U.S. Department of Transportation
Federal Railroad Administration

RESEARCH RESULTS
FRA OFFICE OF RAILROAD POLICY & DEVELOPMENT

RR 15-11 | **May** 2015

WISESight™: A Multispectral Smart Video-Track Intrusion Monitor

SUMMARY

International Electronic Machines Corporation (IEM) developed, tested, and validated a unique smart video-based intrusion monitoring system for use at highway-rail grade crossings. The system used both thermal infrared (IR) and visible/near-infrared (NIR) imaging to detect, identify, and evaluate potential obstacles such as cars and people while ignoring inconsequential objects such as blowing paper, shadows, and smaller animals.

In response to a Small Business Innovation Research solicitation for improvements in monitoring intrusions at grade crossings, IEM performed this work under contract to the Federal Railroad Administration (FRA). IEM performed the work at the company's Troy, NY facilities and at an actual grade crossing in Watervliet, NY.

Despite an overall reduction of collisions and casualties at grade crossings of over 50% in the last few decades, incidents at grade crossings (Figure 1) and illegal trespassing remain the largest sources of deaths and injuries related to railroad operations.

IEM proposed a smart video approach to monitoring grade crossings. Its solution would use a computer to identify and track relevant targets by directly evaluating video sequences. To handle inclement weather and darkness, IEM also proposed to use IR and NIR with illuminators.

IEM conducted initial Phase I research to demonstrate the feasibility of its solution, and also investigated the effectiveness of visible light/NIR versus IR. In Phase II, IEM further developed this system, creating software that could discriminate between different targets, evaluate their location and movement, and determine if they were or could become hazards to rail operations.

Figure 1: Examples of Grade Crossing Accidents

After the system was tested in both laboratory and real-life rail settings, IEM demonstrated that it had created a feasible and practical system for detecting grade crossing intrusions, and that a multispectral approach was clearly superior to either thermal infrared or visible/NIR alone. Testing at an actual grade crossing in a variety of lighting and weather conditions verified the system's reliability, quick response, sensitivity, and ability to discriminate between real targets and distractors.

BACKGROUND

As of 2015, there are 129,582 public crossings in the United States. Of these crossings, approximately 42,300 had gates, 22,050 had flashing lights, and 1,200 had interconnected highway traffic signals and other forms of active or automatic advance warning devices. Despite many improvements in safety over the past few decades, highway-rail grade crossings are still one of the primary locations for fatal or near-fatal events involving rail vehicles; in 2014 alone, there were nearly 2,300 such incidents. Given the tremendous forces involved in a typical train collision, these impacts can be devastating, and in 2014 they caused approximately 267 fatalities and 832 injuries.

In 2014, 526 people were killed and 419 were injured while trespassing on railroad rights-of-way. These incidents often result from deliberate evasion of gates and signals by motorist or pedestrians.

Thus, there is a significant interest in a reliable, affordable, and accurate method for detecting intrusions at grade crossings and alerting appropriate authorities to the situation.

OBJECTIVES

The WISESight™ project's goals were to first, test the feasibility of an all-weather, all-lighting multispectral smart video solution to grade crossing monitoring and then apply the results of these tests to develop such a system. The basic performance specifications for developing WISESight™ were:

- Operate reliably in all weather and lighting conditions
- Reliably detect and track all targets of interest in the region of interest
- Not distracted or confused by non-relevant targets (shadows, small animals, blowing paper, etc.)
- Able to accurately track physical location of target in 3-D space
- Customizable alerting conditions and thresholds
- Low cost
- Easy deployment

METHODS

IEM performed initial experiments from the roof of its Troy, NY facility (Figure 2) using the highway in front as a stand-in for a grade crossing. A virtual track was emulated in software to provide the key regions for "safe" "caution" and "warning/danger" status. Images were simultaneously captured in IR and vis/NIR, analyzed by prototype software, and examined by IEM personnel for key features and potential confounding events/objects. IEM then created a reasonable database of target and confoundable objects.

Figure 2: WISESight™ prototype on IEM rooftop

Additional testing was performed at a Watervliet grade crossing with both roadway and walkway gate systems, with significant foot and vehicle traffic throughout the day and nighttime periods. At the crossing, refined software tailored for real settings was used, and it featured an interface that could define regions of interest (track, road, walkways, etc.)

