A SURVEY OF FOREST FIRE DETECTION TECHNIQUES

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ABSTRACT

The most important parts of protective and observe systems are the fire detection systems. Fire detection is very significant for the safety of the people. In past there were many methods used in forest fire detection. This paper presents a new type of system which uses Un-manned Aerial Vehicle (UAV), wireless technology and power of artificial intelligence for forest fire detection. The un-manned Aerial Vehicle (UAV) will keep the forest under surveillance through auto piloting and transmits real-time video to the base station using wireless communication based on the acquired data. The base station decides and takes control over UAV (eg. Moving left, right, rotating etc.) and also in base station pattern classification is used to detect whether any fire exists in forest, if it so drone becomes stationary and provides live video of fire and fire alert signal is established.

Keywords- UAV (Drone), sensor, satellite, camera, Feedforward neural network.

INTRODUCTION

Forests are the protectors of earth’s ecological balance. Unfortunately, the forest fire is usually only observed when it has already spread over a large area, making its control and stoppage arduous and even impossible at times. The result is devastating loss and irreparable damage to the environment and atmosphere (30% of carbon dioxide (CO₂) in the atmosphere comes from forest fires) [1], in addition to irreparable damage to the ecology (huge amounts of smoke and carbon dioxide (CO₂) in the atmosphere). Among other terrible consequences of forest fires are long-term disastrous effects such as impacts on local weather patterns, global warming, and extinction of rare species of the flora and fauna.

Fire detection and monitoring is required to reduce damage to forest. Fire detection is necessary for the safety of the people. Millions of hectares of forests are destroyed by fire every year. Specifically, forest surveillance and early forest fire detection have important relevance. These tasks have been usually carried out by means of lookouts on the affected areas. Professional people in watchtowers is the most broadly used method.

Use of satellites and satellite images are another technology for detecting forest fires. Earth-orbiting satellites and even air-floating devices have been employed for observation and detection of forest fires. Satellite images gathered by two main satellites launched for forest fire detection purposes, the advanced very high resolution radiometer (AVHRR) [2], launched in 1998, and the moderate resolution imaging spectroradiometer (MODIS), launched in 1999, have been used [3,4]. Unfortunately, these satellites can provide images of the regions of the earth every two days and that is a long time for fire scanning; besides the quality of satellite images can be affected by weather conditions [5].

Several sensor technologies have already been applied for detecting fire. Wireless sensor networks (WSN) have been applied in forest fire detection. Applications of wireless sensor networks are environmental and health monitoring; military target tracking and
surveillance; animals, humans and vehicle tracking and disaster recovery.

Smoke detection method is one of the useful and challenging problems mainly in open environment, such as port, chemical plants and power plants as they cause abuse to surrounding areas. In such areas, fire or flame detection methods [6] are limited because fire or flames sources cannot always fall properly into the range of sensors due to their positions and sizes. Smoke detection is good and effective for early fire detection in such cases. In conventional methods heat or smoke sensors are used for the detection of fire. These sensors had some limitations like time and they cannot cover a wide range of area.

To overcome above limitations un-manned aerial vehicle (UAV) is proposed for detecting forest fires. The un-manned Aerial Vehicle (UAV) will keep the forest under surveillance through auto piloting and transmits real-time video to the base station using wireless communication.

LITERATURE REVIEW

Sensor and camera

These days, two types of sensor networks are available for forest fire detection, wireless sensor network and camera surveillance. The development of sensors, digital camera, image processing, and industrial computers resulted in the development of a system for optical, automated early recognition and warning of forest fires.

Different types of detection sensors can be used in terrestrial systems [7];(i)video-camera, sensitive to visible spectrum of smoke recognizable during the day and a fire recognizable at night,(ii)infrared (IR), thermal imaging cameras based on the detection of heat flow of the fire,(iii)IR spectrometers to identify the spectral characteristics of smoke,(iv)light detection and ranging systems—LIDAR (detection of light and range) that measure laser rays reflected from the smoke particles. The variant optical systems working according to different algorithms designed by the producers, all have the same general concept in smoke and fire glow detection. Simply, the camera produces images every while. The image consists of a number of pixels, where the processing unit tracks the motion in images and checks how many pixels contain smoke or fire glow and then the processing unit sends the results for another algorithm to decide whether or not to produce an alarm for the operator. Most of the optical systems need to be integrated with geographical maps for localization reasons.

Use of a given type of camera or sensor depends not only on the specific conditions of the operation but also on the financial resources available.

AlarmEYE is a video imaging system for forest fires early detection integrated with infrared, black and white and colour frequency detection. Its infrared option can distinguish between flame image and heat vapour. This system was produced and deployed in Thailand [7-9].

