Intelligent Measurement of Power Frequency Induced Electric Field Strength Based on Convolutional Neural Network Feature Recognition

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Abstract. Aiming at the problem of large measurement error in existing electric field intensity measurement methods, an intelligent measurement method of power frequency induced electric field intensity based on convolution neural network feature recognition is proposed. According to the working principle of power devices in power environment, the mathematical model of power frequency induced electric field is established. The power frequency induction electric field intensity signal is collected by the intelligent chemical frequency induction electric field intensity measuring device. The convolution neural network is used to extract and recognize the characteristics of the power frequency induced electric field intensity signal. Through feature matching, intelligent measurement results of power frequency induced electric field intensity are obtained. The test results show that the average electric field intensity measurement error of the proposed method is reduced by 1.24 N/C, which solves the problem of large measurement error.

Keywords: Convolutional Neural Network · Feature Recognition · Power Frequency Induction · Electric Field Strength · Intelligent Measurement

1 Introduction

With the continuous development of power system, more and more transmission lines, the system becomes more and more complex and huge, and the accuracy and reliability of line parameters are also increasingly strict in power system calculation. Accurate line parameters are the basis of power system calculation such as power flow calculation, fault analysis, network loss calculation and relay protection setting calculation. The measurement of power system line parameters has become an indispensable process before the new transmission line is put into operation. Moreover, the commonly known transmission line parameters are measured at the initial stage of the line construction, and these parameters will change more or less due to climate, temperature, environment, geography and other factors after being put into operation. Therefore, it is necessary to measure the line parameters that have been put into operation.

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Power frequency refers to the abbreviation of power grid working frequency, which refers to the frequency of AC power in the power grid. All generators, transmission and distribution equipment and users in the same power grid use AC power of this frequency. The electric field intensity in some areas of power frequency electric field around high-voltage substations, transmission lines and other equipment exceeds the allowable value of 5k V/m in national standards. With the continuous improvement of the voltage level of transmission lines, the environmental problems caused by power frequency electric fields have become increasingly prominent, which has become one of the main factors restricting the construction of ultra-high voltage transmission projects in China. The timely and effective measurement of electric field is an indispensable means to actively face and solve this new threat. Electric field intensity is one of the important indicators of power frequency induced electric field, which is a physical quantity used to express the strength and direction of electric field. The direction of the electric field strength at a point in the electric field can be determined by the electric field direction of the electric field force applied at the point where the electric charge is tested; The electric field strength can be determined by the ratio of the force on the test charge to the charge charge at the test point.

Electric field intensity measurement refers to the measurement of electric field intensity at the receiving site to obtain various propagation data and parameters for correct design of wireless circuits. The measurement of electric field intensity is also an important work in solving electromagnetic compatibility problems. Among the existing methods for measuring power frequency induced electric field strength, the more mature research achievements include: Reference [1] proposes an electric field intensity sensor that can be used for unmanned aerial vehicles to solve the technical difficulties of large range field intensity and wireless data transmission and meet the test requirements of ultra-high voltage substations. Take the pillar porcelain bottle as the test object, carry out the laboratory measurement of the field strength distribution at different voltage levels and different positions. In reference [2], the measurement method of electric field intensity based on the explicit sensitivity matrix of three-dimensional electromagnetic response is studied by using the three-dimensional finite volume method of electric field coupling potential and the direct solution technology. First, the finite volume method is used to discretize the electric field mixed potential equation; The large algebraic equations corresponding to the forward modeling of moving source electromagnetic field are established, and the interpolation operator and projection operator are determined; The projection operator is used to calculate the electromagnetic response of multiple emitters; According to the block model and the conductivity distribution characteristics of the abnormal body, the electric field intensity is calculated by using the discrete vector of the projection operator and the scattering current element. However, the traditional electric field strength measurement methods mentioned above have obvious measurement strength error problem, which is mainly due to the inaccurate analysis of electric field signal characteristics. Therefore, convolutional neural network feature recognition technology is introduced.

Feature recognition refers to the extraction of special information of things or phenomena, and convolutional neural network feature recognition technology applies convolutional neural network to multiple iterations on the basis of traditional feature recognition technology to improve the accuracy of feature recognition. Convolution neural network is a feedforward neural network, whose artificial neurons can respond to the surrounding units within a part of the coverage. Generally, the basic structure of convolutional neural network includes two layers, one is the feature extraction layer, and the input of each neuron is connected with the local acceptance domain of the previous layer, and the local features are extracted. The convolutional neural network feature recognition technology is applied to the optimization design of intelligent measurement method of power frequency induced electric field strength, in order to improve the intelligent measurement accuracy of power frequency induced electric field strength.

