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Deep Learning for Image Classification: A Review

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Abstract

In the discipline of image processing, a variety of techniques are used to achieve various objectives, such as feature extraction, segmentation, enhancement, denoising, and classification. By addressing the possibilities and problems presented by distinct facets of image analysis and modification, these methods as a whole enable applications in a multitude of domains. All of these approaches help us better comprehend pictures, retrieve pertinent information, and make defensible judgements using visual data. Deep learning (DL) models are able to automatically extract complex characteristics that conventional approaches can overlook since they learn feature representations straight from data. Deep learning has contributed to the progress of image classification, which has been a widely pursued field of research for a considerable amount of time. This study proposed a deep learning image classification model to provide a foundation and support for image classification and massive dataset identification. Deep learning performs well in problems involving picture categorisation. However, the need for a substantial quantity of data for the training process is growing as the deep learning model structure becomes deeper and more complicated.

Keywords: Deep learning (DL), Artificial intelligence (AI), Artificial neural system (ANN), Convolutional neural network (CNN), Algorithm.

1 Introduction

Incredible progress has been made in deep learning during the last several years. Deep learning, a branch of machine learning, is the study of a multi-layered deep neural network. Deep learning has become more popular because to recent advancements in machine learning research, substantially enhanced chip processing capabilities, and growing dataset volumes. "Search engines, video games, computer vision,

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speech and audio processing, natural language processing, robotics, biology and chemistry, online advertising, and deep learning" have already shown the benefits of deep learning in a variety of software domains Classification is the methodical grouping or categorization of something based on its attributes. The purpose of image classification is to teach computers with data in order to close the visual gap between humans and computers. The image is categorized into the proper category by being classified differently based on the content of the vision [1].

Images are classified using traditional techniques by a machine learning component, a kind of artificial intelligence (AI). Important attributes such as edges, textures, and so forth are gathered by a feature extraction module, and then used by a classification module to classify the data. It is this way with machine learning. Machine learning's primary drawback is that, when it comes to separation, it can only extract a certain set of features from pictures and cannot extract distinguishing characteristics from the training data set. This problem is addressed via deep learning. Deep learning (DL) is a branch of machine learning that uses a unique kind of computation approach. A deep learning model that can consistently dissect data with a homogeneous structure in a way that is similar to human decision making is presented. This is accomplished via deep learning through the use of "an artificial neural network (ANN)", a multi-layered structure made up of several algorithms. The architecture of a "biological neural network," as it is known in the human brain, is imitated by "an artificial neural network (ANN)". Deep learning models are thus more capable than conventional machine learning models. Neural networks that employ an image's attributes to identify it are taken into consideration in deep learning. By doing this, a thorough feature extraction model that can handle the issues raised by the use of conventional approaches will be built. Remarkably accurate feature extraction from the training batch of pictures is a prerequisite for the integrated model's extractor. The feature descriptors derived from the image are categorized using a variety of methods, including "SIFT, GIST, and Local Binary Patterns" [2].

Convolutional neural networks (CNNs) are a popular deep learning technique. The two main components of CNN are the pooling layer and the convolutional layer. A filter bank, or set of weights, is used to link local areas in the characteristic mapping of a layer above to the feature mappings of a convolutional layer. Subsequently, a ReLU or other non-linearity is applied to the local weighted average outcome. Combining semantically related qualities into a single one is the task of the pooling layer. Given that a motif's constituent elements may have greatly varying relative locations, coarse-graining each feature's location may assist recognize the motif more accurately. The pooling layer sub samples the convolutional layer's output in order to lower the data rate from the layer beyond. The convolutional layer carries several weights. The CNN-based method was used by most of the top rankers in the most recent item recognition competition, the ImageNet Large Scale Visual identification Challenge (ILSVRC)". Their image recognition performance is exceptional. We cover the various deep learning techniques that have been used to pattern recognition and image processing in this work [3].

2 Literature Review

(Archana & Jeevaraj, 2024) [4] Deep learning (DL) models are able to automatically extract complex characteristics that conventional approaches can overlook since they learn feature representations straight from data. Image enhancement, made possible by methods like R2R and LE-net, shows promise for improving visual quality, but difficulties with authenticity and real-world situations still exist. PSPNet and Mask-RCNN are two segmentation approaches that demonstrate accuracy in object separation, even in the face of complexity such as overlapping objects and robustness issues. With trade-offs in interpretability and complexity, automatic recognition plays a key role in revealing picture properties for feature extraction, as shown by techniques like CNN and HLF-DIP. Classification approaches range from CNN-LSTM to Residual Networks, highlighting their promise for accurate classification despite difficulties with interpretability and processing needs. This analysis provides a thorough grasp of the advantages and disadvantages of various approaches, opening the door for well-informed choices in real-world situations. To fully use image processing methods as the area develops, issues like robustness and computing resources must be addressed.

(Yu, 2022) [2] Comparing deep learning models to typical machine learning algorithms, the former may provide results with more accuracy. It is quite helpful in many different contexts, particularly picture categorisation. Recently, there has been a significant increase in the accuracy and reliability of deep learning models used for image classification due to advancements in technology and the development of novel deep learning network topologies. Nevertheless, there aren't many evaluations of contemporary studies in the area of deep learning technology-based picture categorisation. This study aims to evaluate the latest deep learning-based image categorisation research. It contains the most recent research on enhancing deep learning performance. The paper also examines and discusses potential issues and difficulties with deep learning technology as well as potential avenues for future development and research.

