U.S. Department of Transportation

Federal Railroad Administration

RESEARCH RESULTS

FRA OFFICE OF RESEARCH, DEVELOPMENT & TECHNOLOGY

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# AUTOMATED VIDEO INSPECTION SYSTEM FOR GRADE CROSSING SAFETY

## SUMMARY

The Federal Railroad Administration (FRA) has sponsored several programs to help reduce incidents at highway-rail crossings and improve the safety of both vehicles and pedestrians. One such recent project developed an artificial intelligence (AI)-based machine vision system to help inspect highway-rail grade crossings with forward-facing video (FFV) obtained from a Class I geometry car. The goal of this research is to apply the same concepts for locomotive-mounted FFV cameras, currently in common use within the industry; it complements manual inspections. FRA supported this research through its Phase I Small Business Innovation Research (SBIR) initiative.

This SBIR project funded VisioStack, Inc., of Greenville, South Carolina, to begin the development of AVIS: the Autonomous Video Inspection System. AVIS uses AI-based detection models to determine an inventory of key inventory features such as crossing gates, flashing lights, and crossbucks at grade crossings. The system was built using clustered-computing to deliver an efficient solution that can share results in under 30 minutes. Once the data is loaded to the RailLinks® platform, automated workflows ingest, analyze, and then report on the FFV. The video is localized against existing assets and can be displayed alongside additional data streams, such as track geometry and line scan imagery.

AVIS assists with additional aspects of the inspection process, including planning and reporting. Figure 1 shows the synced FFV widget alongside additional data streams, allowing users to interact with the data through the RailLinks thin-client platform. Users can scroll through the attribute toolbar to find a specific crossing and see a first-person view of the track at the same time.

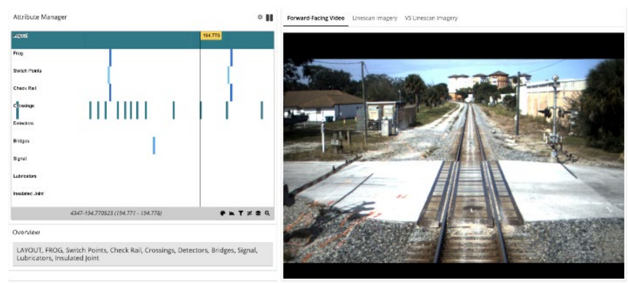

**Figure 1. Screenshot of the FFV in the RailLinks platform**

## BACKGROUND

In the past 5 years, an annual average of 2,000 incidents and 257 deaths have occurred at the more than 200,000 U.S. highway-rail grade crossings (1). The presence and working condition of crossing signs and safety features are essential to promoting and providing safety to vehicles and pedestrians alike. Using locomotive-mounted FFV can supplement currently required crossing inspections. inspecting crossings would greatly improve inspection efficiency and frequency.

## OBJECTIVES

The objective of Phase I was to determine how well an AI-based system can process forward-facing visual data streams.

The main challenge during Phase I was to determine if machine learning models could identify the presence and condition of key inventory features, such as crossing arms, from an FFV data stream. Dozens of features can be present at a crossing, and the research team developed models aimed at detecting each of them.

## METHODS

Researchers first created a method for ingesting the FFV data stream. Ingesting the data began by understanding the track position of the video stream by parsing the location data using optical character recognition (OCR). This helped with the visualization of the data stream that was later synced to underlying infrastructure data in RailLinks. Next, VisioStack's proprietary method for "chunking" concentrated data streams was used so that the imagery could be displayed to users seamlessly across a variety of devices. Once completed, the development team created an FFV widget to visualize the data on various pages in the platform. By leveraging clustered-computing, the process to ingest several hundred miles of FFV took under 30 minutes.

After ingesting the FFV data stream, the team integrated the FFV and imagery into the RailLinks AI platform. The platform allows users to label all key inventory features located in each FFV frame (Figure 2). In creating the training library, a foundation was built for the object detection models to learn how to identify each labeled feature.