2 Design of Intelligent Measurement Method for Power Frequency Induced Electric Field Strength

2.1 Establishing the Mathematical Model of Power Frequency Induced Electric Field

Taking the substation as the research environment, the power frequency induced electric field model is built. Busbars, incoming lines, outgoing lines and other types of conductors are stored in the substation. Considering that the power frequency electromagnetic field in the station is distributed 1.5 m above the ground, the distance between the observation location and the excitation source is far greater than the geometric size of the bundled conductors. The bundled conductors are often considered as one conductor according to the actual needs of the project. The bundled conductors are equally divided on the same circumference, and the equivalent radius is:

$$R_{\text{wireway}} = R^n \sqrt{\frac{nr_z}{R}} \tag{1}$$

In the formula, R and r represent the radius values of the split wire and the child wire, respectively, and n is the number of the split wire. Due to the small span of the conductor in the substation, the influence of conductor sag on the calculation of power frequency electromagnetic field can be ignored, and its calculation error will not lead to the effectiveness of the assessment and prediction of power frequency electromagnetic field distribution in the substation. According to the above method, the electric field of other components in the substation can be obtained. When calculating the power frequency electric field generated by point charge, take Cartesian rectangular coordinate system, set the position of simulated point charge q_0 as (x_0, y_0, z_0), and its coordinate is shown in Fig. 1.

In the power frequency-induced electric field environment shown in Fig. 1, the potential at any point can be expressed as:

$$\psi = \frac{q}{4\pi\varepsilon R} \tag{2}$$

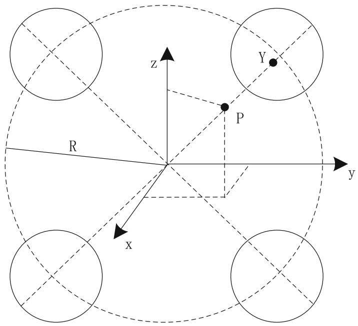


Fig. 1. Mathematical model of the power-frequency-induced electric field

In formula (2), ε is the electric field coefficient, based on which the potential coefficient of a single simulated point charge is:

$$\gamma = \frac{\psi}{4\pi R} \tag{3}$$

The potentials and their coefficients at all positions in the power frequency induced electric field environment are obtained according to the above methods, and are input into the substation structure to realize the construction of the mathematical model of the power frequency induced electric field.

2.2 Installation of Intelligent Measuring Equipment for Power Frequency Induced Electric Field Strength

As the wave length under power frequency is larger than the size of the metal conductor surface, the phase difference of electric field strength between points on the metal conductor surface can be ignored [3]. The working principle of intelligent measuring equipment for power frequency induced electric field strength is shown in Fig. 2.

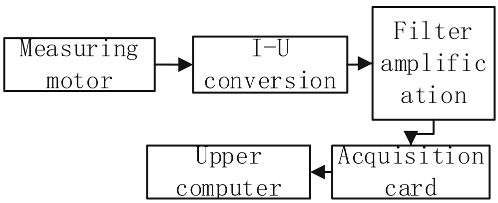


Fig. 2. Structure diagram of intelligent measurement equipment of electric field strength

Place the inductive electrode plate device in the electric field to be measured. After the motor speed is stabilized, the electrode plate will generate and output an inductive current signal with a certain amplitude. After the current voltage conversion circuit, filter and amplify the signal. Then, use the data acquisition card to collect the single frequency signal waveform, and monitor its amplitude and frequency. The amplitude of the output voltage signal has a certain proportional relationship with the DC electric field strength to be measured. After calibration, the magnitude of the electric field strength to be measured can be directly displayed and read through the software interface [4]. The induction electrode plate is made of aluminum plate with a thickness of 1 mm and a diameter of 60 mm by mechanical processing to approximate sector shape. A hole with a diameter of 5 mm is opened in the center of the static electrode plate, and then it is fixed on the motor bracket with PVC pipe. The center of the moving electrode plate is fixed on the motor shaft with a screw with a diameter of 3 mm, and leads from two electrode plates are led out through the motor bracket and shaft respectively. The working principle of intelligent measuring equipment for power frequency induced electric field strength is shown in Fig. 3.

