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Plasma Discharge Patterns Recognition Base on Improved DenseNet

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Partial discharge (PD) serves as an indicator of insulation degradation during prolonged operation of power equipment, representing a crucial element in insulation deterioration. PD detection is an effective approach for insulation monitoring and disaster prevention for power equipment[1]. Currently, phase-resolved partial discharge (PRPD) and the pulse sequence phase spectrum (PRPS) are standard tools in PD detection and analysis [2]. Based on the rapid development of image recognition in deep learning theory, this paper applies visible images to the recognition of discharge patterns, and uses the spatial information and intricate visual features to achieve accurate classification and recognition of diverse discharge patterns and spatial structures.

However, the existing classification methods based on deep learning still have some challenges in handling complex information and fully expressing features. In order to overcome these problems, this paper proposes an improved lightweight DenseNet network. By adding Squeeze-and-Excitation modules (SE) to different module positions in the DenseNet, the dense connection of DenseNet[3] and the attention mechanism of the SE module[4] are combined. This method effectively increases the importance of feature channels, solves the common problem of vanishing gradient in deep learning, and reduces the feature extraction time. Meanwhile, to address the issue of varying quality and limited number of images in the dataset, this paper utilizes a pre-trained convolutional neural network (CNN) with its weight parameters from a large image dataset. By implementing random adjustments of data augmentation techniques such as random brightness, contrast, rotation, distortion and color change, the scale of the dataset is effectively enlarged, thereby enhancing the generalization ability of the model.

Under the deep learning framework-Pytorch, the SE-DenseNet is established and pre-trained weights are loaded through transfer learning. The visible image dataset includes four discharge patterns: arc discharge, corona discharge, creeping discharge and plasma jet. Following a 6:2:2 ratio, the plasma discharge dataset is randomly partitioned into training, validation, and test dataset. In the experimental stage, three SE-DenseNet models with SE modules added at different positions were constructed for comparative analysis. The experimental results show that adding SELayer before and after each Denseblock has the best performance. At the same time, compared with multiple models, the improved DenseNet performs well, with a test accuracy rate of 99.40%. Compared with DenseNet-201, VGG-16, GoogleNet, MobileNet (MobileNetV3) and ResNet (ResNet-34), the overall accuracy rate increased by respectively 0.24 %, 28.18%, 0.61%, 5.19%, 1.80%, the experimental results show that the improved DenseNet of transfer learning can fully extract and utilize image features, realize feature recalibration, deepen the transmission of depth information, and converge faster.

References

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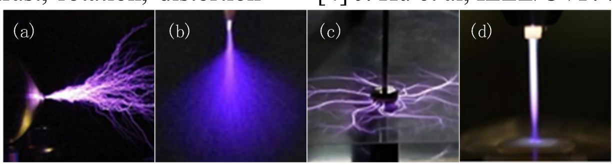

Figure 1. Image examples of discharge. (a) Arc discharge. (b) Corona discharge. (c) Creeping discharge. (d) Plasma jet.

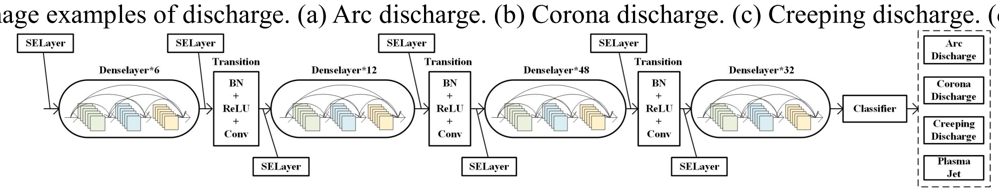

Figure 2. Structure of improved DenseNet.

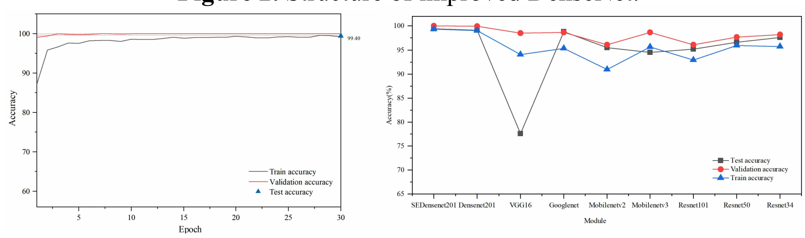

Figure 3. Experimental results. (a) classification accuracy (%) of SE-DenseNet. (b) classification accuracy (%) of different methods.