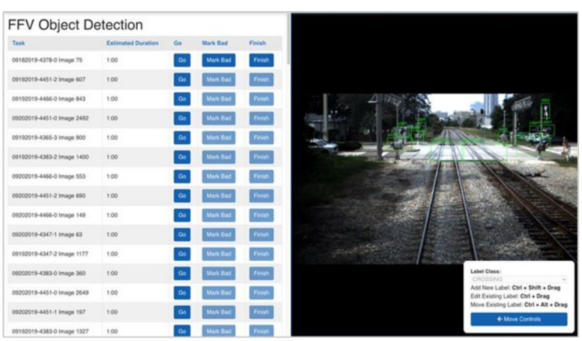


**Figure 2. AI training for RailLinks**

After several hundred frames were labeled, the researchers developed object detection models using the RetinaNet framework. Once completed, the models could detect results over an 85-mile-long asset consisting of approximately 80 crossings in under 2 minutes.

This efficiency would provide value to users who upload video streams from dozens of locations per day. Using a cloud architecture results in the same length in processing time regardless of how many files are uploaded at once.

Detection results are stored in the platform and can be viewed by selecting a crossing attribute in the AVIS workspace. Included in each crossing's results is information from the FRA Grade Crossing Inventory. VisioStack developed a method to integrate information from this database with crossings stored in RailLinks, allowing users to sync this database against all crossings in their network. Furthermore, a dashboard was created to help summarize AVIS results and information in these inventory reports. Figure 3 shows the number of differences detected between the two data sources , in addition to a summary of several statistics, such as the annual average daily traffic (AADT) and the average number of school buses that pass each crossing. This information is automatically updated as additional FFV is processed and can be summarized at the asset, subdivision, and network level.

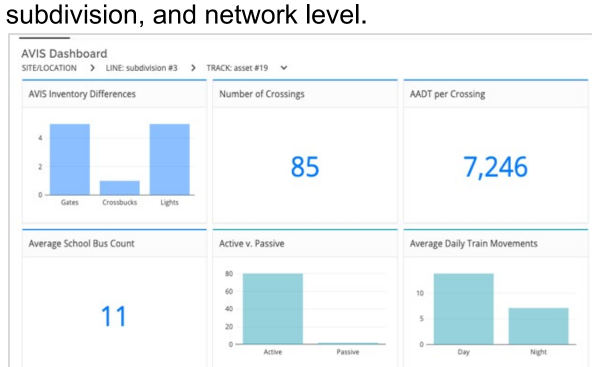


**Figure 3. AVIS dashboard**

## RESULTS

Several challenges arose when developing the object detection models. In some cases, glare and low image resolution affected the quality of the frames and made it difficult to detect inventory features. Second, the angle of the video feed made it challenging to detect features such as gates and crossbucks – since the focus of the feed was directly down the track as the train passed through a crossing. The detection models achieved a moderate rate of accuracy during Phase I. However, the work completed inspired confidence that this system could properly identify the presence and condition of key features when using a better data source.

## CONCLUSIONS

Research completed during Phase I demonstrated that it would be possible to assess the presence and functionality of key grade crossing features from an FFV data stream. Higher-quality sensors would help capture clearer data that would assist the object detection models in their processing and detection. This will allow the detection models to more confidently determine if key crossing features, such as gates, are present and working properly.

## FUTURE ACTION

Possible further development by VisioStack could include the development of a multi-camera FFV system, shown in Figure 4, that captures data from more advantageous angles.

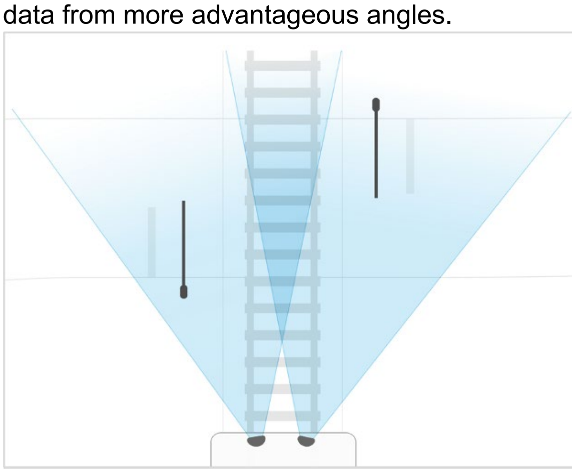

**Figure 4. Multi-camera FFV design**

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## REFERENCES

1. FRA Office of Safety Analysis. Ten Year Accident/Incident Overview.

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## KEYWORDS

VisioStack, RailLinks, artificial intelligence, forward-facing video, grade crossing safety

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