The design of the data preprocessing using AHP in automatic meter reading system

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Abstract

The smart grid is an electrical grid that uses information and communications technology to gather and act on information, such as information about the behaviors of suppliers and consumers, in an automated fashion to improve the efficiency, reliability, economics, and sustainability of the production and distribution of electricity. In the smart grid environment, it is a very important factor that would telemeter the factory, home and building to measure the amount of electricity telemetering would measure the amount of electricity using network and IT technology, and transmit to the server. Using the telemetering, it would measure the real time electrical load, and control the electrical demand. There is a big difference between the data in the automatic meter reading system. It is coming to be important that the efficient data treatability between central control server and the remote automatic meter unit. The delay will be able to occur when controlling a numerous termination provision from server. We design and implement a total method that controls the mass data using the support vector machine(SVM) automatic meter reading system. SVM performs classification by constructing an N-dimensional hyperplane that optimally separates the data into two categories. When the server handle the data from automatic meter reading system, we use the automatic meter reading system's priority using SVM algorithms. In this paper, we propose a method in the remote meter reading data, when processed using SVM and Packet Priority Algorithm using AHP data preprocessing. In Remote meter reading data, the data preprocessing is used to obtain the weights using the AHP. It would be increase the server's efficiency and accuracy.

Keywords: *Automatic meter reading system, Analytic hierarchy process, Support vector machine*

1. Introduction

In the electric power industry, the smart grid would be developed the construction of the next generation intelligent grid and related technologies. The smart grid means the power providers and consumers to optimize energy efficiency and real-time information exchange in both directions, by integrating information and communication technologies into the power grid, smart grid of existing infrastructure. In the fields of electric power anytime, anywhere communications equipment can control ubiquitous environment using the latest IT technology can be implemented. The power generation, transmission, distribution, remote meter reading, etc. scattered terminal equipment attached to the control facility for sending and receiving data through a variety of communications environments. These smart grid environments from the central control of the server between the terminal and efficient data processing methods are becoming increasingly important.

In the smart grid environment, it would cause a delay on the server when processing the number of terminal equipment. There is a big difference between smart grid data and web environment and internal business data. Place in accordance with the importance of the data is attached to the terminal equipment to collect information from the remote terminal equipment, and operating and unattended, there is a difference. Communication disorders as a result of if it is not able to retrieve the data terminal equipment, and the failure of the equipment takes time to recover. Existing Web data and otherwise can get important information to be sent because of research on how to handle the data in a smart grid environment, there is a growing need. In this paper, we propose a method in the remote meter reading data, when processed of data preprocessing using AHP in Packet Priority Algorithm. In Remote meter reading data, the data preprocessing is used to obtain the weights using the AHP. In Chapter 2, we would learn about the related works in AHP and SVM, and in chapter 3, we would design about the data preprocessing using AHP. In chapter 4, we would implement and to evaluate the data preprocessing using AHP in automatic meter reading system. In Chapter 5, we would learn about the conclusions and future research.

2. Related works

2.1 Analytic Hierarchy Process

AHP is an intuitive method for formulating and analyzing decisions. AHP has been applied to numerous practical problems in the last few decades(Shim, 1989). Because of its intuitive appeal and flexibility, many corporations and governments routinely use AHP for making major policy decisions(Elkarmi and Mustafa, 1993). Application of AHP to a decision problem involves four steps[1].

Step 1: structuring of the decision problem into a hierarchical model
It includes decomposition of the decision problem into elements according to their common characteristics and the formation of a hierarchical model having different levels. Each level in the hierarchy corresponds to the common characteristic of the elements in that level. The topmost level is the focus of the problem. The intermediate levels correspond to criteria and sub-criteria, while the lowest level contains the 'decision alternatives'.

Step 2: making pair-wise comparisons and obtaining the judgmental matrix
In this step, the elements of a particular level are compared pairwise, with respect to a specific element in the immediate upper level. A judgmental matrix is formed and used for computing the priorities of the corresponding elements. First, criteria are compared pair-wise with respect to the goal. A judgmental matrix, denoted as A, will be formed using the comparisons. Each entry is formed comparing the row element Ai with the column element Aj:

$$A=(a_{ij})(i,j=1,2,\ldots,\text{the number of criteria})$$

For each pairing within each criterion the better option is awarded a score, again, on a scale between 1(equally good) and 9 (absolutely better), whilst the other option in the pairing is assigned a rating equal to the reciprocal of this value. Each score records how well option “x” meets criterion “Y”. Afterwards, the ratings are normalized and averaged. Comparisons of elements in pairs require that they are homogeneous or close with respect to the common attribute; otherwise significant errors may be introduced into the process of measurement (Saaty, 1990).

Step 3: local priorities and consistency of comparisons
Once the judgemental matrix of comparisons of criteria with respect to the goal is available, the local priorities of criteria is obtained and the consistency of the judgements is determined. It has been generally agreed(Saaty, 1980, 2000) that priorities of criteria can be estimated by finding the principal eigenvector w of the matrix A.

