CORRELATION ANALYSIS METHOD OF SENSOR DATA FOR PREDICTING THE FOREST FIRE

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ABSTRACT:

Because forest fire changes the direction according to the environmental elements, it is difficult to predict the direction of it. Currently, though some researchers have been studied to which predict the forest fire occurrence and the direction of it, using the remote detection technique, it is not enough and efficient. And recently because of the development of the sensor technique, a lot of In-Situ sensors are being developed. These kinds of In-Situ sensor data are used to collect the environmental elements such as temperature, humidity, and the velocity of the wind. Accordingly we need the prediction technique about the environmental elements analysis and the direction of the forest fire, using the In-Situ sensor data. In this paper, as a technique for predicting the direction of the forest fire, we propose the correlation analysis technique about In-Situ sensor data such as temperature, humidity, the velocity of the wind. The proposed technique is based on the clustering method and clusters the In-Situ sensor data. And then it analyzes the correlation of the multivariate correlations among clusters. These kinds of prediction information not only helps to predict the direction of the forest fire, but also finds the solution after predicting the environmental elements of the forest fire. Accordingly, this technique is expected to reduce the damage by the forest fire which occurs frequently these days.

KEY WORDS: Multivariate Correlation Analysis, Forest Fire Prediction, Clustering

1. INTRODUCTION

When the forest fire occurs, it is needed to try to extinguish it initially to minimize the loss of life. To perform it efficiently, it is required to understand the outbreak, the spread, and the extinguishing of the fire systematically. However, the forest fire is influenced so easily by many factors such as configuration of the ground, weather, clinical structure, and so on that it shows the composite aspects like the velocity and the direction of the burning. It is not easy to interpret it organically, concerned with these factors [9]. Because the direction of the forest fire changes according to the situation during the real forest fire occurrence, it is difficult to predict the direction of the fire. Currently there are so many researches to predict the forest fire occurrence and the direction of it using remote detection technique, but it's not enough. Recently due to the development of the sensor technique, many In-Situ sensors have been developed. In-Situ sensors are used to collect the environmental factors such as temperature, humidity, and velocity of the wind. Accordingly, it is needed to analyze the factors of the environment and predict the direction of the forest fire, using the In-Situ sensor data.

In this paper, as a technique for predicting the direction of the forest fire, we propose the statistical technique to analyze the relation of the In-Situ sensor data such as temperature, humidity and velocity of the wind and so on. This information not only helps to predict the direction of the forest fire, but also predicts the environmental factors of the fire and finds the appropriate step. Accordingly, it is expected to reduce the forest fire which breaks out frequently.

This paper comprises as follows. Section 2 will explain the existing algorithm about the prediction of the forest fire. It assumed the spread of the forest fire elliptically. And then they explained the location of the points on the border line which is the forest fire, as the function of the two variables such as the time and the angle. In Section 3 we will propose a prediction method of the forest fire applied the multivariate correlation analysis technique which is one of the statistical techniques, to predict the direction of the forest fire using the In-Situ data. Finally Section 4 will summarize this paper and suggest the future works.

2. RELATED WORK

The efficient algorithm to predict the direction of the forest fire is needed to cope with it efficiently during the forest fire occurrence. The existing algorithm about the prediction of the forest fire is divided into two methods such as raster method and vector method. Forest fire spreading technique in raster method is represented by a small cell which has the same attributes of spatial data,

and then it can predict the spread of the forest fire. This method is so simple and applicable that it has been used widely till now. However, it doesn't reflect enough the time series data such as wind. And because the spread of the forest fire is defined as the course of successive outbreak of fire in the neighbouring cell, it has the problem of geographical distortion phenomenon [6], [7], [8].

Where as the vector algorithm doesn't represent the space of the forest fire spreading as a cell, but defines as a successive space. It represents the spread of the forest fire as a dot and a closed curve. There is the representative modelling example about the forest fire spreading by using the vector method. The method used partial differential equation [3].

2.1 The form of the spread of the forest fire

In case of assuming that the forest fire spread elliptically, the head ROS (ROS: Rate of Spread) is a + c from the ignition point in Figure 1. And also the flank ROS is b and the rear ROS is a-c. In this case, a, b, and c are determined by ROS which is influenced by the configuration of the ground, the fuel, and the weather condition, and LB (Length-to-breadth ratio) which determines the form of ellipse [1].

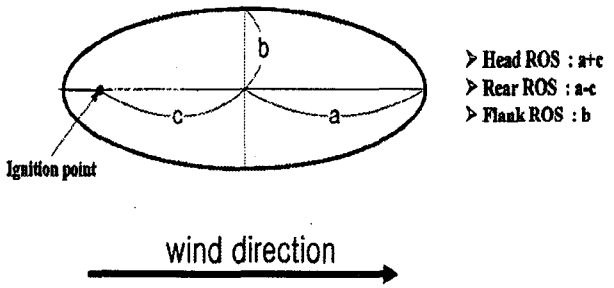

Figure 1. General Shape of forest fire associated with wind direction

2.2 Prediction function about the direction of the forest fire

Partial differential equation suggested by [2], [3] assumes that the forest fire spread elliptically under the influence of the wind, while the configuration of the ground and the weather condition is same. It puts the location of the point as two variables such as time and angle. And then it calculates the spread of the forest fire through the partial differential equation. That is to say, after the forest fire occurs, the border of the forest fire is composed of the set of the points which is the ellipse as t time passes. Here, the time function t is defined as the frequency (j) during the regular time period (Δt). Therefore it is represented as $t = j \cdot \Delta t$ ($j=0, 1, 2, \cdots\cdots$). And the one point of the ellipse which is the border of the forest fire in a regular point of time makes the angle with the direction of the wind. This angle (α) is defined as the frequency (i) of the unit angle (Δs). It is represented as $\alpha = i \cdot \Delta s$ ($\Delta s = 2\pi/n$, $I = 0, 1, 2, \cdots\cdots, n$). Figure 2 shows the relation of this function [3].