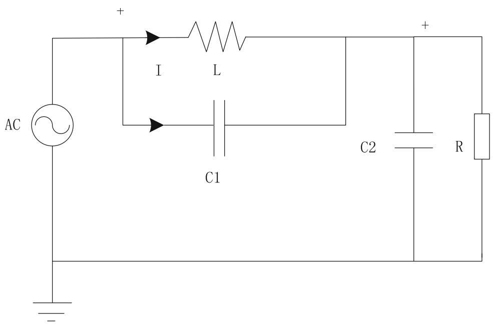


Fig. 3. Schematic diagram of the intelligent measuring equipment of electric field strength

The interface of the electric field strength intelligent measurement equipment is connected to the outer surface, side surface and inner surface of the metal sheet, respectively, and the displacement current flows from the slice outer surface to the ground, and the displacement current from the inner surface and from the side surface flows to the shell. The conduction current flows from the sheet to the metal conductor body by measuring the resistance. Then, the area fraction of the conduction current density detected on the closed surface of the formula can be expressed as:

$$I_R = \oiint_S \rho \bullet \mathrm{d}S \tag{4}$$

In formula (4), the variable ρ is the conduction current density, S is the detection surface area, d is the distance between the measurement points, and the calculation result I_R is the total displacement current.

The alternating current signal induced by the induction device is converted into voltage signal through I-U conversion circuit, and then amplified and filtered. After being adjusted, it is differentially input by AI1 and AI19 input ports of the data acquisition card NI-USB6210, and connected to the terminal monitoring host computer through USB plug and play data bus [5]. The data output by the assistant of the data acquisition device is directly sent to the waveform graph one way to monitor the signal waveform in real time, and the other way is sent to the single frequency measurement function to monitor the signal amplitude and frequency in real time. After calibration, the amplitude of the signal output has a K times proportional relationship with the electric field strength to be measured within a certain range, and the output electric field strength can be displayed directly on the interface.

2.3 Intelligent Acquisition of Power Frequency Induced Electric Field Strength Signal

Using the intelligent measuring equipment installed in the mathematical model of the power frequency induced electric field, the real-time power frequency induced electric field strength signal is obtained. Figure 4 shows the intelligent acquisition process of power frequency induced electric field strength signal.

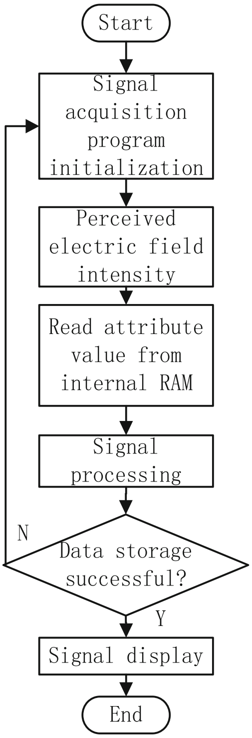


Fig. 4. Flow chart of power frequency-induced electric field intensity signal acquisition

In order to make the SCM better process the measurement signal, a current voltage conversion circuit is added prior to the filter amplifier circuit to obtain the weak electric field signal [6] output by the sensor by taking the current. In order to ensure the acquisition quality of the power frequency sensing electric field intensity signal, the initial collected electric field intensity signal is filtered by using formula (5).

$$\begin{cases} x_{\text{wave}} = f_{\text{wave}}(x) \\ f_{\text{wave}} = med(X) \end{cases} \tag{5}$$

In formula (5), $f_{\text{wave}}()$ is the filter function, $med()$ is the median calculation function, and x, x_{wave} and X represent the initial acquisition of the electric field intensity signal, the signal filtering processing result and the initial acquisition signal set, respectively. Thus acquisition and processing of power frequency sensing electric field intensity signal.

2.4 Establishment of Convolutional Neural Network

The core of convolutional neural network is convolution and pooling operation. The convolution layer is composed of multiple small-scale convolution kernels. During the network training, the convolution kernel updates its own parameters through multiple iterations. After the model converges, the convolution kernel can automatically extract the two-dimensional key features of the sample and generate multiple features. Pooling layer uses the principle of image local correlation to sample features, reduce the scale of neural network and reduce the amount of data processing. After multiple convolution and pooling operations, the hidden feature information will be fully extracted, and the classification results will be output through the full connection layer and the classifier. Figure 5 shows the basic architecture of the convolutional neural network.