Step 4: aggregation of local priorities
Once the local priorities of elements of different levels are available as outlined in the previous step, they are aggregated to obtain final priorities of the alternatives. For aggregation, the following principle of hierarchic composition(Saaty, 2000) is used:

$$\text{Final priority of House } H_1=\sum_{i}\left(\begin{array}{c}\text{Local priority of } H_1 \text{ with respect}\\ \text{to } C_i\times\text{ Local priority of}\\ C_i \text{ with respect to the goal}\end{array}\right)$$

2.2 Support Vector Machines

First, Vapnik invented support vector machines[2]. In its simplest, linear form, an SVM is a hyperplane that separates a set of positive examples from a set of negative examples with maximum margin. Margin maximization can be expressed as given in [3] as

$$\begin{aligned}&\min_{w,\xi}\frac{1}{2}\|\mathbf{w}\|^2+\frac{C}{n}\sum_{i}^{n}\xi_i,\\ &\quad \text{s.t. } \forall i,\ \xi_i\geq 0,\quad \forall i,\ y_i(\mathbf{w}\cdot\mathbf{x}_i+b)\geq 1-\xi_i.\end{aligned}\tag{1}$$

Using a Lagrangian multiplier, this optimization problem can be converted into a dual form which is a QP problem, where the objective function L1 is solely dependent on a set of Lagrangian multipliers α :

$$\max_{\alpha} L_1(\alpha)=\sum_{i}^{n}\alpha_i-\frac{1}{2}\sum_{i}^{n}\sum_{j}^{n}\alpha_i\alpha_j\mathbf{x}_i\mathbf{x}_j,\tag{2}$$

subject to the inequality constraints,

$$\forall i,\ 0\leq\alpha_i\leq\frac{C}{n},\tag{3}$$

and one linear equality constraint,

$$\sum_{i}^{n}y_i\alpha_i=0.\tag{4}$$

There is a one-to-one relationship between each Lagrangian multiplier and each training example. Once the Lagrangian multipliers are determined, the normal vector *w* and the threshold *b* can be derived from the Lagrangian multipliers:

$$\mathbf{w} = \sum_{i}^{n} y_i \alpha_i \mathbf{x}_i,\ b = -\mathbf{w} \cdot \mathbf{x}_k + y_k \quad \text{for some } \alpha_k > 0. \qquad (5)$$

3. The design of the preprocessing using AHP

3.1 The Packet Priority Algorithm Framework

We would propose packet analysis processing technique of using SVM to improve the efficiency of server connection for the configuration in Fig.1[4]. In this process, data preprocessing was applied using AHP to obtain the weights of each of the data.

The remote equipment would connect to the server through the network. If the remote equipment would connect to the server, the remote equipment's details and information is stored in the database. Data is stored in the database through data preprocessing to build SVM model. We would determine the remote equipment's priority using SVM algorithm. The remote equipment are divided into groups based on priority of each. After we would determine remote equipment's priority set forth by the SVM algorithm, then we would analyze the packet information when remote equipment would specifies the access priority. When remote equipment would connect to the server, Packet Priority algorithm by extracting the information of the IP packet is used to analyze the remote equipment's IP. And appointed remote equipment are classified by priority using SVM. We would set the remote equipment access ranking as a result of this classification.

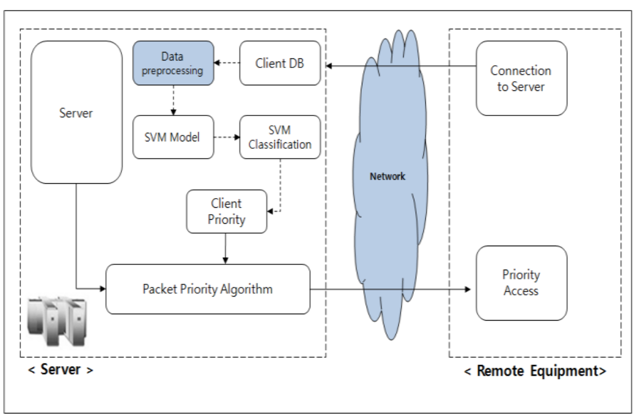

Fig. 1 The Packet Priority Algorithm Framework

There would be divided into two phase that the remote equipment rank analysis and packet processing. The first step is the priority setting phase that would determine using SVM algorithm. It would be grouping the remote equipment data by SVM classification through the resulting model using SVM. Through this process, the priority is determined. The second step is the remote equipment access management through the analysis of IP packet. By analyzing packet when the remote equipment connect to the server, it would be priority classification using the Packet Priority algorithm.

3.2 The data preprocessing using AHP

We would propose the data preprocessing techniques using the AHP in automatic meter reading system. In the database of automatic meter reading system, it would be important field that is usages, area, payment, station field. So we would decide whether to grant the weights in these four field.

