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A Method of Electric Power Equipment Integrated Modeling Based on Carrier

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Abstract

Modeling of electric power equipment is very important in power system. But there are several problems by the current method, such as information is incomplete. This paper proposes a method of electric power equipment integrated modeling based on carrier. Electric power equipment model are numbered and classification, then all of them are knowledge-related through knowledgebase. In the design, user-defined of meta-data structure is supported, which can be integrated with a variety of heterogeneous systems. Finally, the model can be displayed with the dynamic three-dimensional way after rendering by texturing techniques. Experiment indicates that the proposed model contain more information and more realistic.

*Keywords:*integrated modeling; carrier; electric power equipment

1. Introduction

In power grid, the figures can be divided into two types: foreground image and parts and background image. The major component of background image is static symbol: like dot, line, line, curve, text and other basic descriptor. Background image has no characteristics of power system, so its purpose id description of administrative region, geographical map in provincial grid. Foreground image is dynamic data and symbol with the changes of power system state. For instance, the state display of disconnector should be different with the corresponding condition. Also known as the component layer, foreground image consists of the abstract diagram that stands for physical device object. In foreground image, the corresponding dynamic properties are defined. After binding of final generated static image to be drive and real-time data, it can obtain the dynamic pictures that reflect the real situation.

As industry standards and national standards, graph elements of power system are fixed. Represent significance of each graph element can not be changed, and each of them has certain corresponding characteristics. Dynamic graph elements that show the power system components can define attributes associated with database, and can also define various properties of device components, such as device parameters. A vector-based graphics system consists of the large number of primitive. It designs data structure of object structure graphics system with object-oriented programming structure. In the vector-based graphics system, it encapsulates a complete set of graphical object classes, and there are a set of primitive event handler object in each pixel-one correspondence with the primitive object. The inheritance relationship between them likes the primitive objects.

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It defines the action of graph element when external events work on primitive objects, such as Right &Left mouse buttons click and double click, move, keyboard percussion and so on. Those realize the definition, attributes revise, mobile, etc. Defined the primitive type by encapsulating various types of public properties and methods, you can fully reflect the inheritance of object-oriented development and the advantages of encapsulation.

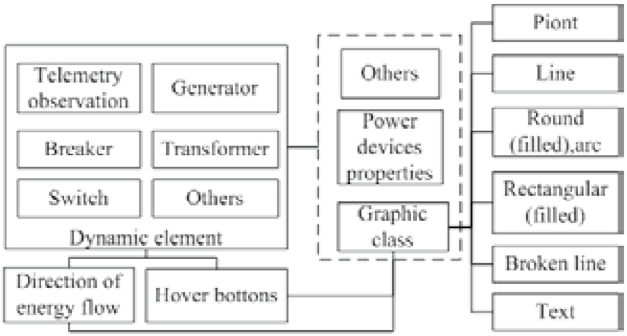

Figure 1. Graph element of power system

2. Method Overview

2.1 Procedure declaration

The vector is a information model apply to power system, the information model is public information model based on IEC61850. It builds the model for special requirements of equipment knowledge dealing with the appropriate additions and deletions. In this way, carrier conforms to requirements of integration. Then, three-dimensional appearance of the model texture is extracted by the texture extraction technology, and finally displayed by rendering.

2.2 Features of Integrated Model

1) Electric power equipment and knowledge integration

Integrated models correlate electric power equipment with knowledge of Knowledgebase. It displays the knowledge through three-dimensional, dynamic form.

Datum was small when power grid operation message is shown; the way of display is too single and lack of high-level abstraction information. That is malpractices of traditional management which based on two-dimensional and simple three-dimensional geometrical figure. The Integrated models overcome these malpractices. In the way of integrated modeling, it makes the operation state "can be saw, can be read, and can be understood". It can increase operating staff's perceptive ability of currently power grid running state rapidly, and can make a warning and the correct decision to potential security threats. In this way, it can meet the requirement that is visualized, intuitive, vivid and concrete.