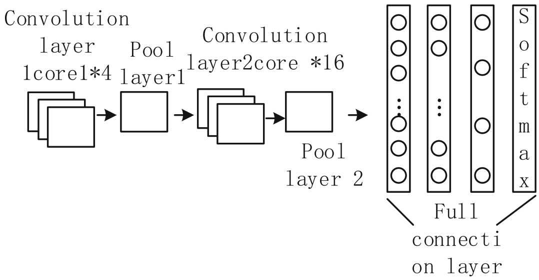


Fig. 5. Convolutional neural network architecture diagram

As shown in Fig. 5, the entire convolutional neural network structure consists of six layers, the first layer is the input layer, the second and fourth layers are convolutional layers, the third and fifth layers are the lower sampling layers, and the sixth layer is the full connection layer. In the convolution layer, the input characteristic map is convolved with the convolution filter. The convolution result plus a bias term is used as the input of the activation function. After the activation function processing, the output characteristic map of the layer is obtained. Is a matrix of order l, including l × 1 trainable parameters [7]. For a size of m × n Input characteristic diagram of n, and l × l After the convolution kernel of l is convolved, the size of the output feature map is $(m - l + 1) \times (n - l + 1)$, and the expression form of the convolution layer is:

$$y_j^i = g\left(\sum_{i \in M_j} x_i^l * \varpi_{ij} + \phi\right) \tag{6}$$

In formula (6), $g()$ is the activation function, M_j is the data set of the input convolutional neural network, x_i^l is the initial input data, and ϖ_{ij} and ϕ are the convolutional kernel and bias terms, respectively.

In the subsampling layer, lower the input features. The extracted data features are mapped into smaller plane ranges to simplify the network structure and reduce the computational scale. Subsampling samples the input features at a certain step size, but not the continuous sampling. Generally, the sampling step size is consistent with the sampling kernel width. If the sampling kernel size is $r \times r$, it is necessary to divide the input feature into several $r \times r$ sub-regions for mapping, and each region passes through the sampling function and output one eigenvalue, which reduces the size of the output feature to the $\frac{1}{r}$ of the input feature. The expression form of the subsampling layer is follows:

$$y_j^l = \omega_j^l h\left(x_j^l\right) \tag{7}$$

In formula (7), variable ω_j^l is the weight value of the sampled data and $h()$ is the sampling function.The downsampling layer works as shown in Fig. 6.

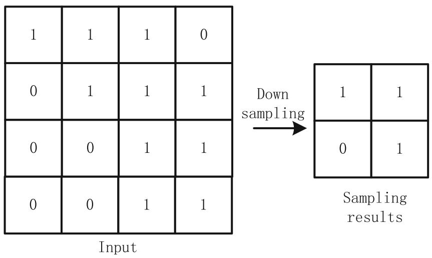


Fig. 6. Schemschematic of lower sampling layer

According to the above way, we can get the working principle of the full connection layer and the output layer in the convolutional neural network, and complete the construction of the convolutional neural network.

2.5 Extraction and Identification of Electric Field Strength Signal Characteristics

The convolution neural network is used to extract the characteristics of the power frequency induced electric field intensity signal intelligently acquired. The feature extraction and recognition process of convolutional neural network can generally be divided into two steps: forward propagation and back propagation. Forward propagation is to input the acquired power frequency induced electric field strength signal into the input layer of the convolutional neural network, and reduce the accuracy of feature location extraction of the previous layer in the new mapping through convolution operation. After the convolution operation, you can choose whether to add paranoia and activate the new features of, and finally form a new feature through the new features mapped by the nonlinear activation function, which is used as the input of the next sub sampling layer [8]. The output results of the convolution layer are directly input to the down sampling layer to complete the statistics and extraction of the features of different positions of the signal, that is, the convolution features are pooled to reduce the dimension. Finally, through Softmax classifier, the initial extraction results of electric field strength signal features are obtained. Back propagation algorithm is the main algorithm used in CNN training. First, the corresponding values are obtained from the input training data through forward calculation, and then the error is calculated in reverse, the gradient is calculated for the weight and offset, and the weight and offset values of the network are adjusted according to the gradient. In the whole training process, forward calculation and reverse calculation are conducted alternately until the deviation is reduced to a threshold range or the required number of iterations is reached, so as to stop iteration. In order to make the network converge effectively, it is necessary to set the optimization objective function. For a dataset Z, set the target function to the average loss value of all data in the entire dataset as:

$$\lambda(Z) = \frac{1}{|Z|}\sum_{i}^{|Z|} g_Z\left(X^{(i)}\right) + \eta(Z) \tag{8}$$

In formula (8), $g_Z()$ is the loss solution function of the electric field intensity signal data. The calculation method is to find the loss value of each individual sample X, and then sum up all, and finally find the mean.