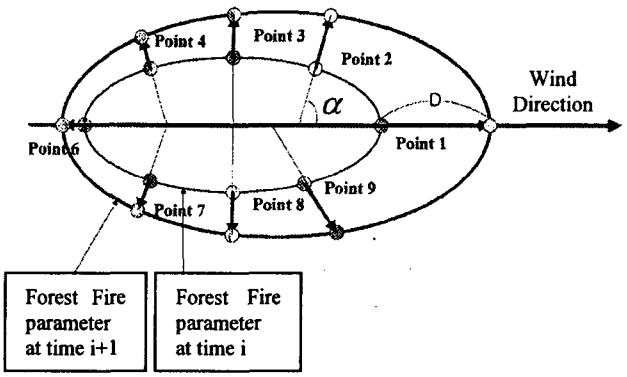

Figure 2. Pattern of fire spread rate associated with wind direction

3. PREDICTION OF THE DIRECTION ABOUT THE FOREST FIRE USING THE CORRELATION ANALYSIS

The In-Situ data which set up on the mountain, using the distance based clustering method. And then we predict the direction of the forest fire using the multivariate correlation analysis.

Correlation analysis represents the relation among two variables or so. Simple correlation analysis estimates the linear relation between two variables and the degree of the intensity. And the multivariate correlation analysis estimates three or more than three variables [5].

In this paper, we are going to analyze the relation among the data which are clustered by using the multivariate correlation analysis.

The multivariate correlation model is represented as follows.

$$\underline{X} = \begin{bmatrix} X_1 \\ X_2 \\ \vdots \\ X_p \end{bmatrix} \qquad (1)$$

($px1$) The probability vector, $\underline{X}$, represents the variables of the forest fire factors in equation (1). The population mean of $\underline{X}$ is μ, and the covariance matrix is Σ in equation (2).

$$\Sigma = \begin{bmatrix} \sigma_{11} & \sigma_{12} & \cdots & \sigma_{1p} \\ \sigma_{21} & \sigma_{22} & \cdots & \sigma_{2p} \\ \vdots & \vdots & & \vdots \\ \sigma_{1p} & \sigma_{2p} & \cdots & \sigma_{pp} \end{bmatrix} \quad (2)$$

Using this, we can define the correlation matrix, P as follows.

$$P = \begin{bmatrix} \frac{\sigma_{11}}{\sqrt{\sigma_{11}}\sqrt{\sigma_{11}}} & \frac{\sigma_{12}}{\sqrt{\sigma_{11}}\sqrt{\sigma_{22}}} \cdots & \frac{\sigma_{1p}}{\sqrt{\sigma_{11}}\sqrt{\sigma_{pp}}} \\ \vdots & \vdots & \vdots \\ \frac{\sigma_{1p}}{\sqrt{\sigma_{11}}\sqrt{\sigma_{pp}}} & \frac{\sigma_{2p}}{\sqrt{\sigma_{22}}\sqrt{\sigma_{pp}}} \cdots & \frac{\sigma_{pp}}{\sqrt{\sigma_{pp}}\sqrt{\sigma_{pp}}} \end{bmatrix} \quad (3)$$

$$= \begin{bmatrix} 1 & \rho_{12} & \cdots & \rho_{1p} \\ \vdots & \vdots & & \vdots \\ \rho_{1p} & \rho_{2p} & \cdots & 1 \end{bmatrix} \quad (4)$$

To apply the above theory to the real data, we calculate the multivariate correlation using the following data [4].

Table1. Input Data

	Wind speed (m/s)	Temperature (℃)	Humidity (%)	Wind direction
cluster1	2.0	27.2	27	SWS
cluster2	1.5	25.3	33	WSS
cluster3	2.5	25.9	30	S
⋮	⋮	⋮	⋮	⋮

Because the above data have the different units of the explanation variables, we must use them after standardization about the data. And we can measure the relation among the clustered variables using the multivariate correlation. Using the standard deviation and covariance of the equation (3), we can calculate ρ in the equation (4). We can calculate the following results after standardization among the variables between two sets;

$$\rho_{12} = 0.67, \quad \rho_{13} = 0.71, \quad \rho_{23} = 0.58, \cdots$$

Accordingly, we can define that the forest fire moves to the cluster 3 through cluster 1.

If the multivariate correlation, ρ, is more than 0.7, there is the correlation among clusters. Therefore the forest fire moves to the same direction. Accordingly, the multivariate correlation analysis helps to predict the direction of the forest fire.

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4. CONCLUSION

In this paper we proposed the method which we apply multivariate correlation analysis to the prediction of the forest fire to predict the direction of the forest fire.

It is difficult to predict the direction of the forest fire, because the forest fire changes the direction according to the environmental factors. The existing forest fire spreading and the prediction function do not manage the real time In-Situ sensor data. Therefore we proposed the statistical model to solve these problems. Accordingly, the new method collects the data through the In-Situ sensor data, and clusters them. And then it can calculate the multivariate correlation through the multivariate correlation analysis among the clustered sets, and using the value, we can predict the direction of the forest fire.

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