<u>Measure Name:</u> Risk assessment using Closed-Circuit Television (CCTV)

<u>Definition:</u> Use CCTV to review crossing warning devices violations and close call incidents to better understand the actions of individuals in the moments before a strike or near miss.

<u>Tags:</u>

Type of Incident:

☐ Non-Motorized Users Only
☐ Motor Vehicles Only
☒ Both

Intervention Strategy:

☒ Data: application and planning
☐ Education: outreach and messaging
☐ Enforcement: policy development and rulemaking
☐ Engineering: technological and physical deterrents

Type of Problem:

☒ Non-Motorized Users Violating Warning Devices
☒ Motor Vehicles Violating Warning Devices
☒ Vehicle ROW Incursion
☒ Vehicle Congestion
☒ Blocked Crossing
☒ Vehicle Hang-up

Measure Category:

☒ Risk Assessment
☐ Policy and Enforcement
☐ Collaboration, Training, and Education
☐ Public Communication
☐ Physical Barriers
☐ Detection and Lighting
☐ Infrastructure Modification
☐ Post-Incident Management
☐ Warning Devices

Description

This measure refers to the use of CCTV detection systems to collect crossing warning device violations and close call incidents data. The U.S. Department of Transportation (DOT) Accident Prediction and Severity (APS) model is commonly used by federal, state, and local agencies to assess accident risk at highway-rail grade crossings. The APS model was developed based on crossing characteristics and past accident data. Since the frequency of crossing incidents is relatively small, close call observations and grade crossing violations data can help improve APS model.

CCTV detection systems can monitor an area for unauthorized access. Grade crossing violations and close call incident data can be gathered by manually reviewing CCTV videos or using more advanced technology for detection such as artificial intelligence (AI). An AI system relies on a computer vision algorithm to review the video footage and detect the presence of a vehicle or person trespassing during a crossing activation. The system can output the close call incidents and violations into a table as well as automatically activate an alert to deliver a pre-recorded warning via loudspeaker, as well as send live alerts to railroad personnel or local law enforcement.

CCTV detection is most effective in a targeted area with a high concentration of trespassers, such as a footpath across a track, bridge, or tunnel [1]. This measure may also be effective at known suicide hotspots. For an intelligent CCTV system to be effective, it should activate in every instance where an individual is trespassing while minimizing activations in other circumstances (e.g., the wind blowing debris across the track). This is especially true for detection systems integrated with police dispatch, as excessive false alarms could result in alarms being muted [2].

One example for a successful setup of a detection system includes three cameras, each streaming live over the Internet, with one at a grade crossing and two at railroad ROWs. This setup allows quick detection and alerts that can be sent to the railroad carrier or local law enforcement by text message or email [3]. There is also the potential for AI algorithms to detect behaviors that may indicate that someone is in distress or at imminent risk for suicide [4].

Additional search terms: *camera, recordings, surveillance, videos*

Advantages

- AI algorithms have been shown to detect trespassing events and achieve near perfect accuracy in some settings. [3]
- Two short-term studies found reductions in trespassers from 18 percent to 60 percent. [1][5]
- An AI-aided CCTV detection system can collect vehicle and pedestrian exposure at a crossing as well as their pathing movement across the crossing.

Drawbacks

- Specialized knowledge is needed to setup and maintain an AI system.

- Strong processing power is needed to support video in real time.
- Access to a high-speed network is required for the most advanced CCTV systems to work reliably. [3]
- Much of railroad ROW lacks easy access to commercial power. Battery powered systems need to be considered and maintained regularly. [1]
- Example of crossing violations are required to train the AI system.
- In some locations, existing cellular infrastructure is insufficient to provide uninterrupted high-definition video from multiple cameras. [2]
- Law enforcement officials may have a low tolerance for false alarms and mute the alarms if they became too frequent. [2]
- Yearly operation and maintenance cost of a system can exceed the initial cost of implementing the system. [1][2]

Notable Practices

- For intelligent systems, the AI must be able to accurately detect violations under a wide variety of conditions (video artifacts, shadows, and other distortions), and environmental variables (e.g., rain, snow, day, night, and fog). [3]
- For intelligent systems, the AI must be able to process frames with sufficient speed to maintain a fast response time to trespassing events. [3]
- Installing "backup or redundant components, such as an extra sensor, could be used temporarily in case the primary sensory component failed". [5]
- Install a mechanism to disable the warning notice during maintenance of track by authorized personnel. [5]
- Ensure that the broadband connection enables constant live surveillance and instantaneous alarm notification. A lag in video feed relative to when the sensors detect an intruder could lead to a trespass event being categorized as a false alarm. [5]
- Develop an operation and maintenance plan for addressing a range of situations, including positive detection of intruders or obstacles in the ROW, or failure of the warning system. [5]

References

[1] Kallberg, V.P, & Silla, A. (2017). Prevention of railway trespassing by automatic sound warning—A pilot study. *Traffic Injury Prevention*, 18:3, 330-335.