$\eta(Z)$ is the regular term which set to attenuate the overfitting phenomenon [9].

Using stochastic gradient descent, we calculate a linear combination of the negative gradient $\nabla\lambda(Z)$ and the last updated weight value to update the weights. The iterative formula is as follows:

$$\begin{cases} \varpi_{t+1} = w\varpi_t - \alpha\nabla\lambda(Z) \\ \omega_{t+1} = \omega_t + \varpi_{t+1} \end{cases} \tag{9}$$

In the formula, ϖ_t represents the weight value of the last update, and w and α respectively correspond to the weight value of the previous gradient and the learning rate of the convolutional neural network. Through the forward and reverse propagation of the convolutional neural network, the results of the extraction of the eigenvectors such as the peak and margin of the power-frequency-induced electric field intensity signal are obtained, which can be quantified as:

$$\begin{cases} \tau_{\text{peak}} = \frac{x_p}{x_{rms}} \\ \tau_{\text{Margin}} = \frac{x_p}{x_r} \end{cases} \tag{10}$$

In the formula, x_p, x_r and x_{rms} represent the mean square, root mean square and effective values of the electric field intensity signal, respectively. Similarly, through multiple iterations of the convolutional neural network, the extraction results of other eigenvectors of the power-frequency-induced electric field intensity signal can be obtained. The final extracted electric field intensity signal features are matched with the standard signal features to complete the feature identification work of the field strength signal. The specific feature matching process can be quantified as follows:

$$s(\tau_{\text{extract}}, \tau_{\text{standard}}) = \sqrt{|\tau_{\text{extract}} - \tau_{\text{standard}}|^2} \tag{11}$$

In formula (11), the variables τ_{extract} and τ_{standard} are the extracted field strength signal characteristics and the set field strength signal standard characteristics, respectively, so that the extraction and identification of the electric field intensity signal characteristics are completed.

2.6 Realize the Intelligent Measurement of Power-Frequency-Induced Electric Field Intensity

The intelligent measurement of the electric field of the power frequency induction. Through the division of the conductor and the search of the simulated charge, the power-frequency electric field intensity value in each direction of the desired point $P(x_p, y_p, z_p)$ in the space can be deduced:

$$\begin{cases} E_{px} = \dfrac{L}{4\pi\varepsilon_0}\displaystyle\int_0^1 \dfrac{\beta(x_p - x_1 - kt)}{\left(\sqrt{t^2 + \kappa_0 t + \kappa_1}\right)^3} dt \\ E_{py} = \dfrac{L}{4\pi\varepsilon_0}\displaystyle\int_0^1 \dfrac{\beta(y_p - y_1 - mt)}{\left(\sqrt{t^2 + \kappa_0 t + \kappa_1}\right)^3} dt \\ E_{pz} = \dfrac{L}{4\pi\varepsilon_0}\displaystyle\int_0^1 \dfrac{\beta(z_p - z_1 - nt)}{\left(\sqrt{t^2 + \kappa_0 t + \kappa_1}\right)^3} dt \end{cases} \tag{12}$$

In the formula (12), L is the linear charge length, (x_1, y_1, z_1) is the coordinate value of the electric field endpoint, k, m and n respectively represent the distance between the measurement point and the endpoint in x, y and z, and β is the constant coefficient. The specific value is related to the identified electric field signal characteristics. The calculation formula of the κ_0 and κ_1 parameters is as follows:

$$\begin{cases} \kappa_0 = -2\left[k(x_p - x_1) + m(y_p - y_1) + n(z_p - z_1)\right] \\ \kappa_1 = (x_p - x_1)^2 + (y_p - y_1)^2 + (z_p - z_1)^2 \end{cases} \tag{13}$$