2) User-defined of meta-data structure

In the design, user-defined of meta-data structure is supported, which can be integrated with a variety of heterogeneous systems. In the design based on characteristics of electric component, it identifies automatically geometric features in the feature layer, and complete the data transfer with a few human-computer interactive methods. The design reflects the people's decision-making role. In the operation of system, it establishes the corresponding relationship with data structure of heterogeneous systems after construction of data analysis. Graphical data integration can be achieved using this approach.

3. Extract texture features of integrated models

Research of texture synthesis in recent years has achieved great success, but there are still some problems.

- Some methods which is not need to deal with mixed boundary are adaptability and strong random. But the computational and time consuming cost is much higher with the epsilon neighborhood increased. And it is easy to immerse in error.

- Some of these methods have the advantage of speed, but the randomness is not strong, prone to produce repetitive texture blocks. The smaller sample map and larger composite map, the more obvious repetition. What is more serious is that it is difficult to deal with mixed boundary.

The traditional method of extract texture features is:

- Obtain various parameters of the image information, after analysis and feature extraction of image.
- Use artificial neural network BP algorithm to produce the BP network model, make the original image's characteristic function as the BP network input, determine the artificial neural network structure of the image through learning – training.
- Synthesis texture image models through the program.

3.1 The Method of the Model Texture Image Generation Based on Artificial Neural Network

Specific to power grid, a new method of integrated models extract texture features is presented. The method consists of the following steps:

3) Determine the effective statistical characterization function of the electric power equipment texture image, extract various characteristic values used to generate the texture of the features.

4) Establish network procedures using artificial neural network BP algorithm, Identify effective training methods and learning rules.

5) Make the extraction characteristic values original image's characteristic function as the BP network input. Calculate the network coefficient of generate images through learning-training, and then extracted corresponding pixel from the pixel library. Finally, the electric power equipment texture image is rapid generated, and the name is recorded.

The traditional method of image generation is using different texture images patterns according to the different structure formation. This method breaks up bound of traditional method. It synthesizes electric power equipment texture by image analysis and feature extraction using the artificial neural network BP algorithm. The speed and generate images of image quality is good.

3.2 Electric power equipment image texture feature extraction

It uses statistical feature function to descript texture. So, texture feature function is the key of model display. Obtained through the analysis, the following 16 texture features function is the best suited to describe the feature:

6) First order histogram characteristics

$$\bar{b} = \sum_{b=0}^{L-1} bp(b) \tag{1}$$

$$\sigma_b^2 = \sum_{b=0}^{L-1} (b - \bar{b})^2 p(b) \tag{2}$$

$$b_K = \frac{1}{\sigma_b^3} \sum_{b=0}^{L-1} (b - \bar{b})^3 p(b) \tag{3}$$

$$b_F = \frac{1}{\sigma_b^4} \sum_{b=0}^{L-1} (b - \bar{b})^4 p(b) - 3 \tag{4}$$

$$b_N = \sum_{b=0}^{L-1} [p(b)]^2 \tag{5}$$

$$b_E = -\sum_{b=0}^{L-1} p(b) \lg[p(b)] \tag{6}$$

Formula (1) - (6) are mean, variance, slant, summer, energy and entropy. In the formula, p(b) is the one-dimensional probability density of image amplitude.

7) Second order histogram characteristics

$$\bar{B} = \sum_{a=0}^{L-1} \sum_{b=0}^{L-1} abp(a,b) \tag{7}$$

$$B_C = \sum_{a=0}^{L-1}\sum_{b=0}^{L-1}(a-\bar{a})(b-\bar{b})p(a,b) \tag{8}$$

$$B_D = \sum_{a=0}^{L-1}\sum_{b=0}^{L-1}(a-b)^2 p(a,b) \tag{9}$$

$$B_K = \sum_{a=0}^{L-1}\sum_{b=0}^{L-1}|a-b|\, p(a,b) \tag{10}$$

$$B_N = \sum_{a=0}^{L-1}\sum_{b=0}^{L-1} p^2(a,b) \tag{11}$$

$$B_E = -\sum_{a=0}^{L-1}\sum_{b=0}^{L-1} p(a,b)\log_2[p(a,b)] \tag{12}$$

Formula (7) - (12) are the autocorrelation function, covariance and inertia, absolute, energy and entropy.

