CONCEPTUAL MODEL OF A STATIONARY SURVEILLANCE SYSTEM FOR THE EARLY WARNING OF FOREST FIRES - ASPires-GEO

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Abstract*:* "Advanced systems for prevention and early detection of forest fires - (ASPires)" includes a Stationary systems deployed for prevention (ASPires-GEO). A conceptual model of ASPires-GEO is discussed. The model is based on already available components on the market. The main objective is to build a real time monitoring system for early warning of forest fires with high reliability. ASPires-GEO obeys the approach called Multi System Appliance Approach (MSAA), which provides high efficiency in deploying and distributing the system.

Key words: forest fire; information systems; intelligent measuring point; stationed monitoring system.

1. Introduction

The forests are vital part of the nature. They provide shelter for animal species, protects soils from erosion, regulates air currents and precipitation, purifies the air and as a result maintain the biological balance of our planet. Unfortunately forest are often victim of fires which cause serious damages to the economy, environment and in some cases lead to human loses [1]. Only in 2017 forest fires have resulted to $14 billion insurance losses in the world which is the highest historical record. Among the most devastating fires is the wildfire in California (Figure 1), estimated on more than $9 billion loses [2].

Fig. 1. The California wildfire (2017)

Bulgaria is not exception from the negative world trend. 583 fires were registered in the country in 2016, and they affected 6 338.9 ha forest territories. The loses of these fires were estimated at BGN 6 million including wood, af-forestation, labor of the people involved in the extinguishing and losses from forestry [3].

The most frequently observed reasons for forest fire are [1]:

- Throw out of unchecked matches and cigarettes;
- Careless handling of fire by workers, pastors or tourists;
- Uncontrolled firing of household waste or large parts of dry grass vegetation near forests;
- Technical failure of machinery and vehicles working in the forest;
- Children's play with fire;
- Self-ignition of substances and materials;
- Natural phenomena (lightning);
- Short circuits and accidents of electric distribution lines that pass over and close to forests;
- By human intention.

The problem with the forest fires shows the necessity not only of regulations and norms but also of monitoring and information system for early fire detection to have fast and effective actions for fire extinguishing.

Currently there are several systems for early fire detection. Some of them are: FireALERT (USA); Forest Watch (Russian Federation); Fire-Watch (Germany).

FireALERT is an early warning, forest fire detection sensor system. It detects in a range of 1 mile, analyses and wirelessly transmits the position of a fire in real time. The key element of the system is the IR detector with narrow band pass filter for higher accuracy of fire detection. The system registered the spectral pattern of the radiated in the atmosphere energy produced by the chemical flame reaction. Once a fire has been detected, the system immediately transmits an alarm and continues to monitor and report the fire's progression. The system uses GPS information for its location which is included in alarm transmission data [4].

Forest Watch is a warning and monitoring system currently operates in 33 regions of the Russian Federation, including reserves and national parks. The system includes high-quality AXIS Q6045-E network cameras with support of 20x optical zoom, and 12x digital zoom as well as lens positioning accuracy of 0.1° for more accurate fire localization. The camera has CMOS sensor with higher resolution (1920x1080, HDTV 1080p) and supports of night mode [5].

FireWatch is a terrestrial, digital, remote surveillance system which is capable of observing larger forest regions, and to analyze, evaluate, link and store the collective data [6]. The system is used in Germany and consists of Optical Sensor System (no CCTV or Still Video Camera) with high resolution and night mode. In case of a recognized event of fire, it automatically sends an alarm signal to the control center. The operator located there evaluates based on his experience and knowledge all events and data registered and transfered by the system [6].

Other system, e.g. Thermal Fire Gard System /Slovakia/ uses thermal imaging camera, fire detection sensor, and CCTV camera. The system is again operator dependent system. [7]

All systems mentioned above have a significant problems with interpretation of the measured data and reliability of their results (in some cases up to 60% faulty detection).

Additional studies [9-12] have shown that the systems for early fire detection may include (but not limited) the following components :

- Infrared camera
- HD camera
- Laser rangefinder
- Pan tilt device
- Meteorological station
- Intelligent software for analysis and event generation

In the next part of this paper is presented advanced concepts for early detection systems of forest fires with significantly increased reliability that integrates sensor networks for data collection and acquisition at existing Crisis Management Information Systems (CMIS). The concept is a part of the project "Advanced systems for prevention & early detection of forest fires - (ASPires)" [8] supported by National Cluster for Intelligent Transport and Energy Systems (NCITES) from Sofia/Bulgaria.

2. Concept

The stationed monitoring system for early warning of forest fires called ASPires-GEO is a multi sensor solution for the existing fire towers, combining thermo-graphic functions and detection of smoke, using specially elaborated cameras and specialized software, which grants greater efficiency. The solution provides detection of the fires at their initial stage with great efficiency in hilly, mountain and alpine terrains with non-stop scanning of the protected area and possibility of a real-time surveillance.

The systems consist of the following basic components:

- Thermal camera
- Pan tilt device
- Meteorological station
- Intelligent software for analysis and event generation

The thermal cameras and meteorological stations measuring temperature, humidity and atmospheric pressure are the main sensor components located on a single surveillance

tower station, however the system is not limited to them and can be extended with additional sensors and even drones. The information from the thermal cameras mounted on several towers spread above the forest terrain is overlapped for increased reliability. For localization of the fire event the geographic location of the towers is also used and transmitted to the remote software platform.

ASPires-GEO supports a data transmission interface in order to ensure integration with other systems for data processing and analyzing.