According to the superposition theorem, the electric field strength generated by the three-phase conductor segment is added to [10] in x, y and z directions. The components of the electric field intensity generated at point $P(x_p, y_p, z_p)$ in all directions are expressed as:

$$E_{iN} = \sum_{i=1}^{N} E_{pi} (i = x, y, z) \tag{14}$$

Finally, according to the electric field intensity in the direction x, y and z direction at any point in space, the total electric field intensity value E of this position can be obtained, that is:

$$E = \sqrt{E_{xN}^2 + E_{yN}^2 + E_{zN}^2} \tag{15}$$

The formula (12)-formula (15) combines the intelligent measurement results of the power frequency-induced electric field intensity at all positions in the electric field environment. Finally, the external environmental interference factors are collected to compensate for the measurement error of the electric field strength. The compensation process can be expressed as follows:

$$E_{out} = E \pm \vartheta \tag{16}$$

In the formula, E is the direct electric field intensity measurement result, and ϑ is the measurement error. According to the above process, accurate power frequency induction electric field intensity intelligent measurement results.

3 Experimental Analysis of Measurement Accuracy Test

For the purpose of testing the field strength measurement accuracy of the intelligent measurement method of power frequency induced electric field strength based on convolutional neural network feature recognition, the measurement accuracy test experiment is designed by means of comparative experiment, and whether the optimized design method achieves the expected effect is completed.

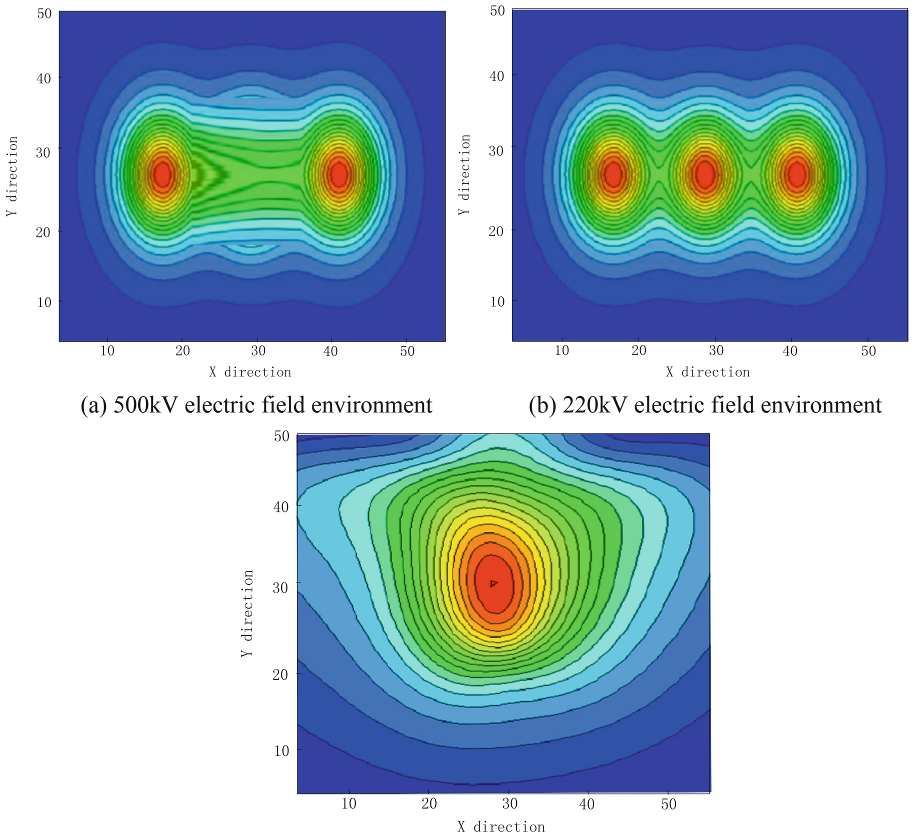
3.1 Configuration of Power Frequency Induced Electric Field Environment

The power grid of a city is selected as the research environment for the experiment. The voltage level of the power grid can be divided into three parts: 500 kV, 220 kV and 10 kV. In the power grid environment, there is one 500 kV substation with a main transformer capacity of 2 * 1500 MVA, 10 220 kV substations with a total main transformer capacity of 5470 MVA, and 15 10 kV substations with a main transformer capacity of 3587 MVA. The total length of the three voltage levels is 687.4 km, 763.9 km and 178.9 km respectively. Through parameter setting, ensure that all power elements in the grid are at the same working frequency. According to the operation of each power element in the grid, the configuration result of power frequency induction electric field environment is obtained, as shown in Fig. 7.