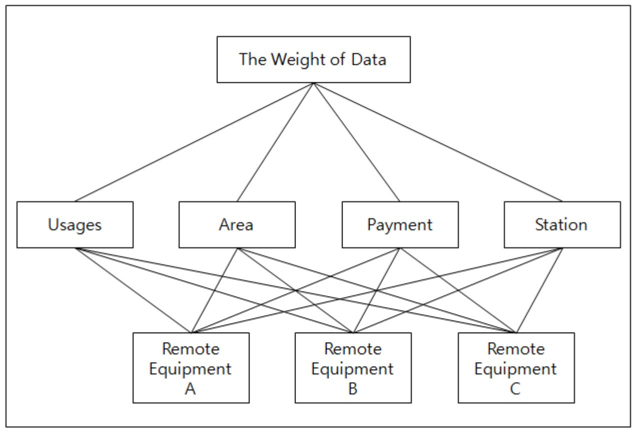

Fig. 2 The weight of data in AHP

We would calculate the comparison matrix about usages, area, payment, station field through the relative comparison. Granted after the comparison value for each field, the relative proportion of the weights were calculated. Table 1 would be the calculation of comparison matrix.

Table 1: The calculation of comparison matrix in AHP

	Usages	Area	Payment	Station
Usages	1.000	3.000	5.000	4.000
Area	0.330	1.000	0.250	0.250
Payment	0.200	5.000	1.000	5.000
Station	0.250	5.000	0.250	1.000
Sum	1.780	14.000	6.500	10.250

The relativity weight of the value of the amount to 0.484, area 0.080, using the amount of the 0.278, Station weighted value of 0.158 was determined. Table 2 is the relativity weight.

Table 2: The relativity weight in AHP

	Usages	Area	Pay	Station	Weight
Usages	0.562	0.214	0.769	0.390	0.484
Area	0.185	0.071	0.038	0.024	0.080
Payment	0.112	0.357	0.154	0.488	0.278
Station	0.140	0.357	0.038	0.098	0.158
Sum	1.000	1.000	1.000	1.000	1.000

4. The implemented and experimentation

In order to apply SVM, we would vectorize the remote meter reading data. In the process of vectorization, we would preprocess granted by the weighting of the data values using the AHP.

Table 3: The database field in automatic meter reading system

Num	Usage	Area	Pay	Stat	Comm	Con	Comm
1	500	Busan	54,000	Factory	On	normal	failure
2	40	Gunsan	3,000	Villa	On	normal	success
3	70	Sokcho	5,000	Villa	On	normal	success
4	200	Jeju	12,000	Apart	On	normal	failure
5	650	Seoul	62,000	Factory	On	normal	success
6	700	Sugi	87,000	Factory	Off	normal	success
7	230	Suwon	17,000	Apart	Off	normal	success
8	90	Daegu	6,000	Villa	On	abnormal	failure
9	170	Inchon	10,000	Apart	On	normal	success
10	540	Muju	60,000	Factory	On	abnormal	success

Table 4: The result of the SVM in the data weight using AHP

Num	1	2	3	4	5	6	7	SVM	Priority
1	261.36	0.72	15,012	1.58	1	1	0	0.99	4
2	19.36	0.24	834	0.158	1	1	1	-1.17	10
3	33.88	0.08	1,390	0.158	1	1	1	-1.08	9
4	96.8	0.08	3,336	0.79	1	1	1	-0.78	6
5	314.6	0.8	17,236	1.58	1	1	1	1.33	2
6	338.8	0.56	24,186	1.58	0	1	1	2.40	1
7	111.32	0.72	4,726	0.79	0	1	1	-0.57	5
8	43.56	0.4	1,668	0.158	1	0	0	-1.04	8
9	82.28	0.64	2,780	0.79	1	1	1	-0.87	7
10	261.36	0.24	16,680	1.58	1	0	1	1.25	3

The relative proportion of the value of the amount to 0.484, area 0.080, using the amount of the 0.278, Station weighted value of 0.158 was determined. Table 3 is the value of a database field in a remote meter reading. Table 4 is the result of the data weight using AHP. Remote metering database in table 3, rough data weighted data preprocessing using AHP values is shown in Table 4. Terminal telemetering so obtained by using the values of Table 4 and apply SVM algorithm to build the SVM model prioritizes. Priority so obtained by the server in a specified order of processing of remote meter reading terminal data processing. Data preprocessing undergone by applying the AHP method, and vectorized data when the value of the experimental results.

5. Conclusions

The automatic meter reading system is growing in importance due to the development of power projects in the smart grid. Through when a surge in demand for remote control through remote meter data management and demand forecasting, demand adjustment is also possible. The automatic meter reading system would command, at the same time, ten thousand down on the automatic meter reading system, data processing delay occurs on the server, or the server could not handle it, because it may fail. To prevent it, the remote meter reading data using the SVM algorithm and Packet Priority Algorithm to prioritize processing framework. In this paper, in order to efficiently handle the remote meter reading data through the framework proposed. Through the comparison, each of the fields of the remote meter reading data and the weights of the field was determined. The weights of the field to affect the priority of remote meter reading equipment.

We would learn about future research by applying different preprocessing techniques that affect the SVM method using AHP and would want to study to compare the SVM algorithm, pre-processing, multi-dimensional research.

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