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ENVIRONMENTAL MONITORING OF WOODLANDS WITH A ROTARY IP CAMERA

***Abstract**: An automated system for environmental monitoring that allows to control large forest areas in on-line mode and to timely detect the landscape fires has been developed. Each IP camera is equipped with a special swivel base with two independent (horizontal and vertical) drives. The system software enables the control of the cameras and communication with sensors and controllers in the robotic mode. The system provides for significant increase in the promptness of detection of changes in the radiation background indicators and emergence of fire outbreak areas; besides, it would save time and effort, reduce material and financial expenses on the activities to localize and eliminate radioactive forest fires and reduce the economic and environmental impact due to accidental and seasonal fires.*

***Key words**: forest fire, monitoring, radiation background, rotating video-camera, environmental impact.*
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Introduction

The current state of natural ecosystems is increasingly subjected to the ravages of devastating hazards and technological disasters. Particular risks are posed by global forest fires which cause not only destruction of large areas of forest, but also pose a significant threat to the population in these regions. In this regard, timely detection of local fire outbreaks and prompt notification of the relevant services on emergency situations are important.

The traditional method of the landscape fires detection is based on the use of special *fire lookout towers* with an observer who (using the communication and optical devices for visual control) detects a fire and correspondingly informs the control center [1]. The advantages of such approach include the towers infrastructure which has been preserved until now, simplicity, scalability and high efficiency. However, this method requires the constant use of human labor at each point of tower locations, as well as an exposure of the forest workers carrying out fire-prevention and radiation measuring monitoring to the increased radiation exposure.

The methods of fire detection from air using various kinds of *airborne vehicles* [2] which fly over the fire-prone territories at regular intervals and, upon detection of the fire, determine its coordinates and communicate the information on the fire to the control center allow to carry out monitoring of large territories. The main disadvantage is the high cost of a flight hour and lack of opportunity to exercise constant radiation control of a specific site. The use of unmanned flying vehicles (drones) may significantly reduce the flight hour cost, however their usage is hampered due to many reasons so far [3].

The global approach to forest fire monitoring is based on the use *of special satellites* located at geostationary orbits which are making pictures of the land surface in IR-range [4]. The picture is sent to special centers from where the concerned users may get the required data via Internet. The advantages of this method are: automatic remote data acquisition, possibility to monitor any terrain, easy access to information via the Internet. The main limitations of the satellite monitoring method are: large area of the smallest detectable fire source (1–50 hectares), low frequency of data acquisition (several times a day) and strong effect of weather conditions. In windy weather, the 4–6 hours delay in detection of even small fire may have serious consequences and may increase the costs associated with its elimination several-fold. However, in spite of all disadvantages, the satellite monitoring is essential to control large forest territories when other methods of monitoring are impossible. Besides, the cost of satellite monitoring is very high.

Video monitoring systems

Since the early 2000s, video monitoring systems for forest fire detection have started to emerge [5, 6]. The main feature of the video monitoring system is its high degree of automation and possibility to use the existing infrastructure of fire lookout towers. The available video systems represent rotary cameras mounted on towers when the video image is sent to the operator's console (in this case, the operator shall be near the video monitoring post and carry out round-the-clock monitoring of the territory). However, this approach requires the constant use of human resources at each point of tower locations and does not allow to remotely determine the fire source coordinates. Besides, it is not possible to scale up such system.

The forest fire monitoring system "Lesnoy Dozor" ("Forest Watch") is somewhat devoid of these drawbacks [7, 8]. The system includes the equipment required to exercise monitoring from high-rise structures (dome rotary cameras, infrared cameras, thermal imaging devices) and ensures high efficiency of forest fire detection with the possibility of remote calculation of the fire source coordinates. The disadvantage of the system is that the complete horizon sweep (360 degrees) with one dome rotary camera is impossible (Figure 1). "Dead zones" necessitate the use of at least two rotary cameras on one tower to guarantee the detection of all fire sources (which results in the increase of the system price). Another disadvantage is the necessity to manually specify the fire source point in the operator's monitor, following which the system calculates the direction (azimuth) of the fire site. Besides, the system does not envisage the possibility of remote radiation control and communication of information on the radiation background change to the operator console.

Automated video monitoring system

We have developed an IP-camera-based system without the mentioned drawbacks [9, 10]. Each IP-camera is equipped with a special swivel base with two independent (horizontal and vertical) drives. The design ensures free rotation of IP-camera in the horizontal plane (360 degrees) and allows to monitor the forest condition without "dead zone" (Figure 2).

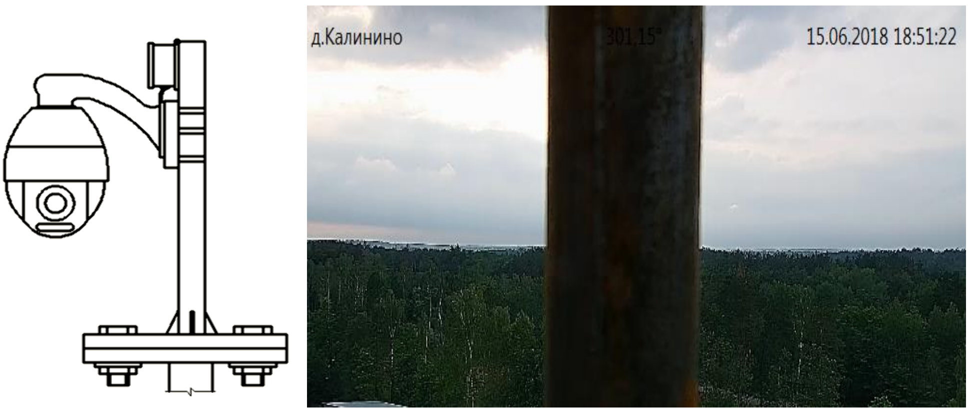

Figure 1. Installation of the dome rotary camera:
a **– video camera installation on a vertical bracket;** ***b*** **– panoramic view of the forest area with a "dead zone"**

Figure 2. IP-camera on a swivel base mounted on a vertical bracket:
a **– video camera installation on a swivel base;** ***b*** **– panoramic view of the forest area without a "dead zone"**

Landscape fire detection and environmental monitoring system includes the hardware (high-resolution IP-cameras installed on swivel bases, special radiation control sensors, rotation angle controllers) and the software that allows to control the cameras and exchange information with sensors and controllers in the robotic mode.

