Integrated Trespassing Detection System

PROBLEM STATEMENT:
Fatalities due to trespassing on railroad property is the leading cause of railroad related deaths, and the previous trespassing system even though proved to be effective, but it could be made much of efficient and effective.

BACKGROUND:
According to the Federal Railroad Administration (FRA), the leading cause of railroad deaths in the United States is due to pedestrian trespassing onto railroad tracks. The annual number of deaths caused due to trespassing increased by 18 percent – from 725 to 855 deaths – between 2012 and 2017. There were 324 pedestrian trespass fatalities from the beginning of the year 2018 to July 31, 2018. From the data, we can conclude that there is no downward trend in trespassing fatalities. Railroad trespassing accidents don't just cost lives; they are incredibly expensive, too. During the four-year period from 2012-2016, fatalities and injuries caused by railroad trespassing cost $43.2 billion and related delays in travel time cost more than $56 million. Hence, the installation of a trespassing detection system is necessary.

The previous trespassing detection system was effective but it had many flaws in it. In 2001, a trespassing detection system was set up in Pittsford, New York which proved to be effective in reducing trespassing events. With the detection system, five lives were saved from three trespassing events during the three-year period, but false detection was a problem, which led to less reliability of the system. Along with these problems, the system was expensive in terms of installation and maintenance; the system constantly failed to work properly in the first year; the components had to be sent to the manufacturer for repair, because of which the system was offline for 112 days out of the 284 days from December 2001 to March 2002; and it lacked a backup system and a failsafe operation (in case of possible failure, appropriate warning are transmitted to the appropriate channels). With newer technology, I believe that we can build a more efficient integrated trespassing detection system.

By installing two integrated trespassing detection systems on either side of the grade crossing, which is more efficient, easy-to-use, less cost for maintenance and installation, easier for evaluation and repair, and less chance of false detection, we can save a lot of lives as well as costs for the society. According to FRA, 74 percent of all trespassing fatalities occurred within 1,000 feet from the grade crossing (intersection between a highway and a railroad line), so placing the integrated trespassing detection systems 1,000 feet from the grade crossing on either side, will be more effective in reducing fatalities. Also, FRA identified the ten counties in four states in the United States where14 percent of trespasser deaths occurred out of 3,100 counties in between November 2013 and October 2017. Los Angeles County in California accounted for most trespasser casualties with 110 casualties followed by Cook County (Chicago), Illinois, with 109 casualties. From the data, it is clear that setting up the integrated trespassing detection systems, starting with these two counties and slowly implementing in these ten counties can save a significant number of lives.

CONCEPT:

❖ The integrated trespassing detection system consists of three major components, a speaker, a camera and a raspberry pi connected to both the camera and the speaker. The raspberry pi will be programmed with an AI (artificial intelligence), which recognizes humans in the video of camera surveillance and alerts both the trespasser with a pre-recorded audio and the guards with live camera surveillance. Two integrated trespassing detection system will be set be 1,000 feet from the grade crossing on either side.

DESIGN:
    ❖ The prototype includes the following components:
- ➢ Security camera
- ➢ Speaker
- ➢ Raspberry Pi
- ➢ Power supply
- ➢ Ethernet cable

Security camera ($2000):
❖ The Laser 2.0 camera is the best fit for this prototype due to the following reasons:
- ➢ It could detect humans up to 950 ft.
- ➢ It has long range night vision up to 1600 ft.
- ➢ It has full protection from dust, rain, snow, and sprinklers.
- ➢ It can withstand temperatures in the range between -40°F to 140°F.
- ➢ It can rotate 360°.
- ➢ It works with ONVIF, that means you could connect the camera to raspberry pi wireless.

Speaker ($30):
❖ The PRO-GM6B speaker is the best fit for this prototype due to the following reasons:
- ➢ The audio output is audible at 115 dB near the vicinity of the detection system, which is similar to the intensity of sound at a rock concert or leaf blower and is also audible (65dB) at 1,000 feet from the detection system, which is similar to the intensity of sound of normal conversation.

  Calculation:
  - o The sensitivity of speaker: 94dB
  - o RMS Power: 140 W

  Maximum output = Sensitivity + 10 * log (RMS Power)
  (Volume of sound
  near the system) = 94 dB + 10 * log(140W)
                            = **115.46 dB**

  Volume at 1,000
  Feet from the speaker   = Max. output – 20 * log (distance in meter)
  i.e. Sound Pressure Level   =115.46 dB – 20 * log (304.8)
  (SPL)   = **65.7 dB**

Raspberry Pi ($30):
❖ The Raspberry Pi 3 Model B+ is the best for this prototype due to the following reasons:
- ➢ It contains 64-bit quad core processor running at 1.4 GHz, which means faster ethernet, and faster processing.

