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Detection techniques of forest fire: Using WSNs

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Abstract

Forests are essential to maintain the ecosystem of the earth and also for human survival.However, because of some uncontrolled natural conditions and abnormal human activities, forest fires occur frequently as we see. One of the major cause of depletion of forests, is forest fire. In order to protect the forest fires, many forest fire detection methods have been adopted like charge-coupled device (CCD) cameras and Infrared (IR) detectors, satellite systems and images, and Wireless sensor networks, Video surveillance. Therefore, this paper reviews differentexisting algorithms based on wireless sensor network and their parameters that work for forest fire detection. This paper provides a comparative study of these forest fire detection algorithm and also provide a new idea for future work.

Keywords: Canadian Approach; Dempster Shafer; Deterministic Topology; FWI; Korean approach; Mobile nodes

1. Introduction

Forests play a crucial role in preservance of natural human resources and the environment, which in return play a major role in maintaining ecological balance. However, in recent years, many forest fires are recorded in various regions of the world, causing enormous losses. Forest fires, also known as wildfires, vegetation fire, is common in vegetated areas of Australia, South Africa, United States and Canada, where climates are sufficiently moist to allow the growth of trees, but feature extended hot and dry periods. The natural disasters like lightning, volcanic eruption, sparks from rock falls, and spontaneous combustion and human activities are responsible for these forest fires. The forest fire cover has been reduced drastically over the past for several years. Forest fires don't just have an impact on the environment, but on economy, society, and human health as well. Traditional methods of this forest fire detection are watching towers, aerial surveillance, long distance video detection and satellite monitoring etc. In fixed ground surveillance, efficiency is less in conditions like dust clouds and shadow areas (areas not visible) and also includes high installation cost with experienced personnel. While in surveillance cameras, technical complexity issues appear with less precision on detection. Therefore, promising technology for detecting forestfires is the use of wireless sensor network. Wireless sensor consists of large numbers of sensors to monitor the physical parameters like temperature, pressure, vibration etc. Each such sensor network node has typically several parts: a radio transceiver with an internal antenna or connection to an external antenna, a microcontroller, an electronic circuit for interfacing with the sensors and an energy source, usually a battery or an embedded form of energy harvesting. Wireless sensor network is emerging technology for forest fire detection as it provides fine resolution and real-time monitoring. Therefore, wireless sensor network is an area of interest for researchers to develop new techniques for forest fire detection.

2. Literature survey

Different researchers have worked for forest fire detection using different methods. Earlier there were different methods, but wireless sensor network advances in self-organizing protocols. With some goals like early fire detection,

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real time monitoring, some algorithms solely based on wireless sensor network are discussed here. These algorithms work upon some parameters like temperature, rain, humidity etc. that are crucial for detection of forest fire. Some algorithms work upon few parameters like temperature and humidity to reduce the complexity of calculation. While some algorithms use many parameters to provide more accuracy in results.

2.1. Canadian and Korean Approach

The Canadian and Korean approach of forest fire detection are based on Wireless Sensor Network. The main focus of these methods is reliable forest fire detection. Basic idea of these methods is to collect the data via communicating through the network and analysis of collected data on basis of some parameters of forest fire detection. FWI (Fire Weather Index) is the main key of Canadian approach to calculate the fire index. FWI avoids the need of communication of each sensor to the sink as it performs aggregation of few index which reduce energy consumption also. This FWI system consists of six standardized index, three of which depicts daily variations of water content of three types of fuel forest with different speeds drying. The other three where, are linked to fire behavior and are also representative of the propagation speed, intensity of the fire and the quantity of burned fuel. Daily weather conditions like temperature, relative humidity, speed wind and rain play an important role in this approach. The Korean approach is implemented on the system FFSS (Forest-fires Surveillance System). The Korean method's index is calculated using the parameters: humidity, light and rain. This Korean approach is to calculate the level of risk of forest fires. But the Canadian approach is better than Korean approach in terms of energy consumption and execution speed.[1]

2.2. Deterministic Cluster Approach

Topology of this approach comprises of 8 secondary cluster head adjacent to single primary cluster head in a 3x3 matrix and 36 total sensor nodes are placed around this topology. Also square grid is preferred over hexagonal grid, due to less overlapping in it. Sensor nodes are deployed in a hierarchical fashion. Nine sensor nodes are arranged in each direction in a 3x3 square matrix. Data fusion is performed repeatedly column wise in every row. Here sensor nodes send regular information messages to secondary cluster head which in turn then transmits to main cluster head by saving energy. Synchronized communication occurs between nodes and they respectively sense the temperature according to their sleep-wake schedules. Danger packet is sent to base station if temperature is found above than threshold. Base station then forwards alert signal to these nodes and broadcasts the best path. Again the base station checks and waits if the threshold is still above, then again broadcast the best path else send synchronization message to nodes. [3]