Mark the actual electric field strength and direction of each node in the power frequency induced electric field environment configured in Fig. 7 as the criteria to judge whether the output result of the measurement method is accurate.

3.2 Structural Parameters of Input Convolution Neural Network

Because the intelligent measurement method of power frequency induced electric field strength optimized and designed uses the convolution neural network feature recognition



(a) 500kV electric field environment (b) 220kV electric field environment

(c) The 10kV electric field environment

Fig. 7. Distribution diagram of the power-frequency-induced electric field

method, it is necessary to set the structure and operation parameters of the convolution neural network. The structural parameters to be set include the number of convolution kernels, the initial weight, the number of batch sample training, and the learning rate. The number and size of convolution kernel is the core problem of convolution neural network. The size of the convolution kernel is the size covered by a convolution kernel on the feature map during the convolution operation. After each convolution operation, the convolution kernel moves once according to the size of the step, and then calculates again. A feature map can be obtained by traversing a convolution check with a feature map, and the number of feature maps can be obtained by the number of convolution cores in a convolution layer. The training number of batch samples is the amount of data contained in each batch, and the learning rate is crucial to the training process of DCNN. If the set learning rate is too large, it is easy to cause the shock of the network recognition rate, which makes it difficult for the network to converge to the minimum point. On the contrary, if the set learning rate is too small, it will lead to too many iterations in the training and spend a lot of time. Set the number of convolution kernels to 60, the initial weight value to 2.0, the number of batch sample training to 20, and the learning rate to 0.001.

3.3 Laying Power Frequency Induced Electric Field Strength Measuring Points

Randomly select multiple measuring points in the configured power frequency induced electric field environment, and install the designed intelligent measuring equipment in the electric field environment. The specific layout of measuring points is shown in Fig. 8.

Fig. 8. Real scene layout of power frequency induction electric field intensity measurement points

In the experimental environment shown in Fig. 8, the installed measuring equipment is adjusted to ensure the normal operation of the measuring equipment in the experimental environment, and the true value of the electric field strength at the position of the measuring point is obtained.

3.4 Describe the Measurement Process of Power-Frequency-Induced Electric Field Intensity

After completing the correction of the power frequency sensing electric field intensity measurement equipment and the program, the measurement is first made in the 500 kV electric field environment. Meanwhile, the electrical equipment and the measurement equipment in the electric field environment get the visual intelligent measurement results of the electric field strength through the operation of the convolutional neural network feature identification technology, as shown in Fig. 9.

The above procedure can obtain the intensity measurement results of multiple measurement points in the electric field environment.

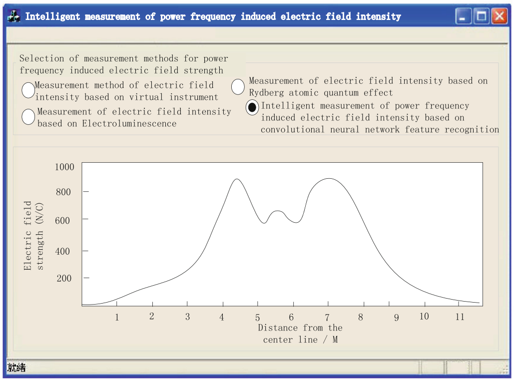


Fig. 9. Intelligent measurement results of power-frequency-induced electric field intensity

3.5 Set the Field Strength Measurement Accuracy Test Index and Comparison Items

When the measurement error of electric field intensity is set as the quantitative test index of the experiment, the numerical results are as follows:

$$\Delta E = |E_{out} - E_{set}| \tag{17}$$

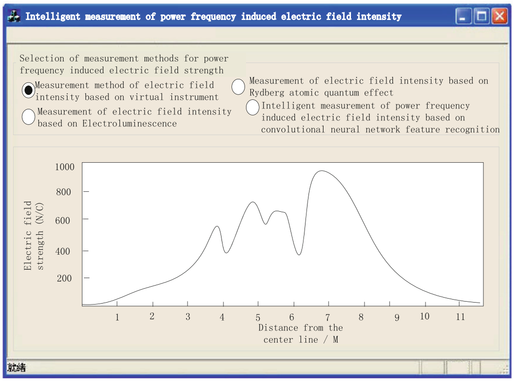
In formula (17), the variables E_{out} and E_{set} respectively represent the measurement results output by the measurement method and the set electric field intensity value. The lower the final calculation value of ΔE, the smaller the measurement error of the corresponding measurement method, that is, the higher the measurement accuracy. In order to reflect the advantages of intelligent measurement method of power frequency induced electric field intensity based on convolutional neural network feature identification, the traditional electric field intensity measurement method based on virtual instrument, electroluminescence effect and electric field intensity measurement method based on the experiment are the corresponding electric field intensity measurement results output by the comparison process, as shown in Fig. 10.

