Paper ID: MT604

The 3rd International Conference on Mechatronics and Automation Technology (ICMAT 2024)

Detection Method for Illegally Increased Capacity of Distribution Transformers Based on DBSCAN-ELM

Lv XUAN, Yifei SUN, Mengyu WANG, Xiaolin SHI*, GUO Ziqi and Changyan YUAN

Yingkou Power Supply Company, State Grid Liaoning Electric Power Co., Ltd., Yingkou 115002, China

*Corresponding author's email: 1285761510@ qq.com.cn

Introduction

Currently, there are some users who, after expanding their production, privately replace their transformers with larger capacity ones without notifying the power enterprises, in order to save on the increased electricity charges for capacity. This behavior, while saving them considerable electricity expenses, significantly increases the risks to the stability of the power system and harms the interests of power enterprises. In the field of power marketing, this is known as the act of illegally increasing transformer capacity for electricity theft.

Currently, the primary method for detecting such illegal capacity increases involves using capacity detection to assess user behavior. References introduce a distribution transformer capacity detection method based on the impedance voltage method, starting from the national standards for transformer manufacturing. It states that transformers of different capacities should have corresponding impedance voltage values that comply with national regulations, and illustrates the effectiveness of using short-circuit voltage as a detection indicator through examples involving multiple large-capacity transformers. By analyzing the means of capacity detection, it can be concluded that there are certain regression relationships among the operating parameters of transformers , and these relationships are determined by the capacity.Therefore, artificial intelligence algorithms can be used t o fit regression models of operating parameters, and anomaly detection methods can be applied to achieve rapid o nline identification of capacity increases.

This paper fully leverages the advantages of the current big data environment in the power industry and proposes a DBSCAN-ELM based detection model for transformer capacity increases. Experiments conducted using real data show that the model proposed in this paper requires less training time, exhibits high detection accuracy, and enables online screening of capacity increase behaviors.

Research objectives

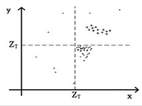
- Research on Data Cleaning Method for Transformer Operation Data Based on DBSCANFor the heterogene.
- Research on Intelligent Detection Method for Unauthorized Capacity Increase of Distribution Transformers Based on ELM.

Methods

Data Cleaning Method for Transformer Operation Data Based on DBSCAN

Considering the data points composed of x and y in equation (5) as an operating point of the transformer, this operating point will be distributed in the fourth quadrant of the two-dimensional plane with $x=Z_T$ and $y=Z_T$ as the origins. As the transformer load gradually increases, the operating point of the transformer corresponding to the above calculation results will gradually approach $x=Z_T$ and $y=Z_T$.As shown in figure , figure is a schematic diagram of the data mapping result.

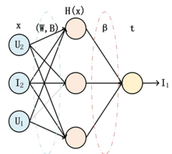
$$\begin{cases} x=\dfrac{k(U_1-kU_2')}{I_2'}=Z_T+\dfrac{kI_0Z_1}{I_2'} \\ y=\dfrac{U_1-kU_2}{I_1}=Z_T\cdot\dfrac{k^2I_0Z_2}{I_1} \end{cases} \quad (1)$$



Capacity Expansion Detection Method Based on ELM

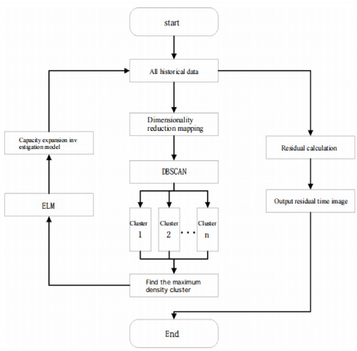
One can set the input feature $\mathbf{X}=[U_1,U_2,I_2]$ and the model output $\mathbf{Y}=I_1$ to construct a regression model. By training the regression model with historical operational data after data cleaning, online troubleshooting of transformer capacity increase behavior can be achieved.

$$\dot{I}_1=\frac{\dot{U}_1-k\dot{U}_2-k\dot{I}_2'Z_2}{Z_1}$$



Process

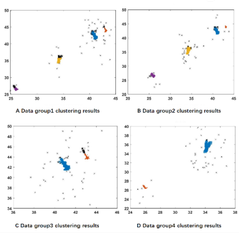
The process of the DBSCAN-ELM augmentation detection method is as follows: the historical operating data of the transformer to be detected is calculated using formula (1) to obtain the x and y coordinates of the two-dimensional plane; Use the DBSCAN algorithm to perform noise reduction on the mapped two-dimensional data, remove outliers, and retain the dense region dataset; Calculate the density values in each dense area, and select the dataset with the highest density as the training set; Train a capacity increase detection model using the ELM algorithm, and calculate the residual of the primary current on all data ; Output the curve of daily average residual current and time, and observe the continuous distribution characteristics of the residual current along time.



Results

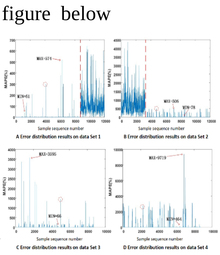
Analysis of Results from Data Cleaning Method Based on DBSCAN

Using the derived data dimensionality reduction formula (1), dimensionality reduction calculations were performed on the dataset, followed by DBSCAN clustering processing. The clustering results under optimal parameters are shown in the figure below.



Analysis of Capacity Increase Detection Results Based on ELM

The model was then used to calculate the primary current values for the entire sample, and the error distribution between the calculated primary current values and the actual values for the entire sample is shown in the figure below



Conclusions

The experimental results indicate that the method proposed in this paper can identify unauthorized capacity expansion behaviors in the historical data of distribution transformers for each user in a region under the context of big data. Compared to traditional methods, it enables online detection with less interference from local abnormal data.

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