2.3. Dempster Shafer and Threshold Method

These forest fire detection algorithms are based on information fusion techniques using wireless sensor network. One algorithm is based on a threshold method where nodes equipped with temperature, humidity and light sensors. The other algorithm adopts the Dempster- Shafer theory. The threshold algorithm is based on the state machine as in automata, which defines five states. A relevant change in the values of temperature, light or relative humidity stimulates the transition from one state to another, indicates the probable existence of a fire. The initial state is the State0, which represents the normal (i.e. no fire) environmental conditions, only the temperature value is evaluated here. The transitional states indicate the probable occurrence of a fire. State2 and State3 are transitional states, representing night fire or a day fire, respectively. The State3 may indicate the sunrise, whereas the State4 might represent that the mote was exposed to direct sunshine. Finally, the State4 stands for the presence of a fire. Every time the temperature is recorded, the ratio between the average of the values of a sliding window of size WT and the new temperature value, is calculated. The most recent WT temperature values get recorded by the sliding window. If this ratio is greater than threshold, it signifies a large change in the temperature value and possibly goes for forest fire detection.

Dempster Shafer method used only temperature and humidity, not light values by saving the energy consumption. The Dempster-Shafer theory, also known as the theory of belief functions, in fact is a generalization of the Bayesian theory of subjective probability. The uncertainty is well handled by D-S theory, being its big advantage; also, it does not need the knowledge of the complete probabilistic model. In the D-S theory, for a problem domain, all the mutually exclusive proposition are enumerated in the frame of discernment. When the motes were exposed to direct sunlight, both algorithms reported false positives. [2]

2.4. Centralized and Distributed algorithm

Forest fire modeling is done using FWI index model. The goals of a wireless sensor network using FWI System designed for forest fires is to provide early warning of a potential forest fire, and estimate the scale and intensity of the fire if it materializes. FWI here consists of two main components :the Fine Fuel Moisture Code (FFMC), and the FireWeather Index (FWI). The forest fire detection problem is modeled as a k-coverage problem in wireless sensor networks. This k-coverage problem can be formulated as a decision problem, whose goal is to determine whether every point in the service area of the sensor network is covered by at least k sensors, where k is a predefined value. Constant-factor centralized algorithm, and a fully distributed version which does not require sensors know their locations is purposed. Real data was recorded and analyzed for the behavior of fires, relating temperature and humidity. Thus approximation centralized and distributed algorithms were purposed to solve the node k-coverage problem efficiently, which is NP-hard. [4]

Table 1 Summary of Forest Fire Detection Techniques

S.NO.	Algorithm	Key Idea	Parameters	Data Handling	Contribution
1.	Canadian Approach [1]	Calculation of the index fire according to FWI (Fire Weather Index)	Temperature, Rain Wind, Humidity	Aggregation	Energy Efficient, More Precise Results
2.	Korean Approach [1]	Potential Fire Danger is calculated using FWI index	Rain, Wind, Humidity	Aggregation	Calculate the level of risk of forest fires
3.	Dempster Shafer [2]	Mutually exclusive proposition are enumerated in the frame of discernment	Temperature and Humidity	Data Fusion	Uncertainty is well handled by D-S theory
4.	Threshold Algorithm [2]	Ratio between the average of the values of a sliding window of size WT and the new temperature value, is calculated	Temperature, Humidity and light sensors	Data Fusion	It is able to detect all the existing fires and false positives are reduced.
5.	Deterministic Cluster Approach [3]	Significant data is sent to the base station during the occurrence of fire explosion which will help fixing the forecast procedure of forest fire.	Temperature	Data Aggregation	Provide fast reaction to forest fires together with efficient energy consumption.
6.	Centralized And Distributed algorithm[4]	Forest fire detection problem as a node k-coverage problem	Temperature and Humidity	Aggregation	Provide early warning of a potential forest fire, and estimate the scale and intensity of the fire if it materializes.

3. Conclusion and future work

These different algorithms are summarized on basis of their key idea, the parameters they have worked upon and their contribution to the forest fire detection using the latest technology i.e. Wireless Sensor Networks. Our idea for forest fire detection is using Mobile nodes, as due to the mobility, mobile WSN has a much more dynamic topology as compared to the static WSN. The advantage of using mobile sensors is that they are able to maintain a safe distance from the fire perimeter. Therefore, mobile nodes can be used instead of static nodes as a novel approach for forest fire-detection using wireless sensor networks.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest.

