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THE ROLE OF EARLY DETECTION OF FOREST FIRE IN ENVIRONMENTAL PROTECTION

Abstract: *Continuous monitoring of open space is of the utmost importance for the protection of forests against fire. Collected data in real time provide fast intervention of relevant services to extinguish the fire. Timely information about the appearance of fire reduce the number of areas affected by this fire and thereby minimizes the costs of fire extinguishing and the damage caused in the woods. The current way of detecting fire in an open area in Serbia is not in real time, and due to this, it is necessary to implement modern technology of collecting data related to early detection of fires. This paper presents an integral project of forest-fire protection on the territory of Serbia in order to provide the reference for the application of terrestrial automated system for early detection and prediction of forest fires. An automated system could be comprised of infrared and high-resolution TV camera surveillance, covering a large part of the forest area and forest land.*

Key words: Forest fire, prediction, early detection.

INTRODUCTION

Serbia is faced with high risk of forest fires [2]. Statistical data indicate a high number of forest fires and the area affected by these phenomena, [14], whereas losses are shown in terms of property damage and other benefits of the forest. Forest fires usually occur in areas remote from populated places, so that their detection at an early stage and timely reports to the competent services are of extreme importance. Early fire detection reduces the extinction time [6], requires fewer executors and fire-fighting equipment, thus increasing the efficiency and reducing the damage to the lowest possible level. Due to the importance of forest ecosystems, the goal is to prevent forest fires at an early stage.

There is no developed and efficient system for early forest-fire detection in Serbia, which is considered as an effective way of minimizing forest fire damage. Present method for detecting forest fires, which is based on human surveillance and transmission of information to the competent authorities, is often untimely and unreliable. An organized human surveillance requires a large number of subjects whose monitoring will cover only the area within the scope of observation. Automatic control and automatic early fire warning are certainly more advanced approaches in forest-fire protection. The duty operator at a particular center uses infrared and TV cameras placed at various locations, and he is able to observe much larger space and to emergently notify the authorized services. Such surveillance provides a clear image with the contours of the fire-affected areas, directional movement of flame front and other details, which can be used to choose the firefighting tactics.

In addition to the methods of preventive measures against forest fire (watch, observation posts, patrols), many countries use the intelligent integrated system for early detection and prediction of the spread of forest fires.

Justification and the necessity to apply these models in Serbia is the fact that the number of fires and the areas affected by them is growing [3, 14]. Fire departments need early fire detection systems, as well as the necessary details about the fire location and its surroundings. A new approach for early forest- fires detection in Serbia has been described and evaluated in this paper.

This paper presents an early forest fire detection model based on the terrestrial systems that rely on the appropriate cameras, with the aim to provide a reference for the development of this model in Serbia.

FIRE DETECTION SYSTEMS

Modern fire detection systems used worldwide today can be divided into three groups: satellite, aerial and terrestrial detection systems [7]. Each of these systems has certain advantages and disadvantages.

Satellite systems implemented in developed countries are extremely efficient in detection of forest fires. The shortcomings are signal delay, [9] and unreliability of detection in case of cloud cover. Some of the commercial satellite systems are FIRE - M3 (Canada) and FUEGO (Europe).

Air systems are used to cover large areas of forest by applying technically equipped aircraft for this purpose. The disadvantage of this method for early fire detection is the reliability in case of strong winds or low cloudiness. Some of the systems in commercial use are BOMEN (Canada) and GerINTRADAN (Denmark).

Terrestrial systems use the cameras in the visible and / or infrared part of the spectrum which transmit the signal to command operations center from the peripheral observation stations, [8]. The characteristic of this system is the continuity of information delivery from a particular area, with the possibility to provide other data (mini weather station) relevant competent fire protection services. The signal can be transferred from the transmitter to the Operations Center by wired or wireless network, with the possibility of receiving a signal on an event from several peripheral observation stations. Some of the commercial terrestrial systems are: BOSQUE (BAZAN-FABA Spain), SR-10 - (ALENIA, Italy), FireWatch (Germany), FireHawk (South Africa), FireV (England), UraFire (France) and others [10].

THE AUTOMATIC EARLY FIRE DETECTION SYSTEM ARCHITECTURE

An early fire detection system consists of several interrelated and dependent subsystems, namely:

- observation subsystem,
- analytical subsystem,
- information subsystem, and
- communication subsystem.

Observation subsystem consists of a network of sensor stations and a central station that are interconnected by telecommunications network, [11]. Sensory stations transfer the data from the cameras to the central station for further analysis. The operator in the command operations center checks the signal obtained from thermal (infrared) and TV (video) cameras. After checking the signal, a duty operator forwards the information to the authorized services. Sensory stations are placed on elevated locations with good visibility. TV cameras are equipped with a zoom lens that allows the operator to make more realistic assessment of the location and the type of fire. Infrared sensors can detect fire area of 6 m^2 and the presence of smoke at 10 m height at a distance of 10 km, so that the maximum signal coverage area of an observation station is about 314 km^2.