Abstract

Objective: The objective of this study was to investigate the effects of a sound warning system on the frequency of trespassing at 2 pilot test sites in Finland.

Methods: The effect of automatic prerecorded sound warning on the prevention of railway trespassing was evaluated based on observations at 2 test sites in Finland. At both sites an illegal footpath crossed the railway, and the average daily number of trespassers before implementation of the measures was about 18 at both sites.

Results: The results showed that trespassing was reduced at these sites by 18 and 44%, respectively. Because of the lack of proper control sites, it is possible that the real effects of the measure are somewhat smaller.

Conclusions: The current study concludes that automatic sound warning may be efficient and cost effective at locations where fencing is not a viable option. However, it is not likely to be a cost-effective panacea for all kinds of sites where trespassing occurs, especially in countries like Finland where trespassing is scattered along the railway network rather than concentrated to a limited number of sites.

[2] Baron, W. and daSilva, M. (2020). *Trespasser Detection Systems on Railroad Rights-of-Way*. Technical Report No. DOT/FRA/ORD-20/34. Washington, DC: U.S. Department of Transportation, Federal Railroad Administration.

Abstract: The U.S. Department of Transportation's Volpe Center, under the direction of DOT's Federal Railroad Administration Office of Research, Development, and Technology, conducted a research study to evaluate the effectiveness of trespass detection technology on rail property linked to and controlled by a local police department. The system was operated for several years, while different communications and sensor technologies were tested for their abilities to overcome shortcomings. Researchers found that wireless broadband service in this area was insufficient in providing uninterrupted high-resolution video from multiple cameras, and while TV white space transceivers had adequate bandwidth, their short transmission range limited their usefulness. Providing live video directly to the local police department resulted in quick response to trespassing events; however, dispatchers were particularly unhappy with false alarms.

[3] Zaman, A., Ren, B. and Liu, X. (2019). Artificial Intelligence-Aided Automated Detection of Railroad Trespassing. *Transportation Research Record: Journal of the Transportation Research Board, 2673*(7), 25-37.

Abstract: Trespassing is the leading cause of rail-related deaths and has been on the rise for the past 10 years. Detection of unsafe trespassing of railroad tracks is critical for understanding and preventing fatalities. Witnessing these events has become possible with the widespread deployment of large volumes of surveillance video data in the railroad industry. This potential source of information requires immense labor to monitor in real time. To address this challenge this paper describes an artificial intelligence (AI) framework for the automatic detection of trespassing events in real time. This framework was implemented on three railroad video live streams, a grade crossing and two right-of-ways, in the United States. The AI algorithm automatically detects trespassing events, differentiates between the type of violator (car, motorcycle, truck, pedestrian, etc.) and sends an alert text message to a designated destination with important information including a video clip of the trespassing event. In this study, the AI has analyzed hours of live footage with no false positives or missed detections yet. This paper and its subsequent studies aim to provide the railroad industry with state-of-the-art AI tools to harness the untapped potential of an existing closed-circuit television infrastructure through the real-time analysis of their data feeds. The data generated from these studies will potentially help researchers understand human factors in railroad safety research and give them a real-time edge on tackling the critical challenges of trespassing in the railroad industry.

[4] Bernert, R. A., Hilberg, A. M., Melia, R., Kim, J. P., Shah, N. H., & Abnousi, F. (2020). *Artificial Intelligence and Suicide Prevention: A Systematic Review of Machine Learning Investigations*. *International Journal of Environmental Research and Public Health, 17*(16).

Abstract: Suicide is a leading cause of death that defies prediction and challenges prevention efforts worldwide. Artificial intelligence (AI) and machine learning (ML) have emerged as a means of investigating large datasets to enhance risk detection. A systematic review of ML investigations evaluating suicidal behaviors was conducted using PubMed/MEDLINE, PsychInfo, Web-of-Science, and EMBASE, employing search strings and MeSH terms relevant to suicide and AI. Databases were supplemented by hand-search techniques and Google Scholar. Inclusion criteria: (1) journal article, available in English, (2) original investigation, (3) employment of AI/ML, (4) evaluation of a suicide risk outcome. N = 594 records were identified based on abstract search, and 25 hand-searched reports. N = 461 reports remained after duplicates were removed, n = 316 were excluded after abstract screening. Of n = 149 full-text articles assessed for eligibility, n = 87 were included for quantitative synthesis, grouped according to suicide behavior outcome. Reports varied widely in methodology and outcomes. Results suggest high levels of risk classification accuracy (>90%) and Area Under the Curve (AUC) in the prediction of suicidal behaviors. We report key findings and central limitations in the use of AI/ML frameworks to guide additional research, which hold the potential to impact suicide on broad scale.

