Smart Data Mining Techniques for Emergency Detection Using Wireless Sensor Networks

Massinissa Saoudi[1,2], Ahcne Bounceur[1], Reinhardt Euler[1] and Tahar Kechadi [2]
[1]Laboratery Lab-STICC, Université de Bretagne Occidentale
[2]University College Dublin, Ireland
massinissa.saoudi@univ-brest.fr

Abstract

Environmental emergencies such as forest fires present a serious threat to the environment and human life. The monitoring system of emergencies should be capable of early detection in order to reduce possible damage. In this paper, we present a new approach for forest fire detection based on the integration of Data Mining techniques into sensor nodes. The idea is to use a clustered WSN where each node will individually decide on detecting fire using a classifier of Data Mining techniques. When a fire is detected, the node will send an alert through its cluster-head which will pass through gateways and other cluster-heads until it will reach the sink in order to inform the firefighters. The proposed approach is evaluated using the CupCarbon simulator. The simulation experiments show that our approach can provide fast detection of forest fires while consuming energy efficiently. [1]

1. Introduction

Environmental emergencies are presented as natural events and also human-induced accidents, that may cause severe environmental damage. There are different types of environmental emergencies, such as forest fires which are one of the main causes of environmental degradation nowadays. In some of these fires, large areas of forests of more than 21 954.61 hectares have been destroyed [4] and many people or animals have died. Therefore, the monitoring and early detection of forest fires is very important in fighting against the damage caused by fires.

Several methods have been proposed to detect forest fire, e.g., a authorities' techniques, satellite systems [2], optical cameras and wireless sensor networks [1, 5].

As a good solution, wireless sensor networks (WSNs) are an emerging technology that can be used for forest fire detection. To detect fire, a sensor node can be deployed in the forest and collect data such as temperature or humidity, and deliver these data to the base station where they can be processed and analyzed automatically for the detection of fire. This application produces a big volume of geographically distributed and heterogeneous data. In addition, the design and deployment of sensor networks has raised many challenges related to their large size, random deployment, lossy communication environment, limited battery power, limited processing unit, and small memory. Energy consumption is a particularly limiting factor for the life-time of a node in a WSN. Therefore, processing and communication should be minimized and there is a permanent need to balance the power consumption on all nodes, on the basis of their residual energy. It is also necessary to integrate Data Mining techniques into the sensor nodes in order to solve the above limitations, e.g., to reduce the size and to improve the quality of the collected data.

To this aim, we propose a new approach based on Data Mining (DM) techniques and a clustered architecture. Each sensor node will individually decide on fire detection using a classifier of DM technique. When a fire is detected, the corresponding node sends an alert through its cluster-head which will pass through gateways and other cluster-heads until it reaches the sink in order to inform the firefighters.

The remainder of this paper is organized as follows. Our approach will be discussed in Section 2. Then, Section 3 exhibits the obtained results. Finally, Section 4 concludes the paper.

2 Proposed Approach

In this section we describe the proposed architecture for forest fire detection based on WSN and Data Mining techniques. As shown in Figure 1, a large number of sensor nodes are manually deployed in the forest. These sensor nodes are organized as clusters so that each node has a corresponding cluster-head. Each sensor node can measure environmental temperature, relative humidity, smoke and light. Consequently, the communication overhead between neighboring nodes is avoided and each sensor node can detect fire locally by itself. Each sensor node predicts the fire using a Data Mining technique and sends the alert containing its identifier, to the corresponding cluster-head.

[1]This work is part of the research project PERSEPTEUR supported by the French National Research Agency ANR,under the reference ANR-14-CE24-0017-01.

The cluster-head calculates the danger rate and sends the identifier and damage rate to the sink via the gateway node. The sink detects the location of fire using the stored coordinate that corresponds to the received identifier for alerting local residents or personal fire fighting.

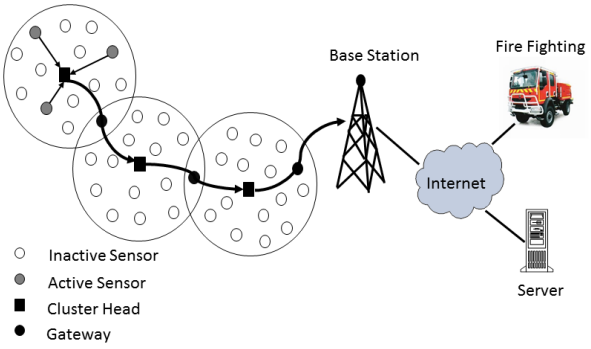

Figure 1. The proposed architecture for forest fire detection.