The ASPires software platform provides a complete technology for collecting data from sensors and processing them. ASPires is a cloud technology that is not limited to any specific geographic location and as a result the platform is geographically irrelevant since the all localization data is transfered from the remote sensor towers. The data that is collected theoretically can be used for arbitrary analysis as well as transmitted to specialized management systems.

The term "sensor" should be considered as an abstract definition. In general, the sensor is an object that converts and transmits formalized information to the ASPires platform. The nature of this information depends on the sensor's functional characteristics.

The basic principles underpinning the use of stationary monitoring stations (ASPires-GEO modeled in this case) regarding to sensor technology and the ASPires platform are:

A) The communication between the stationary station (ASPires-GEO) and the ASPires platform is implemented through an intermediary called conditional ASPires-GEO-Gateway. The Gateway concept allows the provision of normalized data to the ASPires platform. Data normalization allows their universal use, both individually and in conjunction with data from other types of sensors.

B) The pan tilt device on which the cameras are attached is manageable. This allows the predefining of points of the forest area. Each point (PRESET) has a fixed area depending on the distance of the cameras to the object. The intelligent software, an element of ASPires-GEO, defines the warmest object within each PRESET. If the warmest element has a temperature higher than the preset, then an alarm signal is generated.

Generally, each PRESET is a "sensor" (ASPires-GEO-Sensor). This sensor provides information about an area, which should be determined by the settings (depending on the distance of the camera from the scan point and the quality of the camera).

Each Aspires-GEO-Sensor is characterized by the following data:

- Sensor ID
- Geographical coordinates of the center
- Diameter
- Other data to help teams work in a crisis situation (location of specialized facilities, routes, communication points, etc.)

In real environment ASPires-GEO-Sensor provides the following information:

- Sensor ID
- Date of Event (yyyy, mm, dd)
- Event time (hh, mm, ss)
- Temperature of the warmest point
- Alarm Indicator (Y / N)
- Picture of the area monitored by the sensor with the hottest mark.
- Meteorological data at the point of the ASPires-GEO module. (These data can serve as an assessment of the impact of the climate on the accuracy of the data received by the sensor).

C) ASPires-GEO provides an API interface. The API interface is specific to each technical implementation of a monitoring module. Through this interface, the data received from the sensors is transmitted to ASPires-GEO-Gateway.

ASPires-GEO Gateway includes a specialized ASPires Platform driver. This driver is engineered for any existing platform (Figure 2).

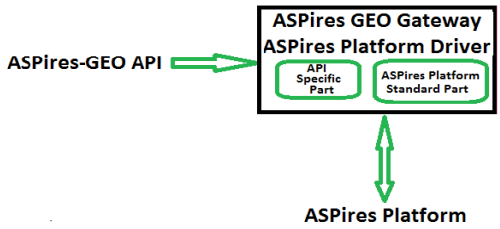

Fig. 2. ASPires-GEO Gateway

The concept of the stationed monitoring system for early warning of forest fires is shown on Figure 3.

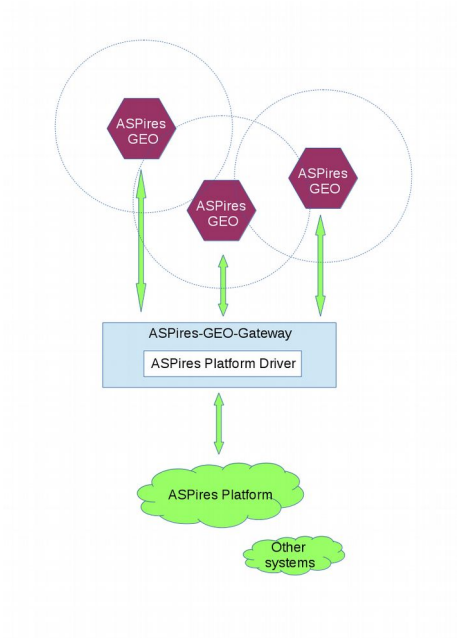

Fig. 3. Concept of stationed monitoring system for early warning of forest fires

3. Test set-up

ASPires-GEO is based on already available components on the market.

The hardware and software equipment, produced by the Bulgarian company OPTIX Ltd., was hired for the experiment. The equipment is mounted on the roof of the business building of CANTEK Ltd., a Bulgarian company and a member of the National Cluster for Intelligent Transport and Energy Systems (NCITES). The initial results are subject of future processing.

5. Conclusions and future work

The stationed monitoring system for early warning of forest fires is designed to be applicable to varios terrains and meteorological conditions.

ASPires-GEO already supports a data transmission interface not only with the cloud technology ASPires explained above but also with other systems, e.g. with the system ASPires WEB Portal. ASPires-GEO and ASPires WEB Portal are subject to the approach called Multi System Appliance Approach (MSAA) discussed in [8]. ASPires WEB Portal consists of 3 parts already developed:

- ASPires Project IDS (a complete system for manageable and secure publishing of WEB content),
- ASPires Project web site;
- ASPires Document management portal.

ASPires GEO and ASPires WEB Portal are currently in test mode by the National Cluster for Intelligent Transport and Energy Systems (NCITES). In the next stage of the project a sufficient software will be developed for processing of collected data to acquire more reliable detection of forest fires.

The information collected by the sensors will be processed, stored and used for long time data analisys and self-updated risk of fire. The estimated risk will be based on varios previously registered information, for example long time sesonal, day/night information for the forest and meteorological conditions. The quantified risk value will be used in real time for decision making and consiquently for improving realiability since it is another information channel used for decision. As a result the entire system will be multy-channel, self-learning decision-making system.

Additionally the concept will be tested with several towers. This hardware redundancy together with overlapping of their information will dramatically increase the system reliability.

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