REDUCTION OF EMERGENCY RISKS WITH THE HELP OF INTELLIGENT VIDEO SURVEILLANCE SYSTEMS

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ABSTRACT

The article considers the use of intelligent video surveillance systems as an additional measure to ensure the safety of train traffic on dangerous sections of railways (crossings, tunnels, complex terrain, etc.). It is proposed to use the resources of the fiber-optic transmission network and the frequency range of train radio communication for organization of communication channels, provided that the existing equipment is modernized.

Keywords: *railway, traffic safety, video surveillance, high definition, video analytics.*

Background. *The main criterion for assessing efforts to improve the safety of train traffic is to reduce the likelihood of an emergency. This parameter reflects the prevention and neutralization of a large number of probabilities: failure of equipment, breakage of communication lines, operator's and driver's errors, landslides, rockfalls, malicious acts and other negative events.*

One of the ways to ensure safety on the roads is the introduction of intelligent video surveillance systems. These systems can prevent road accidents at crossings, accidents in areas with complex terrain or with an increased likelihood of landslides, dangerous situations in conditions of poor visibility, in case of terrorist threat of explosions in tunnels and other protected sites.

Objective. *The objective of the authors is to consider reduction of emergency risks with the help of intelligent video surveillance systems*

Methods. *The authors use general scientific and engineering methods, comparative analysis, evaluation approach.*

Results.

Classification of systems

Automatic and automated video surveillance systems act as one of the key components of integrated security systems [1]. The task of video surveillance involves visual control of a given area of space using video cameras that allow storing and viewing digital video data, as well as assessing the state of the monitored territory, highlighting the so-called «security events» that are involved in various changes in the observed situation.

Historically, the main functions of video surveillance systems are the output of information in a continuous mode to the point of control and recording into the archive. To date, these systems have higher requirements for functionality, which stimulates the transition from analogue methods of obtaining, displaying and storing video information to digital (IP cameras, computer monitors, digital databases).

Modern distributed video surveillance systems are based on the client-server architecture, according to which the video stream from the cameras goes to the server, where it is first processed (compression, digitization of the video signal) and stored. The availability of specialized software for the implementation of video analytics is the core of the entire intelligent video surveillance system, which, in turn, distinguishes it from the conventional video surveillance system. Such software uses computer vision techniques that allow automated collection of data by analyzing the flow of video images.

The result of video analytics are messages about dangerous objects or events that are transmitted to the operator only in case of detection of alarm signs, and also recorded in the video archive.

Video analytics relies on algorithms for image processing and pattern recognition, which allow analyzing video without direct human participation [2].

Depending on the goals, the video analyst can perform one or more functions:

1) detection of objects using video motion detectors;

2) tracking the object with the help of several video cameras and special processing algorithms;

3) classification of objects on the basis of signs of shape and size;

4) identification of objects (for example, people according to the biometric features of the person);

5) recognition (detection) of alarm situations on the basis of an analysis of the behavior of the object of observation.

Video analytics can have additional functions, for example:

1) prediction of the behavior of the object;

2) intelligent compression of video content (only the video containing alarming situations is transmitted), which reduces the load on the communication channel and the video surveillance operator;

3) ranking (prioritizing) the events of video analytics, which allows the operator to focus only on important events and not be distracted by secondary situations.

From the point of view of application, the following types of video analytics are distinguished:

1) perimeter (protection of extended areas);

2) situational (recognition of anxiety situations associated with human behavior, movement of vehicles);

3) biometric (identification of persons);

4) business intelligence (organization management).

