Poster Presentation on "Image Classification Using CNN based Model"

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Abstract

In recent years, the rapid growth of digital content has presented a significant challenge in the field of computer vision—automatic image classification. Unlike human vision, which effortlessly comprehends and analyzes images, systems struggle with this complex task. While various research efforts have aimed to improve image classification, many have focused on low-level image features, resulting in less accurate classifications. In response to these challenges, this research paper introduces a sophisticated deep learning approach that harnesses the power of Convolutional Neural Networks (CNNs) to tackle the problem of automatic image classification. The core premise of our system involves leveraging the MNIST dataset, a collection of grayscale digit images, as a benchmark for our experiments. Grayscale images, owing to their intricate details and subtleties, inherently pose a computational challenge for classification. However, through the diligent training of these images using a CNN network, we have achieved an impressive and noteworthy accuracy rate of 98%, demonstrating the effectiveness of our model for image classification.

Introduction

The explosive growth of digital content in recent years has introduced new challenges in the field of computer vision, especially in image classification. While humans excel at understanding and categorizing images, computers face significant difficulties in performing this task. The challenge arises from the vast amount of data contained in images, with each image consisting of numerous pixels, each with varying values [4]. Consequently, image classification demands substantial computational power to analyze and categorize these images. In the following sections, we will explore the use of Convolutional Neural Networks (CNNs), a deep learning algorithm, to address this challenge and achieve highly accurate image classification results.

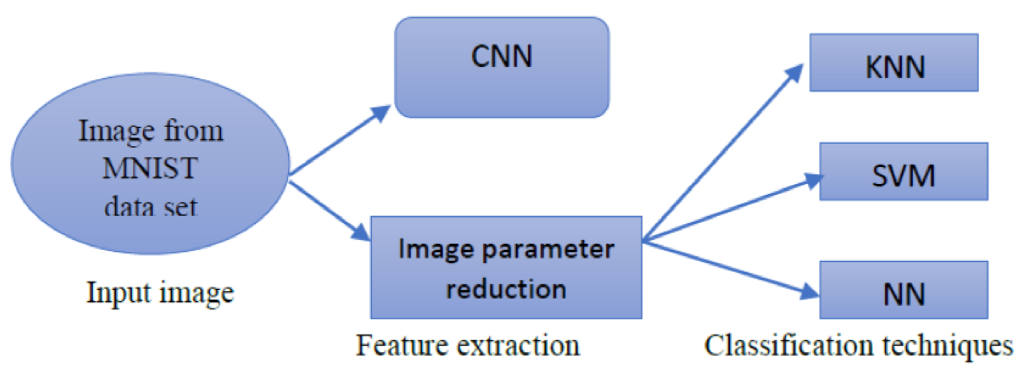

Figure 1. Image classification using machine learning techniques.

As shown in Figure 1, Various machine learning techniques are employed in image classification such as CNN, KNN, SVM and NN.

Convolutional Neural Networks (CNNs) are a prominent choice due to their ability to automatically extract complex features from images. K-Nearest Neighbors (KNN) relies on the majority class of nearby images in feature space, while Support Vector Machines (SVM) aim to find optimal class separation hyperplanes [1]. Neural Networks (NN) can also be utilized for image classification, with Convolutional Neural Networks (CNNs) being a specialized form well-suited for this task. The selection of a technique depends on specific requirements, dataset characteristics, and desired classification performance.

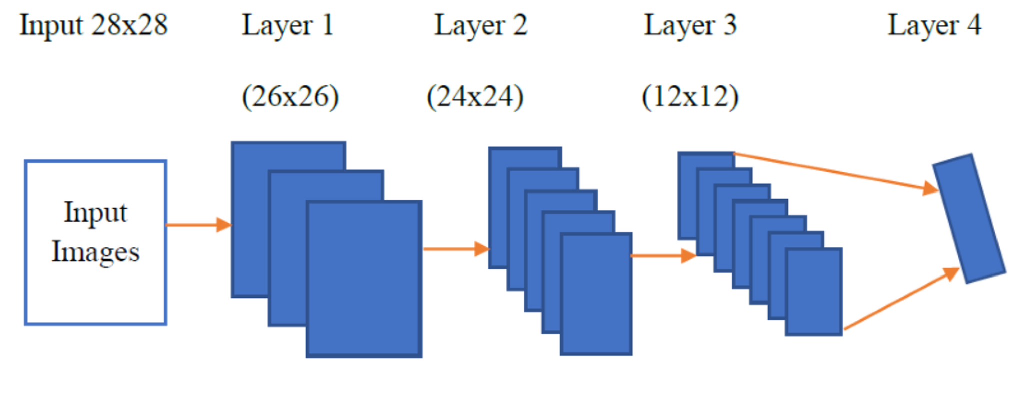

Figure 2. Layers of Convolutional Neural Network (CNN)

The CNN layers journey begins with 28x28 pixel input images, which are fed into the first layer. This initial layer focuses on convolution operations and feature extraction, resulting in a 26x26 feature map. The second layer further refines the features and delivers a 24x24 feature map, deepening the network's understanding of intricate image details. The third layer introduces max pooling, which reduces the spatial dimensions to 12x12, enabling the network to concentrate on the most prominent image characteristics. Finally, the fourth layer is the classification layer, where the network employs the learned features from earlier layers to assign a label or class to the input image.

Convolutional Neural Networks are particularly adept at automatically discerning patterns in images, making them an ideal choice for image classification tasks. The hierarchical feature extraction process within the layers enables the network to progressively learn and recognize both simple and complex image features, ultimately leading to accurate image classification.

