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TOWARDS A SAFE MACHINE LEARNING-DRIVEN CONTINUOUS TRACKSIDE TRAIN LOCALIZATION SYSTEM BASED ON FIBER OPTIC SENSING

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Summary: Control command and signalling (CCS) systems for railway operations are an active research area for potential machine learning (ML) applications. One such application is the train integrity and track occupancy detection based on fiber optic sensing system (FOS-System). As the ML models used in such applications are applied in CCS systems to control safety-relevant system functions, they should be trustworthy and, more importantly, safe. However, due to their opaque decision-making processes, ML-based systems are challenging to prove safe according to existing methods (such as the CENELEC standards). To address this limitation, this paper derives relevant measures to apply ML models in CCS systems. The focus in this paper is on the use-case track occupation detection. First, the paper contains a risk analysis at the railway system level considering the system definition and the defined requirements for the FOS-System. Second, a Failure Mode and Effects Analysis (FMEA) on the system level based on the first step lists potential hazards. A heuristic method generates a list of failures of the FOS-System component, focusing on potential ML-based failures in the training and inference phase that may cause hazards. The paper then proposes appropriate measures to eliminate the mentioned hazards to a harmless level based on the FMEA. Finally, it proposes a Context-Aware Safety Envelope Monitoring Subsystem and performs a plausibility check considering the context while monitoring the safety envelope. Our proposed safety envelope employs physics-based rules and, is, therefore, deterministic. As a result, it can be validated with established norms, such as EN 50126 or 50128.