Research on computer information integration based on some wireless sensor network model

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Abstract

Network model in wireless sensor integrates wireless communication technology, sensor technology and embedded computer technology. This new computer pattern is the joint elements in current network hot technology. Self-organizing feature Map is also termed as SOM network. It can solve conception problem, which can only be fulfilled by human brain nervous tissue. We integrated computer information applying SOM and wireless sensor technology to realize information integration model. We made a conclusion of the characteristics of wireless sensor network model and studied its protocol architecture. We induced information integration system into software engineering and developed it into application in all industries and areas in the perspective of definition, structure, classification and calculation of information integration. This paper integrated information's, reduce redundancy of information, decrease energy consumption and lengthen the service time of network by SOM wireless sensor network model. It also made a analytical research of case on information integration.

Keywords: wireless sensor, SOM network, information integration, network model, evaluation

1 Introduction

Network node in wireless sensor network is powered by batteries. It is usually arranged in places of bad environment. Its special application area determines that battery charge and battery replacement are not allowed in the process of using. Once the battery is out of energy, the node will lose its function. Therefore, application of any technology and protocol [1] should take energy conservation as premise in the process of wireless sensor network design. Wireless sensor network has lots of nodes. Energy is consumed when network node achieve data collection, calculation or transmission. The energy for consumption is related to data size, sampling frequency, sensor types and application requirements. In addition, many scholars have proved that information transmission by sensor will consume more electric energy compared with calculation performance. For instance, electric energy needed in transmitting one bit of information is enough for carrying out 3000 of calculation command. Meanwhile, large data volume produced in short time will lead to network congestion and shorten the life time of network. This paper tried to solve the problem of large amount of transmission and high energy consumption adopting efficient processing method of information integration.

This paper constructed information integration based on SOM neural network clustering method. This method is widely applied in medical area. We introduced it to construct network model to better stimulate reasoning and stimulation ability for information integration. The Fourth Military Medical University in Shanxi studied clinical inspection item and establishes SOM model based on SOM neural network clustering method [2]. Yanshan University of Hebei effectively avoided drawback and fulfil solution [3] by integrating neural network on high-dimensional data visualization area based on self-organizing feature map. Liao Guanglan et al calculated the recognition of dimensional feature on input pattern clustering in neuron weights of SOM network competition layer. The research found that SOM can effectively recognize character subset and realize pattern clustering between different data [4]. The above research area effectively solves relative problems applying SOM technology. It shows the strong processing ability of SOM technology. Introduction of SOM provides indispensable assistance for network information integration of this paper. As an emerging subject, information integration technology increasingly shows its superiority on multi-source information processing from birth to today. Wireless sensor network adopting information integration technology can reduce network burden and improve instantaneity to some extent. It has obvious advantages compared with those without information integration technology. It is of deep theoretical and practical meaning to fulfil analysis and processing of perceptual information of sensor node by relative technology in information integration.

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2 Overview of sensor network

Sensor network largely extend specific internet. It can monitor the objects that is moving, growing and emitting heat. Its appearance will affect our life all the time. Wireless sensor network is a new kind of information processing system facing to physical world and also a new calculation model. Integrated micro sensor terminals real time monitors centre of sensing. Then the information is transmitted to remote user by wireless network. The objective of this network is realization of ubiquitous calculation.

2.1 CONCEPTION OF WIRELESS SENSOR NETWORK

Wireless sensor network combines sensor technology, embedded computer technology, distributed information processing technology and wireless communication technology. It can collaboratively real time monitor, perceive and collect information of different environment or monitoring object, process them and transmit them to users who needed [5]. The process of the work is to provide service for users. The typical working mode is as follows: lots of sensor nodes are thrown into area of interest by aircraft and nodes form a wireless network by self-organizing feature map. Node is the collector and issuer of information and also routing of information. The collected information reaches base station by single hop or multi-hop. Base station is special node. It can communicate with monitoring centre by Internet, mobile communication network, satellite, etc. A typical wireless sensor network is shown in Figure 1. Direction of the arrow shows how information is transmitted to users.