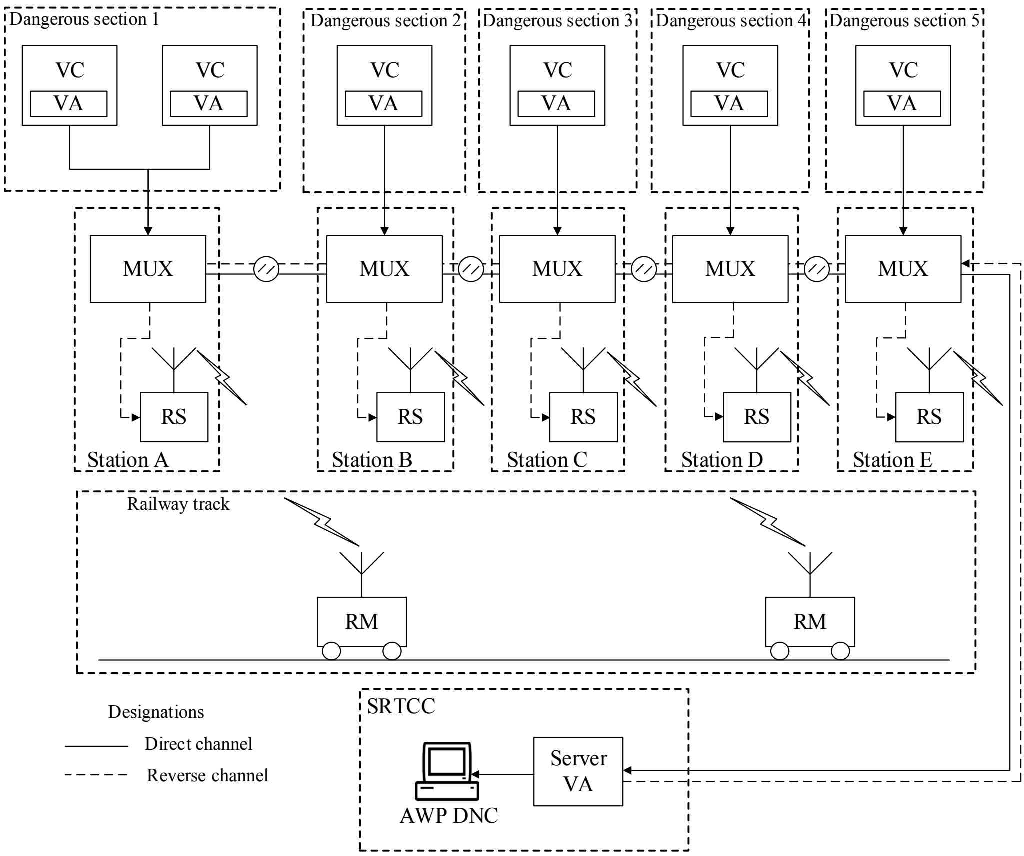
From the point of view of the hardware-software architecture, three types of video analytics systems are best known:

1) server video analytics assumes centralized processing of video data on the central processor, continuous transmission of video from the source of information to the server;

2) built-in video analytics is implemented in the video data source (video camera), works on a dedicated processor, transmits data about the object along with the video stream to a common processing, video analysis and storage server for all cameras;

3) distributed system is implemented as a hybrid version of server and embedded video analytics.

The main disadvantage of many variants of video analytics is the high frequency of false positives. This problem is gradually solved by improving the algorithms of video analysis.



Pic. 1. Scheme of organization of an intelligent video surveillance system in railway transport.

Organization of intelligent video surveillance

Intelligent video monitoring of the movement of trains can be organized with the help of a fiber optic transmission system (FOTS), designed for signals of operational and technological communication, and a digital system of train radio communications (TRC).

The scheme of organization of the intelligent video surveillance system in railway transport, presented in Pic. 1, has the following designations: VC – video camera with built-in VA (video analytics); MUX – hardware complex, including a multiplexer of the primary network and a switching station, which provides the connection of video cameras and radio stations to the access network; RS – stationary radio station; RM – mobile radio station; AWP DNC – automated workplace of the train dispatcher; SRTCC – single road transport control center, which is located at the road control station; CS – control system; DTN – data transmission network; a direct channel is a channel for transmitting a video stream from cameras to an VA server and AWP DNC; a reverse channel is a channel for transmitting the video stream from the VA server to the driver's cabin (includes the radio channel TRC in addition to the wire section).

One or several video cameras (VC) are installed in places of increased danger: in areas with landslides, difficult terrain, poor visibility, crossings, tunnels (at the entrance and exit), etc.

Built-in video analytics (VA), realized with the help of a video processor in the camera, automatically generates a control signal for the beginning and end of the video transmission from the VC to the server located at the road control station when a dangerous object appears in the camera's field of view. After detection, the video image of the object and metadata describing the contents of each frame (location, object identification, time, path, speed, etc.) are transmitted to the server.

In the server decoding, image comparison from several cameras, video analysis, indexing, event risk assessment, storage of information, etc. are performed. Then the image is displayed on the screen of the automated workplace of the operator or train dispatcher (DNC).