The proposed approach can be divided into three main phases : a clustered network architecture, route discovery to the sink, fire detection and routing alerts to the sink. These phases are the following ones:

1. Clustering: this phase consists to make the wireless sensor network in the form of clusters in order to obtain more efficient network processing and data fusion. Cluster-heads can be considered as the important points in the network to achieve data processing, and to provide cooperation and coordination.Then, this network architecture is appropriate for both early fire detection and energy conservation.

2. Routing: this phase consists to build routing tables in cluster-head and gateway nodes in the clustered network. The aim is to maximize the life-time, to ensure the efficient performance of network and to route the alert from the node which detect fire to the sink as rapidly as possible.

3. Fire Detection: this phase consists to apply DM techniques at the member node level in order to detect fire. The DM technique is learned in offline mode in order to create a model from historical fires data. Using the model obtained from learning Data Mining technique, the fire will be detected in online mode. The DM techniques used is a classification e.g., neural network, fuzzy logic, and nïve bayes.

3 Simulation and Results

To evaluate our proposed approach, we have implemented using the CupCarbon simulator which is a Wireless Sensor Network simulator [3].

Figure 2 shows an example of detecting fire with our approach using the CupCarbon simulator.

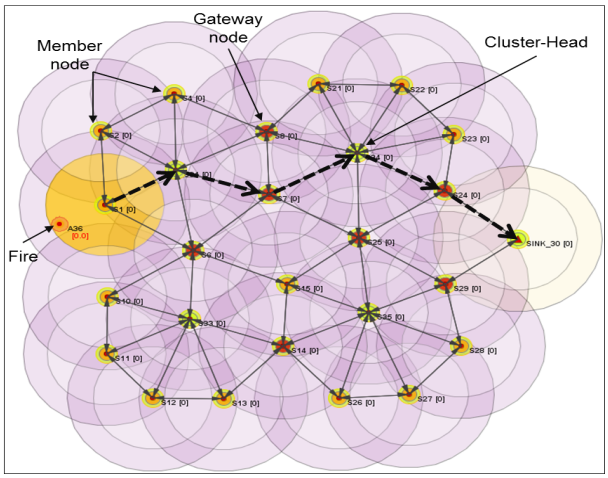

Figure 2. Fire detection using CupCarbon Simulator.

When the member node s_1 detects fire, it sends the alert to its cluster-head s_{32} , which itself sends the alert to the gateway s_7, which corresponds to the first node recorded in its routing table. In the same way the gateway s_7 forwards the alert to the next cluster-head s_{34}, from s_{34} the alert is sent to s_{24} and finally, the gateway s_{24} forwards the alert to the sink.

4 Conclusion

In this paper, we have proposed a new approach by using wireless sensor networks for forest fire monitoring and detection. Our approach takes into account the characteristics of a WSN that regards low energy capacity of sensor nodes which can affect fire detection and performance of a WSN. Our work is based on measuring and combining real data from different sensors (temperature, humidity, light and smoke) and using the DM classifier applied to data for fire detection. Applying Data Mining techniques reduces the size of data, improves the WSN speed and extends the life-time of the network to guarantee short time of decision and fire detection as early as possible.

References

[1] Y. E. Aslan, I. Korpeoglu, and Ulusoy. A framework for use of wireless sensor networks in forest fire detection and monitoring.

[2] J. Lloret, M. Garcia, D. Bri, and S. Sendra. A wireless sensor network deployment for rural and forest fire detection and verification. *Sensors*, 9(11):8722–8747, 2009.

[3] A. P. PERSETPEUR. Cupcarbon simulator, 2015.

[4] PROMETHEE. Database on mediterranean forest fires in france, 2015.

[5] H. Soliman, K. Sudan, and A. Mishra. A smart forest-fire early detection sensory system: Another approach of utilizing wireless sensor and neural networks. In *Sensors, 2010 IEEE*, pages 1900–1904. IEEE, 2010.