RESULTS

IEM determined that neither thermal IR nor visible/NIR was sufficient by themselves to detect and track all targets under all conditions. Lighting, heating by sunlight, reflections, and other phenomena could create situations that would confuse either of these imaging approaches alone. However, there was no circumstance found in which ***both*** spectra were unable to detect and locate the target (Figure 3).

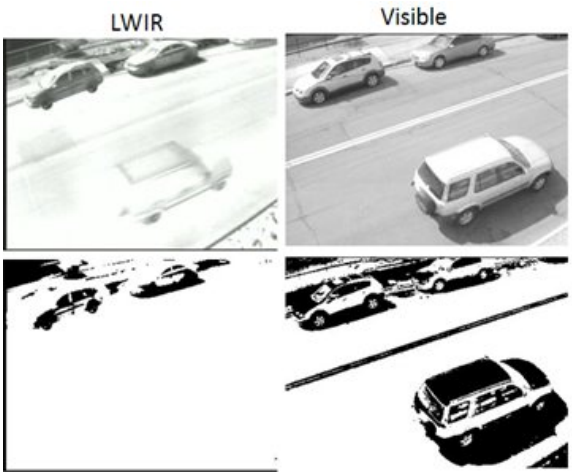

Figure3: SUV invisible in thermal IR but not vis/NIR

In fact, during the development of the WISESight™ monitor, IEM found that the best results were achieved by automatically adjusting the amount of each spectra used depending on lighting and time of day. At night, IR dominates (but is not the sole method used) and in bright light, vis/NIR is the primary, but not only, source used in analysis. IEM developed an adaptable algorithm that decides how and when to change the ratio of vis/NIR to IR imagery.

Testing at the Watervliet location proved that the capabilities of the system met all requirements. The system was easily deployed and it is extremely inexpensive compared to (for example) grade separation. More importantly, the system can detect, track, and evaluate multiple targets at once and recognize which pose potential threats to railroad operation;

Figure 4 shows an example of WISESight™ in operation.

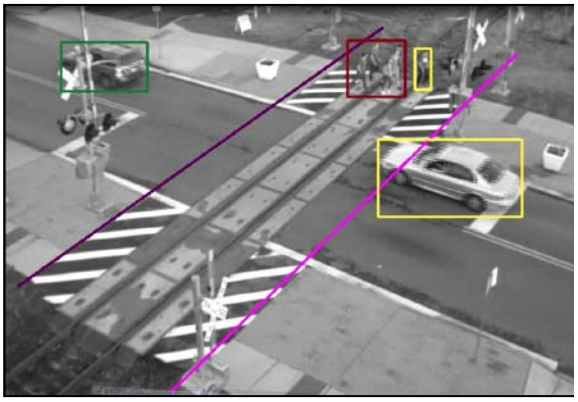

Figure 4: WISESight™ in operation

In Figure 4 we see targets in safe zones (green), others moving through the crossing area at reasonable speed (yellow), and others stopped or moving very slowly through the crossing (red). Note that the system tracks individuals, co-moving groups of people, and vehicles equally well.

CONCLUSIONS

WISESight™ is an efficient, affordable, and versatile method for monitoring grade crossings, or other areas requiring security and safety monitoring. All of the project's goals were achieved.

ACKNOWLEDGEMENTS

IEM would like to acknowledge the U. S. Department of Transportation and the Federal Railway Administration, which provided IEM with considerable support during our execution of this contract. IEM also thanks the city of Watervliet for supporting our testing plan. Finally, IEM wishes to acknowledge Zack Mian, Ron Gamache, Bob Foss, and the rest of the IEM team who made WISESight™ a reality.

CONTACT

Tarek Omar, D.Sc.
Federal Railroad Administration, RPD-33
Office of Research and Development
1200 New Jersey Avenue, SE – Mail Stop 20 Washington, DC 20590
Tel: (202) 493-6189
Tarek.Omar@dot.gov

Robert Foss
Manager of Research and Development
International Electronic Machines
850 River Street
Troy, NY 12180
(518) 268-1636 X 112
rfoss@iem.net

KEYWORDS

Smart video, grade crossing, infrared, multispectral, object tracking, safety