The dispatcher makes a decision on the need to send a circular call about a dangerous object or event to all participants of the movement (locomotive drivers, station duty officers SDO, etc.) and to the operators of the units (of track, power supply, signaling and blocking, etc.) located on his section of the railway. Such a situation mode of video image transmission from VC allows to effectively use communication channels, does not burden the operator, reduces the amount of stored video information, etc.

In addition, it is possible to implement with the help of train dispatch communication (TDC) and train radio communication (TRC) channels, if necessary, the transmission of a video image of a dangerous object in a compressed format to locomotive drivers, using the allocated frequency band of a digital TRC for reception and transmission (6 MHz wide). To implement this option, modernization of the receiving and transmitting equipment of stationary and locomotive radio stations or creation of new broadband radio stations will be required. In this case, the

calculation path for propagation of the radio signal of TRC in the frequency band allocated for the railway transport (antenna-feeder devices, towers for antenna installation, base stations) is retained.

It is possible to transmit video images to locomotives 2 km away from the installation site of video cameras in case of detection of a dangerous object for the timely braking of the train. For this purpose, the creation of sets of transceiver equipment in the free frequency band (2,41 GHz) and the installation of additional towers for antennas is required [3].

The use of a fiber-optic data transmission system for the main channel of video transmission to the road control station enables megapixel high-definition (HD) video analytics to reduce the amount of video data by 5 times compared to standard systems and provide high detailization of the object for better detection, tracking and classification of targets in automatic mode [4].

Conclusions. *The most effective for improving the safety of train traffic is the intelligent video surveillance system with an architecture that connects the algorithms of built-in and distributed video analytics. Such a scheme will transmit information only in the event of alarm events, which will allow connecting several dozens of video cameras to one communication channel and facilitate the operator's work (DNC).*

As a reverse channel from the DNC to the driver, one can use the TRC channels. In the simplest case, transmit voice information in the circular call mode. In more complex versions, provide for transmission of video signals to the locomotive cabin in the frequency range of the railway transport or to create for these purposes an independent radio communication system directly connected with the video cameras.

The main functions of the video surveillance system should be:

– detection of objects;

– tracking them with the help of special processing algorithms;

– identification and classification of objects;

– ranking of events;

– recognition of alarm situations based on the analysis of the behavior of the object of observation;

– prediction of events to prevent emergencies.

The huge capabilities of FOTS over the bandwidth (more than 20 THz) and modern wave-sealing technologies will allow the implementation of intelligent high-definition video surveillance that will provide better detection of objects of observation and detection of dangerous situations.

REFERENCES

1. Information project of the professional community «Technical Vision». [Electronic resource]: http://wiki.technicalvision.ru/index.php/. Last accessed 20.01.2017.

2. Video analytics [*Videoanalitika*]. LLC «Synesis». [Electronic resource]: http://synesis.ru/technology/videoanalitika. Last accessed 20.01.2017.

3. Anopchenko, N. V., Kosilov, R. A., Tereshin, N. V., Bogachev, A. P. Radio-TV system will prevent the collision [*Radiotelevizionnaja sistema predotvratit naezd*]. *Lokomotiv*, 2002, Iss. 8, p. 29.

4. Video analytics of high definition (HD) [*Videoanalitika vysokoj chetkosti (HD)*]. LLC «Synesis». http://synesis.ru/technology/videoanalitika-vyisokoj-chetkosti. Last accessed 20.01.2017.

5. Survey of CCTV systems [*Obzor sistem videonabljudenija*]. LLC «YUKONTROL SB». http://www.ucontrol.ru/videonabludenie/obzor/. Last accessed 26.01.2017.

6. Khrulev, A. A. Intelligent video surveillance system as part of a comprehensive security system on the subway [*Intellektual'naja sistema videonabljudenija v sostave kompleksnoj sistemy bezopasnosti na metropolitene*]. *Sistemy bezopasnosti*, 2014, Iss. 2, p. 40.

7. Makaretsky, E. A., Ovchinnikov, A. V., Nguen, L. Kh. Television measuring systems for controlling the high-speed traffic regime [*Televizionnye izmeritel'nye sistemy kontrolja skorostnogo rezhima dorozhnogo dvizhenija*]. *Komponenty i tehnologii*, 2007, Iss. 4, p. 34 ●

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