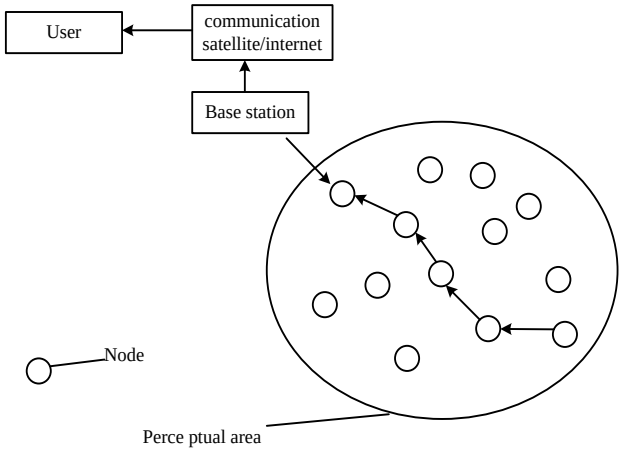

FIGURE 1 Wireless sensor network

2.2 SENSOR NODE

Wireless sensor network is composed of lots of sensor nodes. Therefore, we propose figure of sensor node structure (Figure 2). Every node has its processor. It can perceive data and make a simple processing in node. Then the detailed information is obtained by processing of useful information. And the information is transmitted to users who need information.

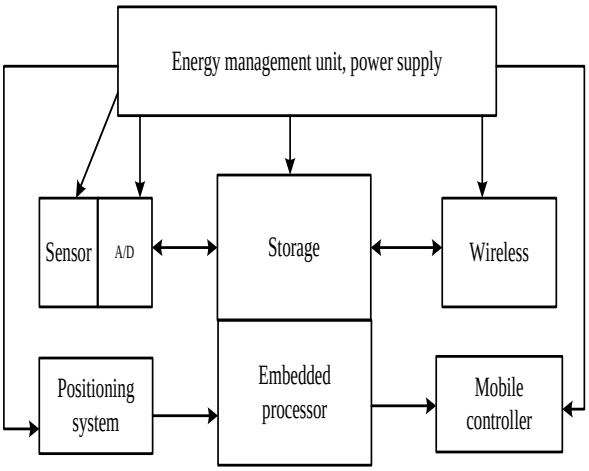

FIGURE 2 Figure of sensor node structure

Node is composed by calculation subsystem composed by micro processor and storage, communication subsystem; subsystems composed by sensor and stimulate device and energy supply subsystem.

3 Information integration and SOM method

Information integration is a process of dealing data or information coming from one or more sources. The process carries out association, interconnection and combination to obtain accurate location and identity estimation and makes a timing and full evaluation on battlefield situation, threat and the important degree [6].

Information integration in wireless sensor network should process perceptual information of different levels adopting mathematical tool and other technologies in the perspective of users. It uses optimal routing to reduce communication consumption, lower energy consumption, lengthen life time of network and satisfy users to the largest extent.

3.1 ADVANTAGE OF INFORMATION INTEGRATION

Information integration is a process of synthetic processing of data in sensor on multiple levels. Every processing level reflects different degree of abstract on original data and produces new meaningful information. In addition, this new information cannot be obtained by any single sensor. Its advantage is enlarging space search scope and instantaneous search scope, lowering reasoning fuzzy degree, reducing cost and time of information obtainment, improving the fault-tolerant ability and self-adaptivity and increasing dimensions of target feature vector.

3.2 INFORMATION INTEGRATION ARCHITECTURE

Information integration can be divided into centralization, distribution and mixing according to the location of integration node in information flow.

(1) Centralization architecture is transmitting original data from multiple sensor nodes to central integration processing centre and fulfilling tasks of data matching and correlation functions and classification of target tracking. This method can process data with high accuracy. But size of data transmission and processing is large. It requires highly on communication line and processor. As shown in Figure 3, F is expressed as integration centre, C is expressed as information user and S is expressed as information source.