The communication unit transmits the images from the infrared and the video camera from the surveillance station to the operational command center. A special type of package in the communication protocol-ALARM package - has been introduced with the aim to provide a reliable detection of an alarm event. In this way, the critical events of great importance to protection of forests against fire can be signaled.

The system topology is one of the standard topologies in computer networks, so-called Star topology, [12]. Figure 1 presents the architecture of the system, consisting of peripheral surveillance stations (PSS) and command operations center (COC).

In addition to automatic mode, there is a manual mode in case of additional verification of events and control of certain locations.

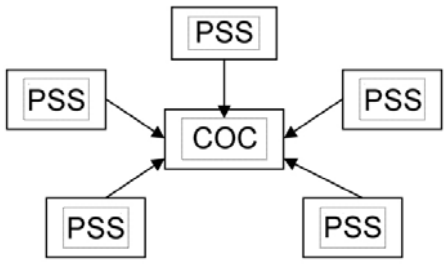

Figure 1. *The architecture of early forest-fire detection systems*

Other subsystems are used for collecting, modeling, storing, analyzing and visualizing information received from surveillance stations.

Figures 2 and 3 provide an illustration of a system and a camera for fire detection, [16].

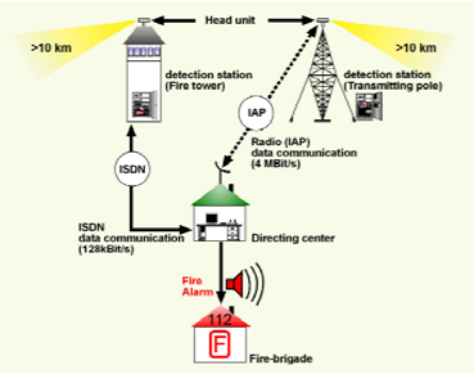

Figure 2. *The components of FIRE-WATCH system*

Figure 3. *FIRE-WATCH camera*

OBSERVATION SYSTEM OF EARLY FIRE DETECTION IN SERBIA

Serbia is located in Southeastern Europe between 18° 49′13″ i 23°00′43″ East longitude and 41°51′05″ i 46°11′25″ North latitude. The territory of the Republic of Serbia is 88361 km^2 with 6164 inhabited areas and

7,120.666 people per 2011 census. The average density of population in Serbia is 91.92 inhabitants per km^2.

The forest area in Serbia is about 2.3 million hectares, not including the wooded region of the Autonomous Province of Kosovo and Metohija; 51% is state-owned and managed by public companies, whereas about 49% are privately owned and managed by the owners of forests [4, 5].

According to the type, deciduous forests are prevailing. Coniferous forests, which are particularly sensitive to the effects of fire, occupy about 10.8% of the forest area. Fire-affected forest areas and forest lands vary from year to year, Figure 4.

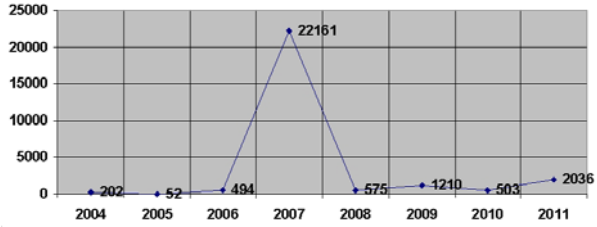

Figure 4. *Fire-affected forest areas on the territory of Serbia, in 2004-2011 period (in he)*

Orographic characteristics of Serbia indicate that the plains up to 200 m above sea level occupy 36.83% of the total area [1]. Gently sloping lands, with sea level between 200 and 500m, occupy 24.70% of Serbia's territory. The altitudes higher than 500m occupy less than 40% of the territory of Serbia. The mean height of land above sea level is 470m. On the elevated locations, there is a number of facilities that are used as receivers and transmitters of TV signals, as well mobile phone masts. Sector for Emergency Situations of the Ministry of Internal Affairs of the Republic of Serbia has anti-hail protection radar centers. The list of radar centers, their locations, elevations (above sea levels) and surface coverage are shown in Figure 5 and Table 1 [13].

Professional staff is taking care about these radar centers which are networked with regional fire-rescue units. There is a regular supply of electricity, as well as backup sources of electricity ensuring continuity of supply of energy to the devices and systems. The current number of radar centers with an installed early fire detection system can cover about 4.6% of the territory of Serbia. The facilities within radar centers can be used for operational command centers and surveillance stations.

