MULTI-SENSOR INTEGRATION SYSTEM FOR FOREST FIRE PREVENTION

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ABSTRACT:
A forest fire occurs mainly as natural factor such as wind, temperature or human factor such as light. Recently, the most of forest fire prevention is prediction or prevision against forest fire by using remote sensing technology. However in order to forest fire prevention, the remote sensing has many limitations such as high cost and advanced technologies and so on. Therefore, we need to multisensor integration system that utilize not only remote sensing but also in-situ sensing in order to reduce large damage of forest fire though analysis of happen cause and prediction routing of occurred forest fire. In this paper we propose a multisensor integration system that offers prediction information of factors and route of forest fire by integrates collected data from remote sensor and in-situ sensor for forest fire prevention. The proposed system is based on wireless sensor network for collect observed data from various sensors. The proposed system not only offers great quality information because firstly, raw data level fuse different format of collected data from remote and in-situ sensor but also accomplish information level fusion based on result of first stage. Offered information from our system can help early prevention of factor and early prevision against occurred forest fire which transfer to SMS service or alert service into monitoring interface of administrator.

KEY WORDS: multisensor data fusion, wireless sensor network, forest fire prevention

1. INTRODUCTION

An arid climate as a continuously an unusual change in the weather for global warming, the world is increased the frequency of forest fire. Especially, it burn out widely area in a short time. Therefore, we need a system that can predict danger rate exactly through an exact analysis for cause of forest fire. These researches began at 1920. Recently, it makes progress researches for forest fire danger rating system based on web. These works developed a system that have characterization notifying real time alert or during 24 ~ 48hours through totally analysis with weather information such as temperate, humidity, wind speed and conditions of forest in order to minimize damage by forest fire. However, the systems that collect data for analysis of forest fire to rate danger have many limitations, because information for forest fire is collected from a field study and remote sensing.

Therefore, in this paper we propose forest fire prediction system by using multi sensor data integration in order to predict forest fire quickly and collect information. The proposed system uses in-situ sensor for collecting environmental information such as temperate, humidity and remote sensor for gathering spatial information such as shape, altitude. Our system is able to predict a forest fire by using fusion of multi sensor data from various sensors such as in-situ and remote sensors. It accomplishes two ways for prediction of forest fire. One way is pre-prediction and another is post-detection. The pre-prediction means a prediction of danger rating through analysis of attributes for previously collected multi sensor data before a fire occur. The post-detection establish strategies that determine an expected path of forest fire.

The remainder of the paper is organized as follows: section 2 analyze of the existing forest fire danger rating system and describe problems of related work, section 3 design of our forest fire prediction system, section 4 discusses forest fire applications scenario, section 5 discusses conclusion.

2. RELATED WORK

The most important task for forest fire management is to assess the values at risk. Conducting risk assessment studies can help authorities impose greater surveillance and/or restrictions on fire use in these areas [5]. Risk assessment considers variables such as mountain height and kinds of tree, forest fire history, and urban interface.

Remote sensing is used to derive vegetation stress variables, which are subsequently related to forest fire occurrence. The most frequently used data source for this information is NOAA/AVHRR [7] data. Alternative data sources are MODIS, ATSR-2; the VEGETATION onboard SPOT 4, as well as the GLI (Global Imager), which will be launched on-board ADEOS-II [6]. Measurement of vegetation stress is one of the most frequent uses of remote sensing in forest fire management.

Many works have been done for managing forest fire. The National Fire Danger Rating System of USA (NFDRS) is a system used by wildland fire management agencies to assess current fire danger at local levels [2,3]. The system is the keystone of interagency fire danger predictions and provides quantification of risk elements that are critical for daily decisions regarding firefighter resource placement, staffing levels, appropriate suppression responses, and strategic decisions at local, geographical area and national levels. And the Canadian Forest Fire Danger Rating System (CFFDRS) is national system of Canada of rating forest fire danger [1,4]. The system includes aids, both existing and planned, for evaluation of forest fire danger, description of fire occurrence, and prediction of fire behavior characteristics.

However, these works do not support real time data collection from in-situ sensors, and real time data analysis. This is because their works is based on a data collected from a weather station and field survey, so they can just use a past weather information and topography information to predict a forest fire.

Therefore, we propose a forest fire prediction system for predicting and detecting the fire. The proposed system can collect a real time sensor data from in-situ sensors deployed at a frequent area of forest fire, and do real time analysis the collected data.

3. MULTISENSOR INTEGRATOR SYSTEM

We assume that in-situ sensors are deployed at frequency area of forest fire with regular distance. These in-situ sensors sense environmental information such as temperate, humidity, wind speed, and wind direction of ground. Except in-situ sensor, remote sensors collect information such as topography. In-situ and remote sensor collect data through wireless sensor network based on event centric structure. Wireless sensor network based on event centric structure means that any sensor data are not exist at the time which user want to that, if user want sensor data, it transform asynchronously to user by oneself occurring at the any time. It is difficult to predict when a forest fire occurs. Though user want much information in terms of forest fire before real fire, it is difficult to collect it right now, because data in terms of forest fire can be collect after real forest fire. Therefore, in this paper we focus on occurrence and transformation of sensor event asynchronous.