(2) Every sensor makes processing on own monitoring data and produces state vector and attribute parameter. Then the processing result is transmitted to integration centre for integration processing. That is the distributed architecture. Corresponding to centralized architecture, distributed architecture have little load but its integration accuracy is lower than that of centralized architecture. Common distributed architecture includes architecture of parallel distribution, serial distribution and feedback.

(3) Mixing architecture is the combination of centralization and distribution. It is complicated. It requires pre-processing sensor of distributed architecture and high-speed communication link that transmitted original information to integration centre. And the calculation amount of processor is large. It is commonly used for large integration system.

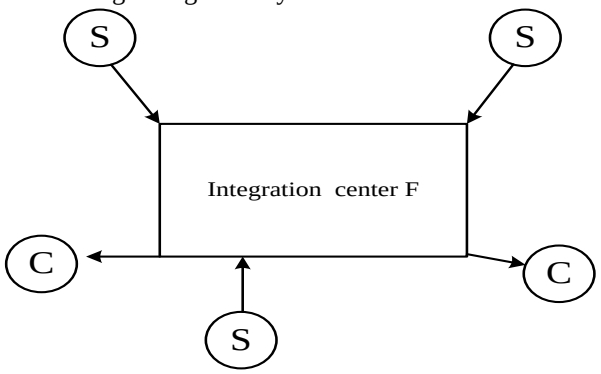

FIGURE 3 Centralization integration architecture

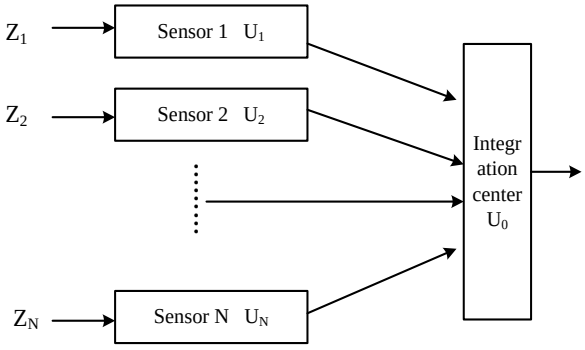

FIGURE 4 Parallel distributed architecture

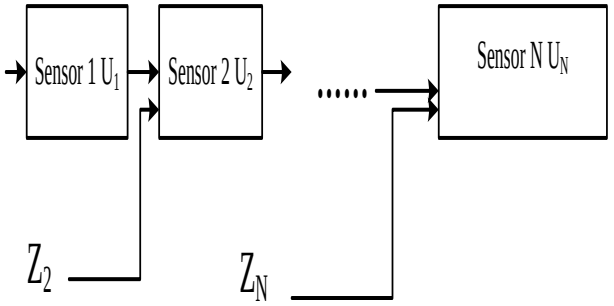

FIGURE 5 Parallel distributed integration architecture

3.3 INFORMATION INTEGRATION BY SOM METHOD

Self-organizing feature map at the earliest is an effective algorithm of data compression and clustering proposed by neural network expert TeuvoKohonen from University of Helsinki in Finland in 1981. In the past 20 years, SOM was widely studied and applied in robot vision, mechanical control, speech recognition, and vector quantization machine and pattern recognition. In addition, SOM can be widely used in sample order, sample classification and sample detection as a sample characteristics detector.

3.3.1 SOM network model

Output that have similar function will be close and output that have different function will be apart after competition learning of output sample [7] by SOM. It automatically lines some ruleless output. In the process of adjustment of joint weight, distribution of weight and probability density of input sample are made similarly.

SOM is a two-layer network composed of input layer and output layer. Figure 6 gives a hidden-free SOM model composed of input layer and output layer. Input layer is used for receiving input pattern. It is one dimensional sequence composed of N neurons. Junction points of output layer are relative to space dimensions of output pattern. Output layer is two dimension planar array composed of M*N=H of neurons. Its junction points are relative to pattern space dimension after map. It can be dot matrix of one or two dimensions. Junction points of input and output layer are full of joint. Junction points within input layer and output layer have no connected relation. Every neuron in output layer is connected with neighbourhood. This connection is a relationship of manual encouragement. Different junction points of output layer represents different classification pattern after training.

