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CNN Based Machine Vision

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A B S T R A C T

Automating the recognition of human-written digits is known as handwritten digit recognition. Because human handwriting varies so much, notably in terms of writing styles, typefaces, and sizes, it is a difficult undertaking. High accuracy handwritten digit recognition has been accomplished through the application of machine learning techniques. Convolutional neural networks (CNNs) are among the most widely used machine learning methods for handwritten digit recognition. CNNs are a subset of deep learning algorithms created especially for applications involving image recognition. They function by identifying characteristics in photos that are pertinent to the current activity. The support vector machine (SVM) is another popular machine learning approach for handwritten digit recognition. SVMs are a class of supervised learning algorithms that are applicable to regression and classification problems. SVMs can be used to learn a decision boundary that divides the various digits in the instance of handwritten digit recognition. There are several ways to increase the accuracy of handwritten digit recognition systems, including feature selection, data augmentation, and ensemble learning. The technique of producing new data from the current data in order to artificially increase the size of the training dataset is known as data augmentation. The process of choosing the characteristics that are most pertinent to the task at hand is known as feature selection. Combining several learning methods is called ensemble learning.

Keywords: Handwritten digit recognition, Machine learning,, SVM,MLP,MNIST dataset Variability in handwriting styles , Accuracy , deep learning.

Introduction

Computers' capacity to identify handwritten letters and numbers is known as handwritten digit recognition, or HDR. Handwritten numbers can differ significantly in appearance even when written by the same person, making it a difficult process. Nonetheless, high dynamic range (HDR) technology is significant and has many uses, including medical image analysis, bank check processing, and postal automation.The 1960s saw the development of the first HDR systems, which made use of a number of methods including statistical analysis and template matching. But the accuracy of these early systems was lacking. HDR accuracy has increased in the 1990s as a result of the development of neural networks. In addition to being highly successful at reading handwritten text, neural networks can learn intricate patterns from data.These days, HDR is a developed technology with a solid foundation of methods. Convolutional neural networks are the foundation of the most widely used HDR approaches (CNNs). A particular kind of neural network called a CNN is made especially for tasks involving image recognition. Images can have elements extracted from them, including shapes and edges, and these features can be used to categorize the image.Usually, massive handwritten digit datasets are used to train HDR algorithms. A well-liked dataset for HDR research is MNIST. There are 60,000 training in it. photos, along with 10,000 test images. Every image in the file is a handwritten digit in 28 by 28 grayscale.

Literature Survey

In Paper [1]:

The purpose of the research is to examine how hyperparameters affect neural network-based designs for handwritten digit recognition in terms of accuracy and time efficiency.The paper's thorough experimentation setup offers precise and quick solution models for choosing hyperparameter values that are optimized.The paper's comprehensive experimental setup offers precise and quick solution models for choosing the best hyperparameter values.

No particular restrictions are mentioned in the study. It is important to note, though, that additional aspects that can have an impact on handwritten digit identification are not explored in the research; instead, it concentrates on how hyperparameters affect accuracy and time efficiency.

In Paper [2]:

The research aims to increase classification accuracy by addressing the drawbacks of current handwritten digit classification methods and putting forth a novel strategy based on Convolutional Neural Networks (CNN).A CNN technique for classifying handwritten numbers is proposed in this study.In order to determine the effective receptive field (ERF) size and select a typical filter size that improves classification accuracy, the study considers domain knowledge.The suggested CNN method produces handwritten digit identification results that are state-of-the-art, with 99.98% recognition accuracy and 99.40% with 50% noise.

In Paper [3]:

The purpose of the paper is to examine a plausible way to design an OCR solution for a specific dataset of English language numerical digits, as well as to discuss the stages involved in creating an adaptive framework for OCR models.The paper develops a digit recognizer using a convolutional neural network (CNN). The MNIST dataset is used to train the model, and it is compared against other models that were trained using a combination of the MNIST and custom digits.When evaluated on a bespoke dataset of numerical digits, the model produced results similar to those of the baseline. Out of 40 digits, five were incorrectly classified, with the digit "2" having the lowest classification accuracy.