Now we present that proposed multisensor data integrator, then represent the forest fire prediction system by apply our multisensor data integrator.

The components of Multi sensor data integrator are shown in figure 1. Multi sensor data integrator takes charge of function for data fusion that transforms collected sensing data to information form from various sensors such as in-situ and remote sensors. This engine consists of sensor data processor, sensor registration and sensor selection. Sensor registration refers to any means, e.g., geometrical transformations, used to make the data from each sensor commensurate in both its spatial and temporal dimensions, i.e., that the data refer to the same location in the environment over the same time interval. Sensor selection refers to any means used to select the most appropriate configuration of sensors or sensing strategy from among the sensors available to the system.

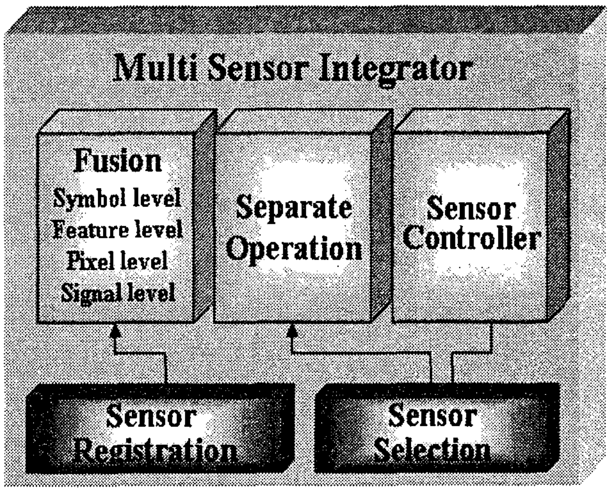

Figure 1 components of Multi Sensor data integrator

In order for selection to take place, some type of sensor performance criteria need to be established. Sensor data processor consists of fusion module, separate operation, and sensor controller in order to accomplish function of data fusion for extracting useful information from calibrated data. The fusion of the data or information from multiple sensors or a single sensor over time can take place at different levels of representation. Sensory information can be considered data from a sensor that has been given a semantic content through processing and/or the particular context in which it was acquired. In order to extract useful information, our sensor data processor accomplishes data fusion as four types. These types are signal, pixel, feature, and symbol level of representation. Most of the sensors typically used in practice provide data that can be fused at one or more of these levels. Signal level fusion can be used in real time applications and can be considered as just an additional step in the overall processing of the signals. Pixel level fusion can be used to improve the performance of many image-processing tasks like segmentation. Feature and symbol level fusion can be used to provide an object recognition system with additional features that can be used to increase its recognition capabilities. The different levels can be distinguished by the type of information they provide the system, how the sensory information is modeled, the degree of sensor registration required for fusion, the methods used for fusion, and the means by which the fusion process improves the quality of the information provided the system. As other components, separate operation of such a sensor will influence the other sensors indirectly through the effects the sensor has on the system controller. Sensor controller takes charge of management sensors.

4. APPLICATION SCENARIO FOR FOREST FIRE

We assume the forest fire application. Before we describe virtual scenario for forest fire prediction, show overall system that forest fire prediction system that contained our multisensor data integrator.

As shown figure 2, our forest fire prediction system consists of multi sensor data integrator, database, forest fire decision engine, GIS data processor, and user interface. These function of components as follows. These function of components as follows.

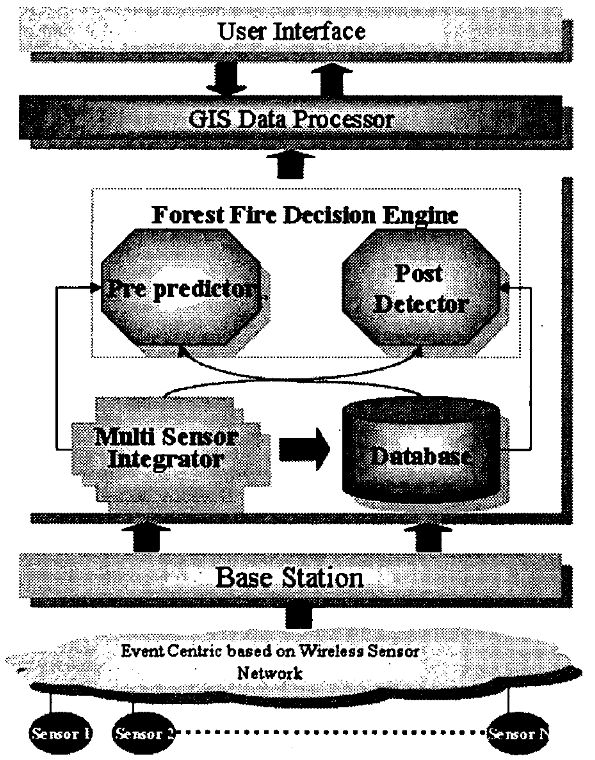

Figure 2 Architecture for forest fire prediction

In order to forest fire prediction, we add to some components such as database for store sensor data, decision engine for prediction, and GIS engine for process of spatial data.