Figure 5. *The network of radar centers in Serbia*

Table 1. *The list of radar centers in Serbia*

Name of radar center	City Municipality	Above mean sea level (m)	Longitude	Latitude	Surveillance surface (he)
Crni Vrh	Bor	1027	21° 58' 12' E	44° 07' 48" N	540 300
Petrovac	Petrovac na Mlavi	280	21° 20' 32" E	44° 19' 34" N	481 400
Valjevo	Valjevo	387	19° 55' 26" E	44° 22' 26" N	587 300
Bukulja	Aranđelovac	695	20° 32' 02" E	44° 17' 55" N	612 500
Samoš	Kovačica	105	20° 46' 37" E	45° 11' 20" N	773 975
Fruška Gora	Novi Sad	507	19° 48' 58" E	45° 09' 25" N	664 000
Bajša	Bačka Topola	105	19° 36' 04" E	45° 47' 10" N	715 625
Užice	Užice	832	19° 50' 47" E	43° 53' 13" N	476 300
Bešnjaja	Kragujevac	559	21° 03' 10" E	43° 59' 49" N	487 200
Kruševac	Kruševac	406	21° 15' 33" E	43° 37' 16" N	568 100
Niš	Niš	813	21° 57' 07" E	43° 24' 18" N	643 500
Sjenica	Sjenica	1244	19° 58' 41" E	43° 15' 43" N	570 700
Beograd	Beograd	203	20° 25' E	44° 46' N	

At the second stage, surveillance stations could be installed on transmitters and repeaters of the Public Enterprise Broadcasting Equipment and Communications (Ser. ETV), distributed all over Serbia, Figure 6 [15]. This enterprise uses 250 transmitters and repeaters to emit radio and television signals and mobile signal. With the current number of radar centers of the Emergency Department and transmitters and repeaters of ETV, 82,582 km^2, would be covered, which is about 93% of the territory of Serbia

CONCLUSION

Fires threaten forests which results in enormous material and environmental damage. Protection of forests against fire is based on a variety of preventive measures and measures for fighting against forest fires, in order to minimize the total damage. In addition to other preventive measures, early detection and fire extinguishing in the initial stage are important in the protection of forests against biotic and abiotic factors.

The existing surveillance of forest areas is unreliable and inefficient; therefore, forest fires are a serious threat to the development of forestry. There is justification and necessity to apply modern system of early detection and prediction of the spread of forest fires on the territory of Serbia.

Figure 6. *The network of transmitters owned by PE Broadcasting Equipment and Communications*

Given the initial investment needed to install these systems on a large area of Serbia, it is worthy to adapt the activities and dynamics based on the condition of vegetation in the area and the chronology of the fire from the previous periods It is justified, in the first period of early detection, to include areas that are under specific protection status (national park, nature park, strict nature reserve, etc.).

Given the social utility of this form of open space surveillance, this project could be a point of interest for many different entities. The use of modern technical solutions for early detection of forest fires would significantly reduce the harmful effects of these fires in Serbia.

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BIOGRAPHY

Stanimir Živanović was born in 1960. He obtained BSc, MSc and PhD from the Faculty of Occupational Safety in Niš. He worked in the Ministry of Internal Affairs - Emergency Management, Department in Bor as a fire safety specialist, from 1983 to 2013. He is the author and co-author of three monographs, over twenty scientific papers published in international journals and scientific conferences. His research interests involve fire protection and environmental protection.

RANA DETEKCIJA ŠUMSKIH POŽARA U FUNKCIJI ZAŠTITE ŽIVOTNE SREDINE

Stanimir Živanović, Darko Zigar, Dejan Krstić

Rezime: *Neprekidni monitoring otvorenog prostora je od najvećeg značaja za zaštitu šuma od požara. Prikupljeni podaci u realnom vremenu omogućavaju nadležnim službama da dovoljno brzo pristupe gašenju požara. Pravovremene informacije o pojavi požara utiču na smanjenje površina zahvaćenih ovim požarima a time i minimiziranje troškova gašenja i pričinjene štete u šumi. Postojeći način otkrivanja požara na otvorenom prostoru u Srbiji nije u realnom vremenu te je potrebno implementirati savremene tehnologije prikupljanja podataka vezanih za rano otkrivanje požara. U radu je predstavljen integralni projekat zaštite šuma od požara na području teritorije Srbije kako bi se obezbedila referenca za primenu zemaljskog automatskog sistema za ranu detekciju i predikciju šumskih požara. Automatski sistem bi mogao biti izveden osmatranjem pomoću infracrvenih i TV kamera visoke rezolucije sa pokrivanjem većeg dela površina pod šumom i šumskim zemljištem.*

Ključne reči: šumski požar, predikcija, rana detekcija.