In Paper [4]:

The research aims to create a reliable model for the recognition and classification of handwritten digits using a combination of Extreme Learning Machine (ELM) and Convolutional Neural Network (CNN) techniques.The study presents a unique CNN-ELM model in which the ELM unit functions as an image classifier and the CNN unit, along with the Rectified Linear Unit (ReLU) activation function, serves as a feature extractor.When it comes to accuracy and computational time, the CNN-ELM-DL4J method performs better than traditional CNN models.The outcomes demonstrate that the suggested CNN-ELM-DL4J method achieves cutting-edge handwritten digit recognition accuracy.

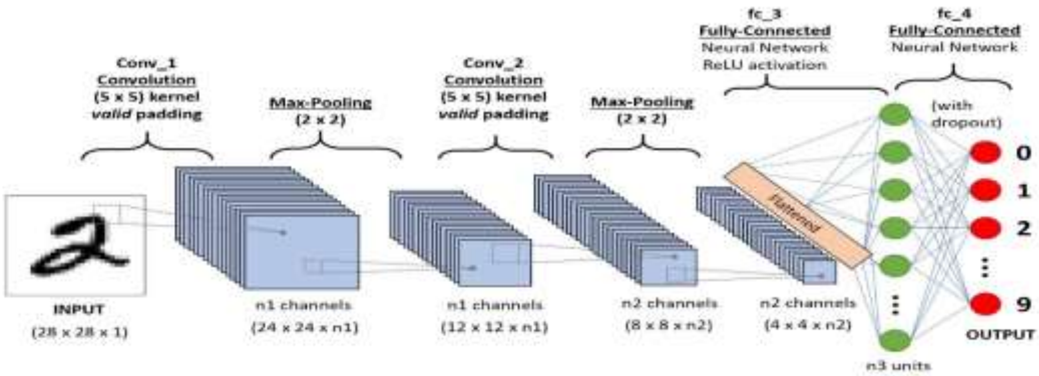
In Paper [5]:

The research aims to enhance the recognition of handwritten digits using Convolutional Neural Networks (CNN) through an examination of diverse design possibilities and an assessment of various optimization strategies. The goal is lower operational complexity and expense while achieving accuracy similar to ensemble designs. The article also attempts to provide a suitable set of learning parameters for CNN construction, which will result in a new absolute record for MNIST handwritten digit classification.

Methodology

Convolutional neural networks:

One kind of deep learning technique that works very well with processing data that has a grid-like layout is convolutional neural networks, or CNNs. They draw inspiration from the human brain's visual cortex, which is likewise arranged in a grid-like structure. CNNs operate by employing tiny filters that glide across the input data to extract features. Certain features, such edges, lines, and textures, are intended to be detected by these filters. A series of feature maps that show the presence of these features at various input locations are created as the filters move across the data.

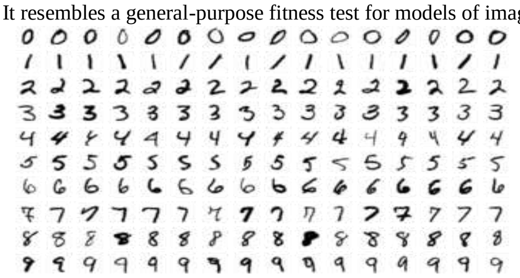


For image processing applications, CNNs are superior to other forms of neural networks in a variety of ways. Firstly, instead of depending on manually created features, they can automatically extract features from the data. They become more resilient to changes in the input data as a result. CNNs can also take advantage of the data's spatial organization. This implies that they can benefit from the exact order in which pixels are placed in an image, which can be useful for tasks like object recognition.A number of Stochastic Gradient Descent (SGD) optimization techniques are assessed in order to enhance the recognition system's performance, including the Adam optimizer.

MNIST:

Machine learning's "Hello World" is the Modified National Institute of Standards and Technology database, or MNIST for short. This is a sizable set of 60,000 handwritten numbers (0–9), all nicely organized into grayscale photos measuring 28 × 28 pixels. Consider it an enchanted collection of handwritten numbers, waiting to be interpreted through the power of algorithms.Aspiring AI thinkers will find MNIST to be the ideal training ground due to its accessibility and simplicity. Because of its standardized format, trainees may concentrate on the fundamentals of picture recognition and classification rather than worrying about data wrangling. Imagine creating a program that uses only these tiny pixel grids to distinguish between a carefully drawn "3" and a disorganized "7".