Methodology

In our methodology, we harnessed Convolutional Neural Networks (CNNs) to achieve precise image classification. Our research centered on the MNIST dataset, a collection of grayscale digit images. The CNN model was designed with a progressive architecture, beginning with the first layer featuring 32 filters, each measuring 3x3, yielding 32 distinct feature maps. The second layer built upon this foundation with 64 filters of identical size, producing 64 feature maps. We implemented a max-pooling layer that effectively reduced image dimensions to 12x12, utilizing a 2x2 subsampling window. The ultimate layer was a fully connected layer boasting 128 neurons, leveraging sigmoid activation for the final image classification.

In addition to the core methodology, we emphasize two crucial points:

- The MNIST dataset, renowned for its extensive collection of grayscale digit images, served as the benchmark for our research.
- The hierarchical architecture of the CNN model, featuring two convolutional layers and a max-pooling layer, played a pivotal role in the accurate classification of images.

Literature Review

In the literature review, we delve into significant research within the domain of image classification and deep learning techniques, with a particular focus on Convolutional Neural Networks (CNNs). Previous studies have extensively examined CNNs' utilization in diverse image-centric tasks, including feature extraction from hyperspectral images, underwater fish recognition, cattle image recognition, and wood quality classification. These investigations collectively highlight the versatility of CNNs and their promising potential for wider implementation in the field of image classification.

Two noteworthy points stand out in this context:

- The successful application of CNNs in tasks like underwater fish recognition and wood quality classification underscores their adaptability in varied image-related scenarios.
- These research endeavors have paved the way for a more extensive and robust integration of CNNs in image classification techniques, opening up new possibilities for enhancing image analysis and understanding.

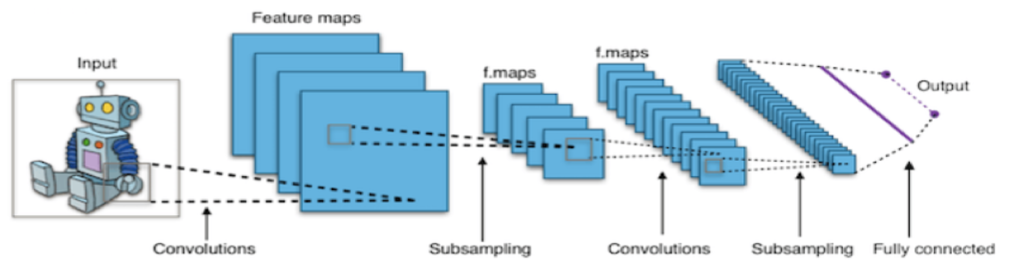

Figure 3. Typical CNN Architecture[3]

The CNN architecture comprises several key components, including an initial input layer for images, followed by feature maps and subsampling layers, convolutional layers, another subsampling layer, a fully connected layer and finally the output layer which is responsible for classifying the images.

- Architecture begins with the input layer, where raw images are fed into the network.Feature maps and subsampling layers are pivotal for feature extraction and dimension reduction.
- Feature maps are generated by applying convolutional operations to identify image patterns.
- Subsampling layers reduce the spatial dimensions of feature maps, lowering computational load.
- Convolutional layers further extract complex image features and hierarchies. Another subsampling layer refines the features.
- The fully connected layer synthesizes the extracted features for precise image classification.
- The output layer assigns images to specific categories based on the gathered information.

In justifying that, the CNN architecture employs a progressive process of feature extraction [2], feature refinement, and classification. This strategic approach gives accurate recognition and categorization of diverse objects, following to the principles of deep learning for robust performance.

Important Point

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Simulation Environment

Our research was conducted in a controlled simulation environment that consisted of computational resources capable of handling the processing demands of CNNs. We employed deep learning frameworks and software tools to create and train our image classification model. The simulations were executed on a system equipped with specific hardware and software configurations, ensuring that the training and testing phases were carried out effectively.

Simulation Results

Our rigorous experimentation with the CNN-based image classification model has yielded highly promising results, affirming the model's efficacy in this context. After training the model on the MNIST dataset's grayscale digit images, we achieved a remarkable accuracy rate of 98%. This impressive performance underscores the potential of Convolutional Neural Networks (CNNs) in tackling complex image classification tasks.

The table below provides a detailed breakdown of the model's performance across five training epochs, showcasing both loss and accuracy metrics:

Table 1. The loss and accuracy of all epochs

EPOCH	LOSS	ACC	VAL_LOSS	VAL_ACC
1/5	0.3450	0.8955	0.0843	0.9739
2/5	0.3452	0.8955	0.08431	0.9617
3/5	0.0448	0.0875	0.0874	0.9743
4/5	0.0451	0.9854	0.0729	0.9787
5/5	0.0628	0.9811	0.0444	0.9860
Total loss	0.5412	0.9842	0.04438	0.986

The cumulative performance metrics for all five epochs reveal a total loss of 0.5412, a total accuracy of 0.9842, a total validation loss of 0.04438, and an exceptional total validation accuracy of 0.986. These results emphasize the CNN model's robustness and accuracy, making it an ideal choice for image classification tasks.

Conclusions

In summary, our research demonstrates the remarkable potential of Convolutional Neural Networks (CNNs) in the domain of image classification.

- Through our experiments with grayscale digit images from the MNIST dataset, we achieved an impressive accuracy rate of 98%. This not only highlights the efficiency and accuracy of CNNs but also opens up exciting possibilities for their utilization in a wide range of fields such as medical imaging and autonomous vehicles.

The exceptional accuracy rate demonstrates the CNN model's robustness and competence in handling image classification tasks, which is particularly crucial in applications where precision is imperative.

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