8) Gray - gradient characteristics

$$b_1 = \frac{1}{m\times n}\sum_{i=1}^{m}\sum_{j=1}^{n} GT[i,j] \tag{13}$$

$$b_2 = \frac{1}{m\times n}\sum_{i=1}^{m}\sum_{j=1}^{n} (GT[i,j]-b_1)^2 \tag{14}$$

$$b_3 = \frac{1}{m\times n}\sum_{i=1}^{m}\sum_{j=1}^{n} (GT[i,j]-b_1)^3 \tag{15}$$

$$b_4 = \frac{1}{m\times n}\sum_{i=1}^{m}\sum_{j=1}^{n} GT[i,j]\log GT[i,j] \tag{16}$$

In formula (13) - (16): GT [i, j] is gray level-gradient co-occurrence matrix, m, n is the size of input image.

The artificial neural network based on BP algorithm structure is:

- Extract characteristic function of texture image after analysis, and then obtain the image characteristic value.
- Make the extracted 16 feature vectors as input, that is, the number of input vector is 16.
- Establish three BP networks, size is 16 * n * n2, n is the size of texture image, and its value is based on the structure of the different texture and different.

4. Integration model experiment

In the experiment, the actual texture of electrical equipment is simulated by a method of integrated model texture feature extraction. In this way, it implements the following functions:

- Establish carrier parameters of the model, such as height, quality, material, etc.
- The 16 characteristic functions of texture images are extracted automatically;
- Simulation establish BP neural network;
- The automatic generation of the texture image.

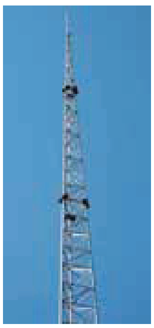

Figure 2. Actual lightning rod tower graphic

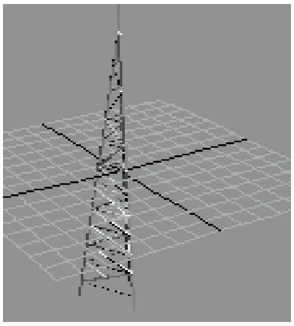

Figure 3. Generated lightning rod tower graphic

Figure2 and Figure 3 contrast basically no difference, the generation effect is rather good. As show in Figure 4 and Figure 5, the original image histogram and generated image histogram are basically the same.

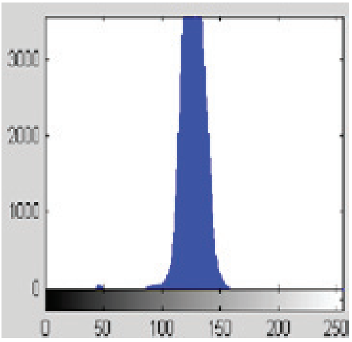

Figure 4. Histogram of the actual lightning rod tower

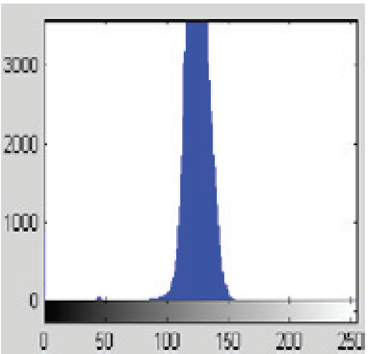

Figure 5. Histogram of generated lightning rod tower

Conclusion

The method of electric power equipment integrated modeling based on carrier is practical and valuable. The experiments prove that the original image histogram and generated image histogram are basically the same. The proposed model contain more information and more realistic. This method can increase operating staff's perceptive ability of currently power grid running state rapidly, and can make a warning and the correct decision to potential security threats. In this way, it can meet the requirement that is visualized, intuitive, vivid and concrete.

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