References

[1] Kechar Bouabdellaha, Houache Noureddine, Sekhri Larbi, Using Wireless Sensor Networks for Reliable Forest Fires, Science directs, SEIT 2013, pp . 794 – 801.

[2] Arnoldo Díaz-Ramírez, Luis A. Tafoya, Jorge A. Atempa, and Pedro Mejía-Alvarez, Wireless Sensor Networks and Fusion Information Methods for Forest Fire Detection, Science directs, 2012 , pp . 69 – 79.

[3] Ankit Kumar Jain, Ankit Khare, and Kaushlendra Kumar Pandey, Developing an Efficient Framework for Real Time Monitoring of Forest Fire Using Wireless Sensor Network, IEEE International Conference on Parallel, Distributed and Grid Computing, 2012.

[4] Mohamed Hefeeda and Majid Bagheri, Forest Fire Modeling and Early Detection usingWireless Sensor Networks, Ad Hoc & Sensor Wireless Networks Vol. 7, pp. 169–224.

[5] C. F. Garcia Hernandez, P. H. Ibargliengoytia-Gonzalez, J. , J. A . Perez Diaz and Garcia Hernandez, Wireless Sensor Networks and Applications a Survey, International Journal of Computer Science and Network Security, vol.7 no.3, Mar. 2007.

[6] M. Bahrepour, N. Meratnia, P. Havinga and C. P. Bean, Automatic Fire Detection: A Survey from Wireless Sensor Network Perspective, Technical Report TR-CTIT-08-73, Centre for Telematics and Information Technology University of Twente, Enschede, ISSN1381-3625, 2008 .

[7] D. M. Doolin and N. Sitar, Wireless Sensor Nodes for Wildfire Monitoring, SPIE Symposium on Smart Structures and. Materials, San Diego, pp. 477484, 2006.

[8] Yunus Emre Aslan, Ibrahim Korpeoglu, Özgür Ulusoy A framework for use of wireless sensor networks in forest fire detection and monitoring., Elsevier in press 2012.

[9] L. Yu, N. Wang, X. Meng;, Real-time forest fire detection with wireless sensor networks, in: Proceedings of the InternationalConference on Wireless Communications Networking and Mobile Computing, Maui, Hi, 2005, pp. 1214 – 1217.doi:10.1109/WCNM.2005.1544272.

[10] M. Cardei and J. Wu. Coverage in wireless sensor networks. In M. Ilyas and I. Mahgoub, editors, Handbook of Sensor Networks. CRC Press, 2004.

[11] Doolin, D. M., & Sitar, N. (2006). Wireless sensor nodes for wildfire monitoring. In Proc. of SPIE symposium on smart structures and materials, San Diego (pp. 477– 484).

[12] Garcia, E. M., & Serna, M. A. (2008). Simulating a WSN- based wildfire fighting support system. In Proc. of IEEE international workshop on modeling, analysis and simulation of sensor networks (MASSN) (pp. 896–902).

[13] B. Wenning, D. Pesch, A. Giel, C. Gorg, EnvironmentalMonitoring Aware Routing: Making Environmental Sensor Networks More Robust, Springer Science Business MediaTelecommunication Systems, Vol. 43, Numbers 1-2, pp. 3-11, 2009

[14] .X. Wang, S. Wang, and J. jie Ma, Sensor deployment optimization for detecting maneuvering targets, 8th International Conference on Information Fusion, 2005.

[15] E. D. Breejen, M. Breuers, F. Cremer, R. Kemp, M. Roos, K. Schutte, J. S. D. Vries, Autonomous forest fire detection, in:Proceedings of the 3rd International Conference on Forest Fire Research, Vol. 2, Nov, 1998, pp. 2003 – 2012.

[16] F. Derbel, Reliable wireless communication for fire detection systems in commercial and residential areas, in: Proceedings of theWireless Communications and Networking, Vol. 1, 2003, pp. 654 – 659. doi:10.1109/WCNC.2003.1200428.

[17] L. Sun, Wireless Sensor Networks for Fire Detection and Monitoring - I, Nanyang Technological University, Singapore 2010.

[18] \http ://www.nifc.gov/fireinfo/2004/index.html,Wildland fire season 2004: statistics and summaries, National interagency coordination center

[19] Nukhet Sazak and Haldun Abdullah , The importance of using Wireless Sensor Networks for Forest Fire Sensing and detection in Turkey, 5th International Advanced Technologies Symp osium (IATS‟09), May 13-15, 2009,Karabuk, Turkey

[20] B. Wenning, D. Pesch, A. Giel, C. Gorg, Environmental Monitoring Aware Routing: Making Environmental Sensor Networks More Robust, Springer Science Business Media Telecommunication Systems, Vol. 43, Numbers 1-2, pp. 3- 11, 2009.