AI-Based Real-Time Video Surveillance of Stuck Vehicles and Debris on Railway Grade Crossings

Deliverables and Reporting Requirements for UTC Grants Awarded in 2023 (June 2023)

Exhibit D

Recipient/Grant (Contract) Number: University of Texas Rio Grande Valley (UTRGV)/Grant No. 69A3552348340

Center Name: University Transportation Center for Railway Safety (UTCRS)

Research Priority: Artificial Intelligence and Machine Learning, Networked Sensors and Sensing

Principal Investigator(s): Gasser Ali (PI, UTRGV), Sergei Chuprov (Co-PI, UTRGV), Li Ai (Co-PI, UTRGV), Constantine Tarawneh (Co-PI, UTRGV)

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Research Project Funding: $200,864 (Federal), $83,303 (Non-Federal Cost Share)

Project Start and End Date: 09/01/2026 to 12/31/2027

Project Description: Rail grade crossings are inherently dangerous due to the risk of collision between vehicles and trains. Although there are many safety measures for safety at crossings, there is still a need to find more innovative methods to improve safety. Previous research has investigated many methods such as Light Detection and Ranging (LiDAR), radar, computer vision, and many others. Previous research by the proposing team has investigated the use of Deep Learning (DL) to identify hazards in images from video feeds, and to track vehicles passing over grade crossings. However, there is a need for a robust DL method for video feeds as opposed to independent frames. In this proposal, a multi-model image processing approach is proposed to identify vehicles that are stuck on the grade crossing for extended time. The method will involve multiple models to (1) dynamically identify the “Zone of Interest” (ZOI) in any crossing while considering possible camera movement; (2) track individual vehicles passing over the crossing using object detection and tracking; (3) evaluate the movement of vehicles in the ZOI and raise an alert if the vehicle is stuck; and (4) perform anomaly detection to identify unexpected physical objects, such as debris, that might appear at the grade crossings. The method will only rely on video feeds from regular cameras. The team will further test the model on a Graphics Processing Unit (GPU)-enabled edge computing device, namely an Nvidia Jetson or similar one. The outcomes of this research are twofold: (1) in the immediate term, the software tool will be able to monitor crossings and send alerts that may be used by other systems; and (2) in the long term, the data logs of incidences can be used for further processing to identify dangerous crossings which can lead to further research on grade crossing design and safety policies.

US DOT Priorities: SAFETY: 1.2 Reduce surface transportation-related fatalities and serious injuries. SAFETY: 1.4 Develop improved safety management systems across transportation modes. INNOVATION: 3.3 Invest in transformative technologies

Outputs: The expected products include:

1. AI-enabled software tool for real-time monitoring and other unexpected physical objects detection on grade crossings.
2. A GPU-enabled hardware prototype for edge computing that deploys the developed software tool.
3. Dataset of collected videos at grade crossings.
4. Documentation that includes user guides and manuals, source code and report with empirical validation results and deployment recommendations.
5. Research publications for dissemination with the stakeholders and the broader rail community.

Outcomes/Impacts: The primary impact of the research is providing a framework that contributes to improving safety at railway crossings. The research will have impacts beyond this specific goal. **Industry Impact:** The model can be used by rail operators to monitor grade crossings and automatically detect stuck vehicles and debris, for immediate safety actions. Deploying this solution will safeguard human lives and will yield significant economic benefits by mitigating financial losses associated with infrastructure damage and emergency response. Furthermore, preventing unexpected train delays ensures a more reliable and cost-effective supply chain. The data from the monitoring will also allow further research to identify and improve problematic crossings. **Educational Impact:** The project will educate students on advanced methods for AI in computer vision. The students will be directly involved in the development of the AI models under the supervision of the PIs. The students will also be exposed to the needs of the rail industry as related to safety.

Final Research Report: Upon completion of the project, a URL link to the final report will be provided.