[5] DaSilva, M., Baron, W. and Carroll, A. (2012). *Railroad Infrastructure Trespassing Detection Systems Research in Pittsford, New York*. Technical Report No. DOT/FRA/ORD-06/03-1. Washington, DC: U.S. Department of Transportation, Federal Railroad Administration.

Abstract: The U.S. Department of Transportation's Volpe National Transportation Systems Center, under the direction of the Federal Railroad Administration, conducted a 3-year demonstration of an automated prototype railroad infrastructure security system on a railroad bridge. Specifically, this commercial-off-the-shelf technology system was installed at a bridge in Pittsford, New York, where trespassing is commonplace and fatalities have occurred. This video-based trespass monitoring and deterrent system had the capability of detecting trespass events when an intrusion on the railroad right-of-way occurred. The interactive system comprised video cameras, motion detectors, infrared illuminators, speakers, and central processing units. Once a trespass event occurred, the in-situ system sent audible and visual signals to the monitoring workstation at the local security company where an attendant validated the alarm by viewing the live images from the scene. The attendant then issued a real-time warning to the trespasser(s) via pole-mounted speakers near the bridge, called the local police, and then the railroad police, if necessary. All alarm images were stored on a wayside computer for evaluation. The system was installed in August 2001 and evaluated over a 3- year period ending in August 2004. This paper describes the results of this research endeavor. Topics addressed include the project location, system technology and operation, system costs, results, potential benefits, and lessons learned. The results indicate this interactive system can serve as a model for railroad infrastructure security system for other railroad ROW or bridges deemed prone to intrusion.

[6] Ceccato, V., Wiebe, D. J., Vrotsou, K., Nyberg, U., & Grundberg, A. (2021). The situational conditions of suicide in transit environments: An analysis using CCTV footage. *Journal of Transport & Health, 20*, 100976.

Abstract: Introduction: We explore the use of CCTV footage to map suicidal self-injurious behavior on a subway platform to better understand the settings and the situational conditions of individuals just before they attempt suicide.
Methods: We use footage from CCTV cameras for gaining new insight into the situational conditions that relate to suicidal self-directed violence in the transit system in Stockholm, Sweden. We adopt a space-time budget template to record, step-by-step, what happens over time as individuals on the platform wait for an incoming train. The analysis applies visualization tools (VISUAL-TimePAcTS) and uses a cross-over design to identify risk factors associated with suicide.
Results: Findings show that suicide risk varies both temporally and spatially. Among all types of possible behaviors and places, being close to the edge of the platform of the opposite direction of the train and crossing the security line – this behavior and place combined – are associated with increased risk of suicide.
Conclusions: We confirm that using CCTV footage as data source provides valuable insight into relevant situational conditions in which suicides take place, which can be useful to inform prevention strategies,

particularly information about behavior and place combined. The article concludes by reflecting upon the importance of these results for future research.

[7] Catalano, A., Bruno, F. A., Pisco, M., Cutolo, A., & Cusano, A. (2014). An Intrusion Detection System for the Protection of Railway Assets Using Fiber Bragg Grating Sensors. *Sensors*, *14*(10), 18268–18285.

Abstract: We demonstrate the ability of Fiber Bragg Gratings (FBGs) sensors to protect large areas from unauthorized activities in railway scenarios such as stations or tunnels. We report on the technological strategy adopted to protect a specific depot, representative of a common scenario for security applications in the railway environment. One of the concerns in the protection of a railway area centers on the presence of rail-tracks, which cannot be obstructed with physical barriers. We propose an integrated optical fiber system composed of FBG strain sensors that can detect human intrusion for protection of the perimeter combined with FBG accelerometer sensors for protection of rail-track access. Several trials were carried out in indoor and outdoor environments. The results demonstrate that FBG strain sensors bonded under a ribbed rubber mat enable the detection of intruder break-in via the pressure induced on the mat, whereas the FBG accelerometers installed under the rails enable the detection of intruders walking close to the railroad tracks via the acoustic surface waves generated by footsteps. Based on a single enabling technology, this integrated system represents a valuable intrusion detection system for railway security and could be integrated with other sensing functionalities in the railway field using fiber optic technology.