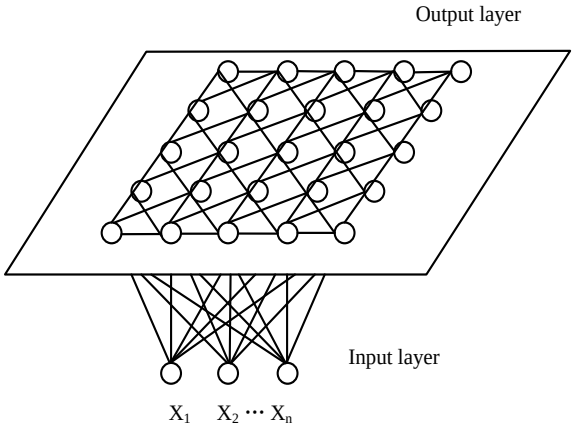

FIGURE 6 Topological graph of SOM network

SOM network model is made up of processing element array, compared selection mechanism, partial interconnected function and self-adaptative process. Model of Figure 2.4 can process the distributed topological graph with input signal on cell array. However, in initial state, there is no distributed topological graph with signal characteristics on cell array. SOM can extract characteristics from internal environment according to some measure or topological space.

3.3.2 SOM algorithm

Procedure 1, initialization. Continuous weights of N input neuron and output neuron is given the small value. J of adjacent neurons in output neuron is selected to gather Sj. Where Sj (0) is expressed as set of adjacent neurons of Neuron j at time t = 0 and Sj (t) is expressed as set of adjacent neurons of neuron j at time t. Area Sj (t) will decrease with the growth of time.

Procedure 2, new output pattern X is provided.

Procedure 3, Euclidean distance dj is calculated. That is, the distance between output sample and every output neuron j:

$$d_j = \left\| X - W_j \right\| = \sqrt{\sum_{i=1}^{N} \left[x_i(t) - w_{ij}(t) \right]^2} \ . \tag{1}$$

A neuron with minimum distance is calculated. Select a unit k that makes any j

$$d_k = \min_j (d_j) \ . \tag{2}$$

Procedure 4, neighbourhood Sk (t) is given.

Procedure 5, out [put neuron j^* and its weight is revised according to Formula (3).

$$w_{ij}(t+1) = w_{ij}(t) + \eta(t) \left[x_i(t) - w_{ij}(t) \right], \tag{3}$$

where η is gain item that is decreased with the change of time.

$$\eta(t) = \frac{1}{t} \ . \tag{4}$$

Procedure 6, calculate output o_k

$$o_k = f(\min_j \left\| X - W_j \right\|) \ . \tag{5}$$

The formula (5) is generally function between 0-1 or nonlinear.

To sum up the above procedures, SOM can be simply described as only part of weight vector can be adjusted to close the latter and away from input vector for every network input. All weight vectors are separated from each other within input vector space. And pattern that represent input respectively are formed. That is the clustering function of SOM characteristics automatic identification.

4 Case analysis

Safety production of coal mine is the key point in current coal mine development industry. Monitoring of gas density and temperature is the basic of safety production. The detected environmental parameter of coal mine is mostly fulfilled by single sensors. When a sensor is broken down, the environmental parameter data of that location can not be detected, which will lead to false-alarm and even no alarm. In addition, the processing of environmental parameter is simple. Therefore, the evaluation of real time safety situation is not accurate and effective measurement can be not carried out. It will cause collapse of coal mine and fire disaster. These situations will bring large hidden danger for safety production of coal mine.

4.1 PARAMETER ANALYSIS

For the prevention of gas coal fire to harm personal and equipment safety, working face, heading end, main roadway and mechanical and electrical bully chamber should be equipped with sensors of gas, temperature, carbon dioxide and wind speed to real time monitor environment [8].

(1) For temperature, when the temperature under the coal mine well reaches certain condition, oxidation of coal will be promoted and lead to spontaneous combustion or gas combustion. Temperature of working face in coal well digging should not exceed 26℃. Air temperature of mechanical and electrical equipment room should not exceed 30℃. Working time of workers in high temperature place must be shortened and they should be provided high temperature care treatment when the temperature exceeds the value. If air temperature of digging working face exceeds 30 ℃ and that of mechanical and electrical room exceed 34 ℃, the operation should be stopped.