WORKING OF TRESPASSING DETECTION SYSTEM:

- ❖ The raspberry pi will receive the video surveillance from the security camera, the speaker will also be connected to the raspberry pi and an ethernet connection to connect with the computer of the guard or the attendant and stores all the data in the cloud server.
- ❖ The raspberry pi will be programmed with an AI (Artificial Intelligence) known as YOLO (You look only once): Real-time object detection, which will identify humans, animals, and other objects from the video surveillance.
- ❖ The raspberry pi will be programmed to send audio of warning the trespasser to get off the track if humans are identified by the AI from the video surveillance.
- ❖ The auto-track in the camera could be activated by raspberry pi, which would zoom-in on the human or humans who are trespassing so that the guard could get a better sense of the situation.
- ❖ If anything, other than human is identified, the following procedure will be followed:
    - ➢ If a train is identified, the AI will ignore it.
    - ➢ If rodents or birds are identified, the AI will ignore it.
    - ➢ If a vehicle is identified, the AI will notify the attendant in the grade crossing office.
- ❖ If one or more humans are identified, the following procedure is followed:
    1. The AI using the GPS of the train, it will receive the location of the train and it will estimate the time left before the train hits the trespassers.
    2. It will notify the guard with the live video surveillance, time estimate for the arrival of the train, an option to notify the operator of the train if the estimated time is less than the time it would take for the guards to get to the spot and an option to stop the train with the guard's approval to using the positive control system in the train.
- ❖ The raspberry pi will be programmed to run self-diagnostic test in regular interval of time to make sure that every component is working perfectly. If something is wrong, the raspberry pi will be programmed to notify the attendant with the possible cause of an error.
- ❖ The raspberry pi will also be programmed in such a way that it can be disabled for a while in case there is maintenance work going on the tracks so that the alarm doesn't go off because of the maintenance workers.
- ❖ All the video footage will also be saved in the cloud so that there will be no need for a storage device for all those data, and all the video could be accessed easily from various locations for overseeing the program by the officials of FRA.
- ❖ The raspberry pi will be covered by galvanized steel electric box, with two locks to hold raspberry pi on place and if necessary, the raspberry pi could be removed by unlocking those locks. So, it is easier for replacement.
- ❖ Along with the AI, the raspberry pi will also maintain a well-defined database to record all the detection events, which will be useful during the evaluation of its performance.

SYSTEM COMPONENT COSTS:

ITEM	COST
Surveillance Camera (2)	$ 4,000

Speaker (2)	$	60
Raspberry Pi (2)	$	60
Pole, Installed (2)	$	2,000
Miscellaneous (Ethernet cables and Power Supply)	$	1,000
Total	$	**7,120**

COMPARISION:

TRESPASSING DETECTION SYSTEM IN PITTSFORD, NEW YORK	NEW INTEGRATED TRESPASSING INTEGRATION SYSTEM
It had a lower positive detection rate (9 percent) because the system detected a maintenance worker, the presence of maintenance vehicles, trains, and animals.	It will have a higher positive detection rate because the AI will identify only humans and ignore other entities.
The components wore off due to harsh weather conditions since all the components were exposed outside.	All the components of the system can withstand any temperature.
Slower video transmission.	With ethernet cable, the video transmission is much faster.
Expensive to install the system because it consisted of more than seven major components.	Cheaper to install the system because it only consists of three major components.
Expensive to maintain, because the components weren't efficient.	Cheaper to maintain, because the components are efficient.
An attendant was required to look over the system 24/7.	No attendant is required because the AI does the job of the attendant more effectively.
The database with records of detection wasn't automatically done.	The raspberry pi will be programmed to maintain a well-defined database, so it's easier for evaluation.
The range of detection was very limited.	With two systems, the detection range is 950 feet on either side of the grade crossing.
Cost of this system: $13,500	Cost of this system: $7,120
It was hard to set up the system because it involved so many components and also, it was hard to maintain it because, in case of repair, the components had to be sent to the manufacturer.	It is easier to set up because there are only three components, and in case of any possible failure the AI will send alerts, after running a self-diagnostic test in regular interval of time.

CONCLUSION:

I propose to implement this integrated trespassing detection system so that we can save a significant amount of lives as well as costs for the society, also, this system is more effective than the previous system.

REFERENCE:

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