) or electrical resistivity tomography (ERT), enables subsurface characterization of sediment layers and void formation as well as detecting real time movement of the bed around the asset.

The system utilizes data fusion and machine learning algorithms to process multi-sensor data to create a digital twin, enhancing the accuracy and reliability of scour detection by correlating visual, hydrodynamic, and geophysical inputs.

Real-time monitoring enables early warnings and predictive insights, reducing the risk of catastrophic failures. Field deployments and laboratory-controlled experiments have validated the system's effectiveness in various flow and sediment conditions with the field trails carried out on 3no. Network Rail assets. The integration of AI-driven analytics with geophysical and hydrodynamic data offers a novel, robust approach to scour detection, which improves infrastructure resilience and safety. This research contributes to the advancement of smart monitoring systems and allows Network Rail to transform from a reactive, manual inspection regime to a more predictive and proactive approach that benefits the railway, the engineering community, and the wider traveling public.