EYEfiSPARC Optical sensors produced by EYEfi, Australia, for forest fire detection consist of(i)camera (colour during the day and ultralow light gray scale at night),(ii)weather station,(iii)lightening detection sensor,(iv)communication unit (0.25 Mpbs),(v)power system. Thermal camera or pan tilt zoom cameras can be added to the system. EYEfi does not offer automatic detection of smoke but plans to introduce it sometime in the near future. Simply, EYEfi can provide images for fire agencies whenever the operator notices smoke and can use EYEfi software to use the GIS map and locate the smoke position on the ground. A weather station and lightening detector are included in the system for more accuracy [8,10].

UraFire system is based on identifying smoke by clustering motions with a time input to reduce the number of false alarms and is used and produced in France [7, 11,12].

Forest Fire Finder This optical system has totally different techniques and is a system
based on intelligent analysis of the atmosphere instead of detecting the smoke or fire glow. Forest Fire Fire Finder tracks the way the atmosphere absorbs the sun light, which depends on the chemical composition in the atmosphere. Different composition has different absorption behaviour, so Forest Fire Finder can recognize the organic smoke from burnt trees and the industrial smoke in range of 15 Km. The equipment can be installed in tree crowns for faster detection and this system is used in Portuguese forests [7,13].

ForestWatch is an optical camera sensor system which provides a semiautomatic fire detection produced by EnviroVision Solutions, South Africa. A tower camera scans the area for smoke during day and fire glow during night. It can detect smoke in range of 16–20 Km and then report it over 0.25 Mpbs 3G or microwave connections [9].

ForestWatch consists of [10] (i)a Pan tilt camera to allow a 360° rotation and +33 to −83 tilt from horizon, with 24x optical zoom,(ii) imagesamplingengine,(iii) communication system, such as 3G, microwave, or satellite,(iv) ForestWatch software to process the received data and produce sufficient evaluation for the operator to make the final decision. Schroeder (2004), in his article “Operational trial of the FireWatch wildfire smoke detection system,” argued that the microwave links are inexpensive and do not require a licence. However, these systems require a very high line of side transmitter and receiver every 50 Km. Schroeder suggested that satellite connection might be more effective and cheaper [14].

ForestWatch is the most popular system in forest fire detection and only Canada has a documentation test. ForestWatch performed adequately in this test: fires were reliably detected up to a 20 km range but false alarms were also generated. Operational Forest Watch systems are in use in South Africa (83 towers), Swaziland (5 towers), USA (22 towers), Canada (4 towers), Chile (20 towers), and Slovakia (4 towers). A pilot scale operation (two towers) is installed in Greece. The related Harbour Watch system has been deployed in South Africa and Namibia [9].

FireHawk A risk management system which provides fire location consists of the following three layers [7]: (i) imaging layer represents installing cameras on suitable places,(ii) communication layers set up the wireless link,(iii) machine vision layer is the layer where FireHawk uses the ForestWatch software and GIS to provide a location and the shortest path to the fire. Currently, FireHawk is installed in two areas in South Africa [15].

FireWatch is an automatic smoke detection system which can identify smoke within a range of 10–40 km. It has been studied for years (since 1992) in Germany, and now it is produced by German Aerospace Institute (DLR).

Operational FireWatch systems are in use in Germany (178 towers, 22 control rooms), Estonia (5 towers, 1 control room), Cyprus (2 towers, 1 control room), and Mexico (1 tower, 1 control room). Pilot scale systems (1 or 2 towers) are in use in the Czech Republic, Portugal, Spain, Italy, Greece, and the USA [9].

FireWatch system overview is as follows [16] (i) Optical sensor system (OSS): each OSS rotates 360 every 4 to 6 minutes in day time and 8–12 minutes during the night in 10 degree steps.(ii) Data transfer: OSS at the tower has a wireless connection to the officer computer.(iii) Central office: the forest workers are provided with work space (computers, monitors, and printer).

If the sensor detects a cloud or a column of smoke, the information is transmitted to a central forest fire control office via ISDN (64 bits) or radio transmission of 1 Mpbs; it can be transmitted over 3G but not recommended [9].

The three systems are EYefi, FireWatch, and ForestWatch, all of which had been tested on three types of fires: research burning, private burning, and agency burning in Tumut in NSW and Otway Ranges in Victoria in 2010.
One of the first proposals of the use of wireless communication for fire detection was the SIGMASPACE system. That used smoke detectors [17]. In [18], Chen et al. proposed a method based on data fusion. The algorithm used temperature, smoke density and CO density values, and neural networks and fuzzy inference to determine if a fire has occurred. However, none of these proposals are based on the use of WSN technology.

Doolin and Sitar described in [19] a system to monitor forest fires, based on the use of WSNs. The nodes of the system were able to sense temperature, humidity and barometric pressure, and were equipped with GPS units. However, the authors did not describe any method to detect fires.

**Satellite based systems**

Giovanni Laneve et al [20] proposed a satellite based fire detection system can be considered operationally useful for Mediterranean countries when fires with a minimum extent of 1500 m² can be detected with a temporal resolution of 30 min. In fact, such a system should be able to detect fires at their first stage when it is possible to extinguish them more easily.