- **Database**

The data form collected from all sensors is stream format. These stream data have limitation that it is difficult to store into general relational database. Therefore, we are store by two steps. First, collected data from sensor nodes are centralized into base station after collecting into prime node. Where prime node means sink and base station means small server that can accomplish computing function. Base station has temporary storage for storing collected data from each prime node, and base station send result to user when user execute query to there. Then over time, these data store permanently into relation database though analysis of variant of data. For example, if the value of temperate sensor of sensor node 1 is collected same value continuously as 20℃ during recently one hour, in relational database store one time 20℃ as the value of temperate sensor of sensor node 1. That is, our database removes redundancy data.

- **Decision Engine**

This engine takes charge of prediction for a danger rate or path of forest fire. Our decision engine divides into pre-predictor and post-detector. These based on previous stored data in relational database. The pre-predictor construct model by applies classification among data mining technique with early collected spatial data and weather data such as temperate, humidity, wind direction, and wind speed.

For example, the result of pre-predictor can be described as follows. If we assume temperate=350℃, humidity=3%, wind direction=ES(East South), and wind speed=20m/s as input attributes, then the result is predicted like form "Danger rating=High". The post detector is model that makes strategy for putting out a fire after detecting occurrence of forest fire. In our model the rule is predefined for strategies of putting out a forest fire. Then if happen the forest fire, making decision for strategy compare with predefined rules. For example, form of our signature for strategy is as follows. "Alert Forest fire level 1 $weather_info any and $spatial_info any -> $Response level 1 any". Where $weather_info is variance that store any values of attributes of weather information, and $spatial_info is variance that store any values of attributes of spatial information. $Response level 1 means the result of matched rule for strategy. If Both values of these variances is satisfied, then send to user like title "Forest fire level 1" the result of $Response level 1.

- **GIS Engine**

GIS engine take charge of processing of GIS data. We process spatial data for frequently area of forest fire through ArcIMS, and use ArcSDE in order to store collected spatial data from remote sensor.

- **Forest fire prediction Scenario**

In this section, we describe a concrete scenario of forest fire prediction based on the proposed system. Occurrence rate of forest fire is different depending on shape of forest, topography, and weather condition. In order to gather information in terms of forest fire, we use in-situ sensor to collect weather information such as such as temperate, humidity, wind speed, and wind direction, and remote sensor to collect gradient and height of mountain, a species of tree, topography and shape of forest. In order to predict forest fire and discover the moving path of forest fire, we analyze sensor data by fusing in-situ and remote sensing data.

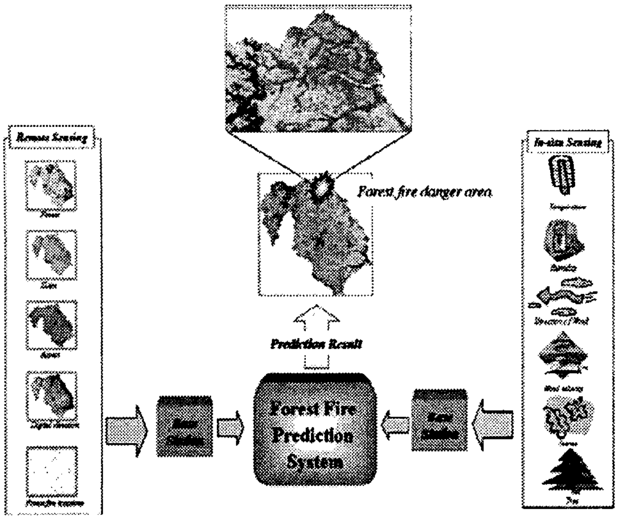

Figure 3 Scenario for prediction of the forest fire danger area using remote and in-sensing data fusion

Figure 3 shows an example of prediction of forest fire danger area using multi-sensor data fusion. The data transmitted from remote and in-situ sensor is collected and integrated in the forest fire prediction system. In the results, the dangerous area is presented by red color. The predicted hazardous area has the high danger rating level.

5. CONCLUSION

In this paper, we proposed a system that is able to real time prediction of forest fire through analyzing of collected data from various sensors. The proposed system consists of multi sensor data fusion engine, database for store sensing data, decision engine for prediction and detection of forest fire, GIS engine for analysis of spatial data, and user interface. For real time data collection, we collect sensor data for real time danger factor of forest fire from deployed remote and in-situ sensor through wireless sensor network based on event centric structure. Then, the collected sensor data from various sensors are transformed useful form through multi-sensor data integrator.

We expect that the proposed system can be reduce the big damage from forest fire, because it predict and detect a forest fire by analyzing environmental data round the mountain through a fusion of in-situ sensors with low cost and remote sensor based on wireless sensor network. It can be also reduce the time and cost for collecting data from field survey.

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