(Lv et al., 2022) [3] To increase the deep learning model's accuracy and efficiency in categorisation, its structure was optimised. Experiments were conducted to analyse the link between the number of iterations and the accuracy of different typical network models for image classification in order to validate the efficacy of the deep learning model suggested in this study. The model presented in this research outperformed other models in terms of classification accuracy, according to the findings. Using the training and test sets, the classification accuracy of the deep learning model was also compared and examined before and after optimisation. The findings demonstrated that after the model suggested in this research had been somewhat optimised, the accuracy of picture categorisation had significantly increased.

(Mohamed et al., 2022) [5] A classic challenge in image processing, computer vision, and machine learning is picture categorization. Photograph classification is a complex and varied procedure. In this study, we investigate deep learning-based picture categorization. The topics discussed include deep neural networks, computer vision research, and photo classification techniques. This article describes

how to create "a convolutional neural network (CNN)" and covers its many architectures. CNNs have shown excellent efficacy and assessment in the categorisation of images. To demonstrate the importance and specifics of convolutional neural networks in many applications, a survey of the literature is done.

(Chen et al., 2021) [6] "Convolutional neural networks (CNNs)" became the industry standard technique for image classification starting in 2012. For many visual recognition tasks, including "object identification, object localization, and semantic segmentation, the CNN architecture" is often based on the image categorization network design. In the wake of these successes, CNN-based methods have emerged for improving remote sensing image scene categorization accuracy. This paper investigates the evolution of CNNs from their predecessors to the latest state-of-the-art (SOAT) network topologies, with an emphasis on their use in image classification problems. We now examine the following subjects: "(1) the fundamental architecture of artificial neural networks (ANNs) and CNNs; (2) the traditional precursor network system; (3) the latest SOAT network algorithms; and (4) a thorough examination of all the various image classification techniques discussed in this article". Lastly, we have introduced some of the most recent trends and provided a summary of the key findings and debate in this piece.

(Ahmed et al., 2020) [7] Using the top view data set, this paper investigates popular deep learning-based algorithms for human segmentation. Convolutional neural networks (CNNs) that have been trained to encode feature maps of input images make up the encoder. The encoder extracts vital information, which the decoder uses to upsample and rebuild the result. Pre-trained models are employed, which were trained using a frontal view data set, before any segmentation methods are tested. These models are subsequently trained utilising a human data set that was taken from a top perspective in order to enhance performance. In the top view photos, each model's output is a segmented human. Experimental findings demonstrate the efficacy and performance of the categorization models: "mIoU values of 80%, 82%, and 84% for FCN, U-Net, and DeepLabv3, and IoU values of 83%, 84%, and 86% for each". Additionally, a discussion of the output findings is given, along with some guidance for the future.

(Obaid et al., 2020) [8] As the big data era approached, deep learning evolved into a more intricate network structure with more potent feature extraction and learning capabilities than conventional machine learning techniques. Since its introduction, the model created using the deep learning approach has shown excellent performance in a variety of large-scale identification tasks within the computer vision sector. An introduction to deep learning is given first, followed by a discussion of the most recent models used in deep learning-based picture categorization. The last step involves comparing the accuracy of the two most challenging datasets, "CIFAR-10 and CIFAR-100", against every other deep learning model that has been used in research to date.

(Cai et al., 2020) [9] Big medical data mostly consists of genetic information, medical picture data, electronic health record data, and so on. The great majority of medical data at this point is comprised of medical imaging data. How can clinical practice make use of massive medical data? Researchers in the fields of medicine and computers are quite concerned about this, and deep learning and intelligent imaging provide a promising solution. This review combines the most recent developments in the field with the successes of our team in the big data examination of medical images, specifically the

categorization and segmentation of medical images. To demonstrate how deep learning and intelligent visualization are being used to large-scale data analysis for early illness detection.

(Xin & Wang, 2019) [10] We provide novel training parameters for maximum interval minimum error in deep neural network classification, based on a study of "the error reverse propagation technique". Meanwhile, to get better results, "the cross entropy and M3CE" are investigated and combined. Lastly, we tested our suggested M3 CE-CEc on the MNIST and CIFAR-10 deep learning datasets. The experimental findings demonstrate how M3 CE increases cross-entropy, adding importance to the cross-entropy criteria. Good results have been achieved using M3 CE-CEc in both databases.

3 Conclusion

Image segmentation is one of the primary foci of computer vision research. It is essential for many different real-world applications. Deep learning has recently been a major driver of progress in image segmentation; algorithms that have been built can now identify, categorise, and segment items of particular interest in pictures. These categories include real-time situations, botanical research using photographs of flowers and fruits, and medical and satellite imaging. The customised DL strategies for every area highlight how flexible and effective these techniques are in a variety of complex real-world scenarios. The segmentation models based on deep learning outperform traditional segmentation techniques by a significant margin. Some recent developments in image classification-based deep learning algorithms. The last step involves comparing the accuracy of the two most challenging datasets, "CIFAR-10 and CIFAR-100", against every other deep learning model that has been used in research to date. Deep learning in medical imaging applications may be used to effectively treat uncommon illnesses in addition to detecting common diseases from large data sets. It is noted that even for a percentage of the test photographs, the images are properly identified, demonstrating the efficacy of the deep learning system.

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