Additional Resources

US Department of Transportation Federal Railroad Administration. (2022). Railroad Trespass Detection Using Deep Learning-Based Computer Vision.

Excerpt: The U.S. Department of Transportation John A. Volpe National Transportation Systems Center (Volpe), under the direction of the Federal Railroad Administration (FRA) Office of Research, Development, and Technology, developed an AI software application for automating the detection of grade crossing violations and trespass activities from static camera video feeds. The Grade Crossing Trespass Detection GTCD software application outputs predicted grade crossing violations and right-of-way trespassing as tabular data in MS Excel format along with annotated video files of trespass events. Accurately detecting when a trespass event occurs using standard video input reduces the time needed to collect safety data. Currently, railroads and many state DOTs have a wealth of video data on their systems, but that data is generally only analyzed if there is a documented incident. Automated identification and processing of trespass events from the existing video data may yield significant safety data currently not being analyzed.

Related Measures

- Identify and monitor hotspots
- Improved data collection after an incident
- Crossing Illumination
- Removal of obstructions to increase visibility
- Connected Vehicles (V2V and V2I)

Images

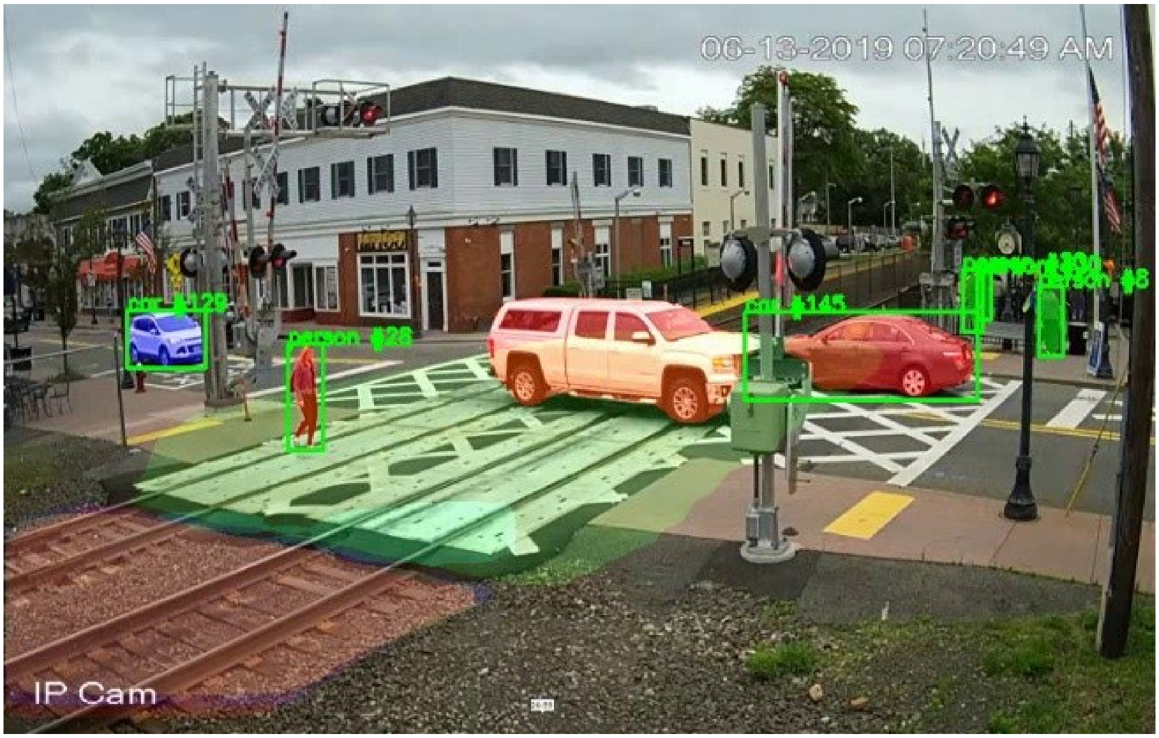

Figure 1. Example of AI-aided video processing output in Ramsey, NJ
Image Credit: Volpe Center

Figure 2. Example of live CCTV feed to local police dispatch in Brunswick, ME
Image Credit: Volpe Center

Figure 3. Example of CCTV surveillance equipment on rail right-of-way in Brunswick, ME
Image Credit: Volpe Center