Similarly, the output results of other conventional measurements can be obtained.

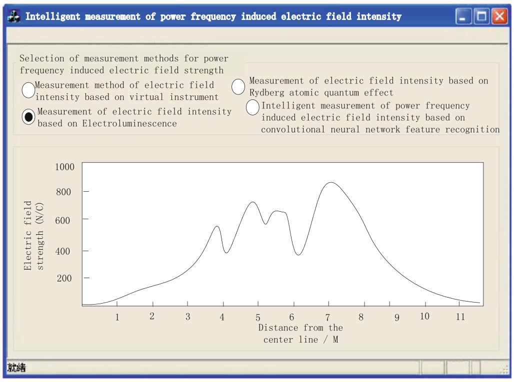
3.6 Analysis of Measurement Accuracy Test Experiment Results

Through the statistics of the relevant data, the test and comparison results reflecting the intelligent measurement accuracy of the power-frequency-induced electric field intensity are obtained, as shown in Table 1.

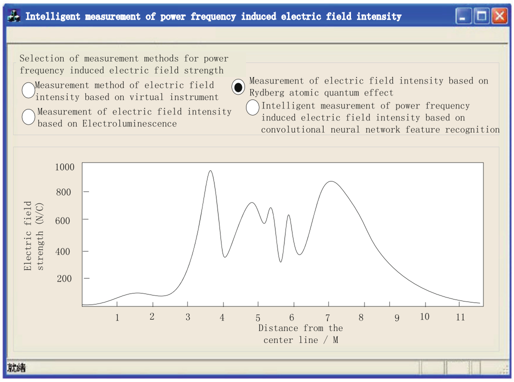
By substituting the data in Table 1 into Formula 17, it can be concluded that the average measurement errors of the three comparison measurement methods are 1.66 N/C, 1.41 N/C and 1.53 N/C. In addition, the average measurement error of the intelligent measurement method of power frequency induced electric field strength based on convolutional neural network feature recognition is 0.29 N/C. It is proved that compared with the traditional electric field strength measurement method, the optimized design



(a) Electric field intensity measurement method based on virtual instrument



(b) Field strength measurement method based on the electroluminescence effect



(c) Field strength measurements based on the Rydberg atomic quantum effect

Fig. 10. Output interface of the conventional electric field strength measurement method

measurement method has higher measurement accuracy. The reason for the advantage of this method is that the mathematical model of power frequency induced electric field

Table 1. Test results of intelligent measurement accuracy of power frequency sensing field strength

Electric field strength measuring point number	Set the actual value of the power frequency induction field intensity (N/C)	Measurement results of reference [1] method (N/C)	Results of reference [2] method (N/C)	Results of the electric field intensity measurement method based on the Rydberg atomic quantum effect (N/C)	Results of Electric Field Strength Based on Convolutional Neural Network (N/C)
1	857.5	855.4	856.1	855.7	857.3
2	623.8	621.6	622.5	622.3	623.5
3	756.1	754.3	754.8	754.4	755.7
4	474.2	473.1	472.7	473.0	473.7
5	567.4	566.3	565.9	565.8	567.1
6	575.8	573.2	574.3	574.1	575.6
7	674.9	673.7	673.6	673.3	674.7
8	803.2	802.0	801.7	802.1	803.0

is established according to the working principle of power devices in the power environment, which provides a basic model for subsequent accurate measurement. Through feature matching, the intelligent measurement result of power frequency induced electric field intensity is obtained, which further solves the problem of large measurement error.

4 Conclusion

The difficulty of electric field intensity measurement is that the probe is placed in the field to be measured, which is easy to cause distortion due to electrostatic induction. In addition, the following signal processing is difficult due to impedance, temperature drift and other factors. Through the application of convolutional neural network feature recognition technology, the intelligent and accurate measurement of electric field strength is realized, providing reference data for the setting and management of power components, electric fields and other parameters.

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