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Advances in Machine Learning and Deep Learning Techniques for Image Classification and Clustering

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Abstract : Ranging from the field of health care to self-driving cars, machine learning and deep learning algorithms have revolutionized the field with the proper utilization of images and visual-oriented data. Segmentation, regression, classification, clustering, dimensionality reduction, etc., are some of the Machine Learning tasks that helped Machine Learning and Deep Learning models to become state-of-the-art models for the field where images are key datasets. Among these tasks, classification and clustering are essential but difficult because of the intricate and high-dimensional characteristics of image data. This finding examines and assesses advanced techniques in supervised classification and unsupervised clustering for image datasets, emphasizing the relative efficiency of Convolutional Neural Networks (CNNs), Vision Transformers (ViTs), Deep Embedded Clustering (DEC), and self-supervised learning approaches. Due to the distinctive structural attributes present in images, conventional methods often fail to effectively capture spatial patterns, resulting in the development of models that utilize more advanced architectures and attention mechanisms. In image classification, we investigated both CNNs and ViTs. One of the most promising models, which is very much known for its ability to detect spatial hierarchies, is CNN, and it serves as a core model in our study. On the other hand, ViT is another model that also serves as a core model, reflecting a modern classification method that uses a self-attention mechanism which makes them more robust as this self-attention mechanism allows them to lean global dependencies in images without relying on convolutional layers. This paper evaluates the performance of these two architectures based on accuracy, precision, recall, and F1-score across different image datasets, analyzing their appropriateness for various categories of images. In the domain of clustering, we assess DEC, Variational Autoencoders (VAEs), and conventional clustering techniques like k-means, which are used on embeddings derived from CNN models. DEC, a prominent model in the field of clustering, has gained the attention of many ML engineers because of its ability to combine feature learning and clustering into a single framework and its main goal is to improve clustering quality through better feature representation. VAEs, on the other hand, are pretty well known for using latent embeddings for grouping similar images without requiring for prior label by utilizing the probabilistic clustering method.

Keywords : machine learning, deep learning, image classification, image clustering
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