Schematic block diagram of the automated system for early detection of landscape fires is shown in Figure 3.

The system operates as follows.

Install swivel device 8 with video camera 1 on one of the high-rise structures. Scan the terrain by rotating video camera 1 around its vertical axis (360 degrees) with rolling assembly 20 and by rotating in the horizontal plane with rolling assembly 21. Then the information from the video camera is sent to local server 14 where the obtained image of a natural fire is analyzed and the azimuth of the source of ignition is calculated (by means of software module 17 for image analysis and software module 16 for calculation of the source of ignition azimuth). Then the image is compressed with software module 17 and is sent (in the compressed form) by data transmission unit 6 to information reception software module 18 from where it is transmitted to remote operator's surveillance station 7.

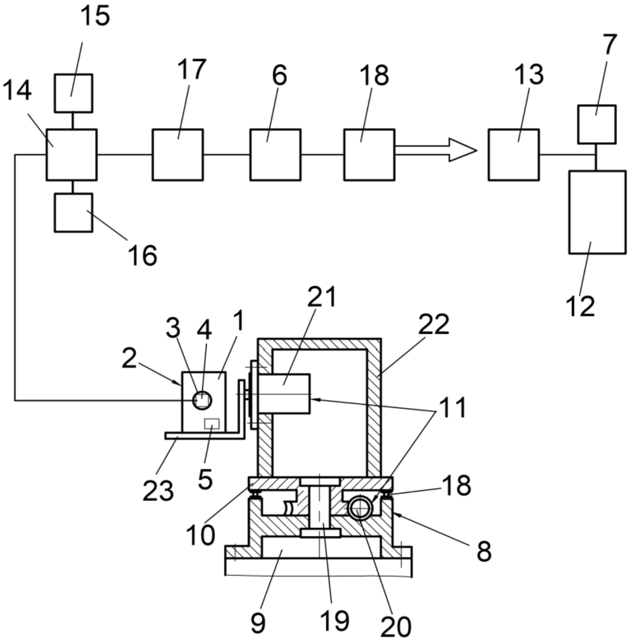

Figure 3. Schematic block diagram of the automated system for early detection of landscape fires: 1 - video camera (including body 2, lens 3, image capturing matrix 4, azimuth indicating goniometer 5); 6 - data transmission unit; 7 - remote monitoring station; 8 - swivel device (including base 9, platform 10 and electric drive 11); 12 - control unit; 14 - local server (including software module 15 for image analysis, as well as software module 16 for automatic calculation of azimuth or angle of rotation of the video camera); 17 - software module for data compression; 18 - bearing support; 19 - axis; 20, 21 - rolling assemblies; 22 - body; 23 - bracket.

After the terrain has been scanned, all images are stored in the memory of two servers: local 14 and remote (control unit 12). Thus, double reliability of data storage is ensured. When a signal from the remote server is poor or missing, the information exchange with video camera 1 is still carried out continuously, and the video camera stores all data at local server 14. At the signal resumption, all written data are synchronized with the remote server, thus ensuring the integrity and continuity of the storage of preliminary processed information.

When a fire outbreak is detected in the automated mode, the system stops automatic scanning, determines the fire source coordinates and sends the real-time video image, as well as the coordinates of the fire outbreak to the operator. In order to make a correct decision on further actions to eliminate the fire, the operator may manually zoom in the image from the video camera and view the source of ignition in a separate window. Besides, the system notifies the operator and designated persons in the event of a recorded increase in the value of measurements or when the radiation background threshold is exceeded. The system envisages integration with different types of cards where the video camera and radiation monitoring sensors installation points are marked.

Adaptation and improvement of such monitoring systems will make it possible to ensure fire and radiation safety in the forests contaminated by radionuclides, early detection of forest fires in the contaminated areas, improvement of fire-prevention and biological stability of forests and reduction in the radiation exposure of the forest industry personnel. For this purpose, it is necessary to ensure remote video monitoring, as well as the radiation background control of the territories along with registration of changes in its values in case of forest fires when the smoke contaminated with radionuclides may penetrate the atmosphere.

Conclusion

The automated system for environmental monitoring and detection of landscape fires using modern computer vision technologies, GIS technologies (*geographical information systems*), distributed computing technologies and client-server Internet technologies is an important part of a complex of measures to protect forests against fires, as well as radionuclide contaminated territories. The system provides for significant increase in the efficiency of detection of changes in the radiation background indicators and emergence of fire outbreak areas; besides, it would save time and effort, reduce material and financial expenses on the activities to localize and eliminate radioactive forest fires and reduce the economic and environmental impact due to accidental and seasonal fires.

A significant positive effect of the introduction of an automated system for detection of landscape fires and environmental monitoring is the reduction in the radiation exposure of the forest industry personnel engaged in fire-fighting and radiation monitoring in the area, as well as improvement of the quality of control over public access to the forest areas with high levels of radioactive contamination.

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