(2) Wind speed can directly affect ventilation quantity. Unreasonable ventilation quantity may increase

or induce the oxygen supply factor for natural fire. And it will also have certain effect on heat dissipation and increase the risk degree of natural fire. Different roadway have different requirement for wind speed. For instance, minimum wind speed in roadway of electric locomotive stringing is 1.0 and the maximum is 8. Minimum and maximum of wind speed in stone drift under digging is 0.15 and 4. Minimum and minimum of wind speed in conveyor lane, digging area and air return way is 0.25 and 6.

(3) Gas is formed from coal or other C class material in mine well. Methane is the major ingredient. It is lighter than air and easy to burning and blast. When gas concentration of air current in return air lane and digging working face exceed 1.0%, the operation should be stopped and workers should leave. And relative measurement must be carried out.

In addition, there are the effect of concentration of carbon monoxide and dust [9]. Maximum value of parameter is given in Table 1.

TABLE 1 Maximum reference value of major parameter in coal well

Name	Maximum parameter
Temperature	26
Wind speed	1.0/8
Gas	1.0
Carbon monoxide	0.0024
Dirt	10

4.2 CONCRETE ANALYSIS

Facing with single node, size of transmission amount is taken into account to determine whether compression is needed. Compression can be divided into lossless compression and lossy compression according to whether loss is allowed. For instance, searching for the temperature of some node at some time can be directly relative to the node. When we search for the temperature of some node during some period, compression can be considered because of the large size of data. Another reason is that the change of temperature is small. For instance, for a temperature signal of 20 ℃, in most data that record environment, only the data after radix point change while the integer part do not change. That is, the integer part is the same. If few records derivation is recorded adopting method of known value derivation, then it can effectively lower the storage space of data.

Whether the information needed by users comes from homogeneous sensor node should be considered facing with area. If the information comes from homogeneous sensor node, the purpose of information integration is how to make a synthetic processing on this information to obtain more reasonable index value of characteristics of research object. Integration algorithms that can be adopted are weighted average, Bayesian method, Dempster-Shafer, etc. For instance, if the average temperature of some area is needed, then the node in the area is made weighted average according to reliability. At last, only the needed average temperature value is transmitted to users rather than all node data. It saves node energy, improved efficiency and lengthens the life time of network. Output of n sensor nodes for detection of parameter x is written as xi, I = 1, 2,…n. Information integration adopt weighting algorithm. And the formula of algorithm is:

$$x^{+}=\sum_{i=1}^{n}a_i x_i\ ,\ \sum_{i=1}^{n}a_i=1. \tag{6}$$

The key is to determine coefficient a_i to make accuracy of integration algorithm highest. Determination of coefficient becomes a critical factor because the node location is different and the interference suffered by sensor node is also different. If the information come form non-homogeneous sensor node, then the purpose of information integration is to synthesize information implied in different indexes to estimate the global property of research object. For example, neural network method can be adopted. For example, in some area, there are various sensors such as temperature sensor, humidity sensor, pressure sensor, light sensor, etc. After synthesis of all perceptual information, the judgment of the air quality levels can be obtained. Facing to network also need distinction of homogeneous information and non-homogeneous information and application of relative algorithm. The procedure is shown in Figure 7 and Figure 8.

