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Power Quality Disturbance Classification Based on IGWT-SNHMM

Xueting Liu[*1], Youquan Wang[2]

[*1]School of Electrical and Electronic Engineering, Shandong University of Technology, Zibo, 255049, China

[2]Department of Mechanical and Electrical Engineering, Jining Polytechnic, Jining, 272037, China

Abstract

By using the optimum-interval interpolation estimation, in this paper, a new composite model which is based on the improved second generation wavelet transform and second order nonhomogeneous Hidden Markov Model(ISGWT-SNHMM) is proposed and applied in the power quality disturbance classification. By adopting the interpolating scheme and the optimum-interval interpolation estimation, the prediction coefficients which are solved by least square method with constraint of vanishing moment number can represent features of the given date.

Keywords: optimum-interval interpolation estimation, improved second generation wavelet transform, second order nonhomogeneous Hidden Markov Model, power quality disturbance classification.

Introduction

In recent years, with the wide application of power grid development and power electronics, a large number of new energy power generation device and the impact load connected to the grid. At present, the power quality events are more complex than ever, and power quality problems have become increasingly prominent. All kinds of transient power quality events occur frequently, causing power equipment damage, sensitive load is not working properly, and even lead to large-scale blackout. Therefore, the power quality disturbance classification has become one of the hot issues of power quality analysis field and many approaches and practitioners have been proposed to many methods; a convenient, fast, accurate classification algorithm can provide more high-level modern smart meters and real-time monitoring system [1-10].

But in the traditional method, some direct results on wavelet transform vector quantization, which may lead to characteristic sequence is too long, which increase the amount of calculation, so that the convergence and the accuracy of classification are affected, while ignoring the role of text context information model on extraction performance and the state transition probability and the observation value relevance of the output probability with the model the historical state.

Motivated by the above and [11-12], A new composite model which is based on the improved second generation wavelet transform and second order nonhomogeneous Hidden Markov Model(ISGWT-SNHMM) is proposed and applied in the power quality disturbance classification. By using the interpolating scheme and the optimum-interval interpolation estimation, the prediction coefficients which are solved by least square method with constraint of vanishing moment number can represent features of the given date.

The Improved Second Generation Wavelet Transform

Traditional Wavelet Transform

The basic idea of wavelet transform originated in the early twentieth Century Haar work is based on the window function can automatically adjust the length of the source, to flex and translation, with the traditional Fourier transform by trigonometric basis function expansion, the wavelet basis function for the fast decay, smooth, energy tight support function and mutually through
the expansion and translation generating set[13-15].

The basic wavelet is a real valued function with special properties, it is a shock attenuation, and usually decay very fast, in mathematics satisfy the integral condition of zero:

$$\int_{-\infty}^{\infty} \psi(\mathrm{t})dt = 0,$$

where its spectrum satisfies the condition

$$C_\Psi = \int_{-\infty}^{\infty} \frac{|\psi(\mathrm{s})|^2}{s} ds < \infty .$$

A set of wavelet function is through the scale factor and displacement factor from the basic wavelet to produce:

$$\psi_{a,b}(\mathrm{t}) = |a|^{-\frac{1}{2}}\psi\left(\frac{t-b}{a}\right) \qquad (1)$$

where b is a real number, called the displacement parameters. Function set is called a wavelet family. Since the parameters (a, b) is a continuous value transform, called continuous wavelet transform. The classic definition of waves as a function expansion means that the high frequency wavelet corresponds to or narrow width, and the low frequency wavelet with or more wide. In wavelet transform, is represented as a linear combination of scaling and wavelet functions. A complete set is consisted by two scale function and wavelet function. However, this is usually adopts the wavelet and scaling function transform. Shift parameters can be described as a general wavelet, $a = a_0^j$, $b = kb_0 b_0^j$, （2）

Traditional Wavelet Transform

The second generation wavelet transform is a kind of lifting algorithm wavelet transform method, and obtain certain characteristics through the design prediction operator and update operator wavelet, which is proposed by Dr. Sweldens. The second generation wavelet method is a more rapid and efficient wavelet transform method, which has the advantage of the following four points: (1) it does not depend on the Fourier transform, entirely at the completion of biorthogonal wavelet domain structure, highlight the advantages of adaptive design and construction aspects of the structured; (2) constructor flexible, from a few simple wavelet function, wavelet function improvement by enhancing features to construct a wavelet with the desired characteristics; (3) no longer is a given wavelet function scaling and translation, it is suitable for the wavelet construction zone, land surface and sampling intervals ranging issues; (4) the algorithm is simple, fast speed, small footprint, high efficiency, can be analyzed signals with arbitrary length[16].

By using the interpolating scheme and the optimum-interval interpolation estimation, in this section, we adopt the improved second generation wavelet transform (ISGWT) is proposed. The prediction coefficients which are solved by least square method with constraint of vanishing moment number can represent features of the given date.

Second Order Nonhomogeneous Hidden Markov Model

James P. Hughes and Peter Guttorp proposed the nonhomogeneous hidden Markov model (NHMM) in 1994. In its most general form nonhomogeneous Hidden Markov Model (NHMM) is defined by the following two conditions:

$$\text{(A1)} \quad P(\mathrm{R}_t \,|\, S_1^T, R_1^{t-1}, X_1^T) = P(\mathrm{R}_t \,|\, S_t),$$

$$\text{(A2)} \quad P(\mathrm{R}_t \,|\, S_1^T, X_1^T) = P(\mathrm{R}_t \,|\, S_{t-1}, X_t),$$

and

$$P(\mathrm{R}_t \,|\, X_1^T) = P(\mathrm{R}_t \,|\, X_1)。$$

In the nonhomogeneous hidden Markov model (NHMM), calculating the state transition probability, each state in the sequence hypothesis condition of a state; the output probability calculation of observation value, if any time observe the output probability depend only on the current state of the system. Here we establish a second order nonhomogeneous hidden Markov model (SNHMM). With a first-order hidden nonhomogeneous Markov model is different, the second order nonhomogeneous hidden Markov model (SNHMM) satisfy the following conditions:

(B1) state sequence hidden is a two order Markov chain;

(B2) the output probability, not only depends on the current state of the system, at the same time dependence to the moment before the system state.

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