The use of satellite images to detect forest fire is a well-known application based on the exploitation of different sensors [such as the Advanced Very High Resolution Radiometer, the Terra Moderate Resolution Imaging Spectroradiometer (MODIS), GOES, etc.] characterized by various spatial resolutions [21]-[22].

Centro di Ricerca Progetto San Marco (CRPSM) has been studying for several years the possibility of using images acquired by the Spinning Enhanced Visible and Infrared Imager (SEVIRI) sensor onboard the GOES Meteosat Second Generation (MSG) sensor [8]. This multispectral sensor is characterized by a spatial resolution of 3 km (at the equator), an observation frequency of 15 min, and spectral bands needed to implement fire-detection applications. Algorithms specifically devoted to fire detection using low resolution multispectral imagery can be categorized in two classes: fixed threshold and contextual threshold [23]-[24].

Both methods can be based on a single- or multichannel approach and show some limits related to the selection of the thresholds to detect fire or potential fire pixels. In fact, the fixed threshold technique gives good results for a particular region/biomass [25]. On the other hand, the contextual technique is applicable for a wide range of conditions, but it requires conservative thresholds in the attempt to reduce false fire detection [25]. Therefore, it results scarcely useful for early fire detection and tactical response.

Zhanqing Li et al [27] proposed satellite-based remote sensing techniques were developed for identifying smoke from forest fires. Both artificial neural networks (NN) and multithreshold techniques were explored for application with imagery from the Advanced Very High Resolution Radiometer (AVHRR) aboard NOAA satellites. The NN was designed such that it does not only classify a scene into smoke, cloud, or clear background, but also generates continuous outputs representing the mixture portions of these objects. The signals of smoke detected by TOMS and AVHRR are quite different but complementary to each other. In fact, AVHRR is most sensitive to low, dense smoke plumes located near fires, whereas smoke detected by TOMS is dispersed, thin, elevated, and further away from fires.

The climatic impact of smoke is twofold: cooling due to smoke particles and warming due to greenhouse gases. Smoke particles scatter and absorb incoming solar radiation, thereby having a cooling effect at the surface, but warming effect on the atmosphere [28].

Federico Alimenti et al [29] proposed the development of a microwave noise-adding radiometer, which is purposely designed for the fire detection in forest environments. The sensor operates at 12.65 GHz and exploits commercial Satellite Television (SAT-TV) components such as a parabolic dish and a low-noise block. First,
a simple system model is presented to estimate the radiometric contrast due to the presence of fire (increase in the antenna noise temperature with respect to the background) at a certain distance from the receiving antenna. Then, the design of the sensor is addressed, underlining the key technologies that allow the required performance to be attained at low industrial costs. An experimental characterization of the developed radiometer is reported focusing on both accuracy and sensitivity issues. Due to a continuous gain calibration based on the noise-adding procedure, the antenna noise temperature can be retrieved with an absolute error of 4 K without any thermal stabilization of the instrument electronics. Last, real fire detection experiments have been carried out both in laboratory and open-space environments. A radiometric contrast of 8.8 K has been recorded for a wooden fire of 0.2 m² placed at a distance of about 30 m from the antenna.

IR sensors (IR cameras) are built to detect the increased electromagnetic radiation produced by the fire in the 3- to 5-μm mid-IR band, which has been selected since it is far from the peak of both the Earth and Sun radiation. High-resolution IR cameras have been shown to be able to detect small fires (about 1 m²) up to 10 km away from the sensor itself. Nonetheless, they suffer from solar reflections in rocks, stones, roofs, roads, and metallic structures, determining a quite high false-alarm rate. In fact, the mid-IR responses of these objects are similar in intensity to the ones produced by fires. Optical sensors (visual cameras) are able to detect the smoke plume due to the fire.

PROPOSED SYSTEM

We are going to use the unmanned aerial Vehicle (UAV), wireless communication, artificial intelligence for forest fire detection.

DRONE

A drone, in a technological context, is an unmanned aircraft. Drones are more formally known as unmanned aerial vehicles (UAV). Essentially, a drone is a flying Robot. UAVs have most often been associated with the military but they are also used for search and rescue, surveillance, traffic monitoring, weather monitoring and firefighting, among other things. Using neural networks the drone has to be trained.

FEEDFORWARD NEURAL NETWORK

The Feedforward neural network was the first and simplest type of artificial neural network devised. In this network, the information moves in only one direction, forward, from the input nodes, through the hidden nodes (if any) and to the output nodes. To train a neural network to answer correctly, we’re going to employ the method of supervised learning. With this method, the network is provided with inputs for which there is a known answer. This way the network can find out if it has made a correct guess. If it’s incorrect, the network can learn from its mistake and adjust its weights.

CONCLUSION

Different fire detection techniques have been proposed for safety and protection of the people and environment. We have discussed about sensors and satellite based systems for forest fire detection. Fire detection using unmanned aerial vehicle is also efficient. The unmanned Aerial Vehicle (UAV) will keep the forest under surveillance through auto piloting and transmits real-time video to the base station using wireless communication.

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