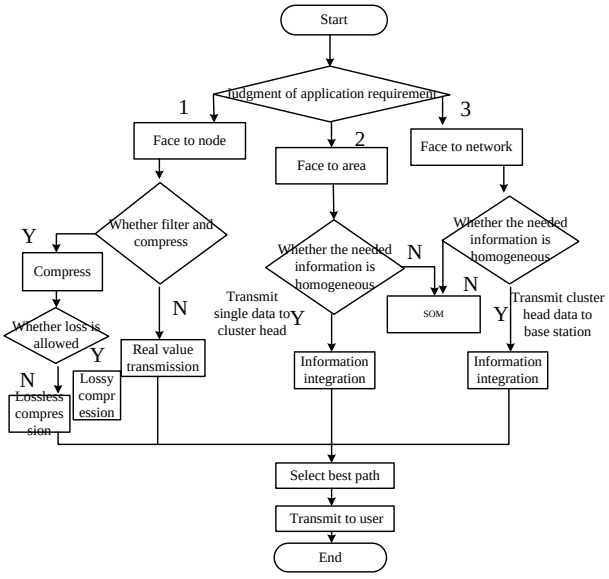

FIGURE 7 Flow diagram of information integration

Property facing to single node in Figure 7 includes type code, location, energy, alarm threshold value, working attitude and sample frequency. Node can be temperature sensor, humidity sensor or the node code of some location. The major task is data connection and calculation. Property facing to area includes size and type. The major task is calculation and evaluation of state. Property facing to network includes types of various requirements.

Analysis of information integration should choose proper integration architecture, integration algorithm and

database support needed in integration establishment according to the requirements of system. In environment monitoring of coal mine, the first step is alarm threshold data setting. That is the setting of alarm threshold of harmful gas for alarm judgment. In advance, alarm threshold is set on node and is expressed as constant. Sensor node makes a comparison on perceptual information and constant. If perceptual information is larger than constant, then alarm will be given. For instance, when the gas parameter exceed threshold, relative equipment can be carried out real time outage. If the parameter is within the normal range, then real time monitoring should be going on.

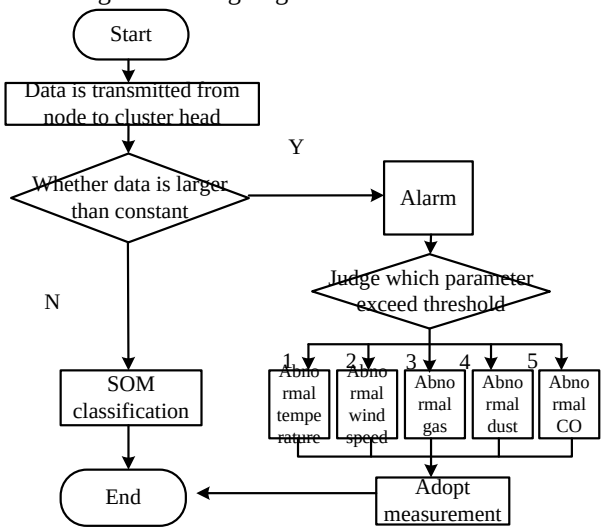

FIGURE 8 Flow diagram of environment monitoring of coal mine

5 Conclusion

Wireless sensor network will change the interactive mode between human and nature, which is the hot point in the current research area. Monitoring data of wireless sensor network have characteristics of large size, redundancy and repetition. In addition, the power of sensor node is supplied by battery. And the energy consumption should also be reduced. These factors make information integration not to be neglected. The conception of integration at the earliest come from military area and then penetrates into other areas. Single uses of one method have certain limitation because the application area of information integration is quite wide. We make advantages integration of various methods, which gradually become the key point of research of information integration algorithm. Application of algorithm and architecture in information integration can save energy and lengthen the life time of network. We construct network model on the basis of SOM algorithm for achieving expected effect in application.

This paper considers the user demand in the perspective of software engineering. Class is regarded as base class in application and extended based on the property with good definition. At first, we analyse the problem of current monitoring system if coal mine safety in the background of coal mine safety. Then we discuss the advantages of equipping wireless sensor network according to the actual situation, which can increase the confidence level of system monitoring and improve monitoring performance. Afterwards, we analyse some critical parameters such as effect of temperature, gas concentration and dust concentration. The current coal mine system is mainly to monitoring the major parameter applying sensor and transmits the result it monitoring centre. Analysis and processing data by integration data is superior to traditional monitoring system of coal mine safety. With the assistance of SOM and its strong functions of analysis and display, this research vividly reflects data characteristics and processes single parameter and synthesis judgment in the form of flow diagram.

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