In addition to being a playground for beginners, MNIST is an essential benchmark for evaluating the effectiveness of increasingly sophisticated algorithms. A novel neural network's accuracy on MNIST can be compared against baselines to provide researchers with important information about the network's advantages and disadvantages. It resembles a general-purpose fitness test for models of image processing.



Extreme Learning Machine (ELM):

This particular kind of feedforward neural network is renowned for its blazingly quick learning rate and exceptional generalization capabilities.

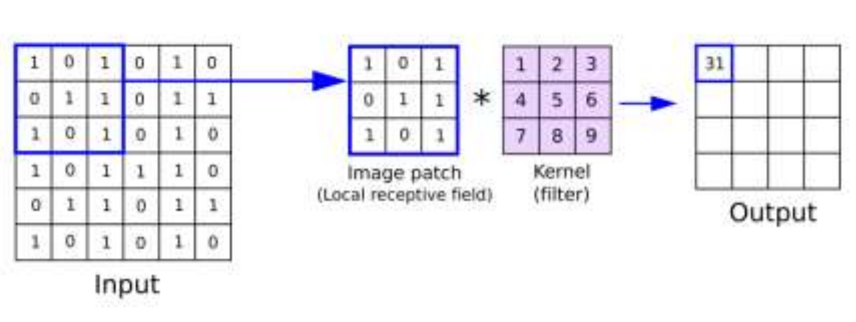
It is unique in that it avoids repetitive tweaking and possible overfitting by assigning input weights at random and determining output weights analytically.

Tasks involving feature learning, compression, clustering, regression, and classification usually make use of it.

Structure of CNN:

The greatest sleuths in the realm of images, Convolutional Neural Networks (CNNs) gather hints and piece them together to identify hidden meanings inside individual pixels. They are adept at picture tasks because their structure resembles that of the human brain's visual processing.

Consider the input image to be a scene of a crime. Initially, convolutional layers that resemble magnifying glasses move over the scene, each one carrying a unique filter to look for hints. Different filters could look for different things, such as edges, textures, and forms. Should they discover a match, they annotate the location on a "feature map"—a kind of in-depth report emphasizing the existence of their desired hints.



Subsequently, pooling layers summarize these findings deftly and without being mired in minutiae. They reduce the feature maps, retaining the important discoveries and eliminating extraneous noise. Consider these to be a distillation of the detectives' reports—the substance stripped of the minutiae.The fully connected layers, which function as the genius piecing everything together, finally take center stage. After receiving the condensed feature maps, they examine the overall image, taking into account the relationships between various cues (edges, textures, and forms).The reason CNNs are so effective is because of their tiered approach, in which each stage builds upon the one before it. They do more than just learn pixel patterns by heart; they decipher complex details, examine connections, and eventually unlock the mystery of visual data. Thus, the next time you witness a computer recognize a cat in an image with ease, keep in mind the amazing cooperation taking place inside its artificial brain, which is made possible by the ingenious design of convolutional neural networks.

Results and discussions:

Recent years have witnessed tremendous progress in handwritten digit recognition (HDR), with state-of-the-art algorithms attaining error rates as low as 1% on the MNIST benchmark dataset. This advancement has been made possible by the creation of innovative algorithms, most notably convolutional neural networks (CNNs), designed specifically for image recognition applications. Impressive outcomes have been obtained from recent HDR research .Modern CNNs have achieved error rates less than 1% on the MNIST benchmark, which consists of 10,000 testing photos and 60,000 training images of handwritten digits. Similarly, state-of-the-art CNNs have shown error rates of about 1.5% on the SVHN benchmark, which consists of 73,257 training images and 26,032 testing images of handwritten digits from street view house numbers. Additionally, state-of-the-art CNNs have achieved error rates of about 2.5% on the EMNIST benchmark, which consists of 14,832 balanced testing images of handwritten digits and 47,379 balanced training images. These astounding outcomes demonstrate the extraordinary accuracy that HDR technology can achieve.

Conclusion:

Recent advances in machine learning and deep learning approaches have led to great progress in handwritten digit recognition. It has been demonstrated that Convolutional Neural Networks (CNNs) are very good at correctly recognizing and categorizing handwritten digits. High accuracy rates have been remarkably successful thanks to the combination of complex network topologies and big, carefully managed datasets like MNIST. Handwritten digit recognition has been put to use in a number of sectors, such as form processing automation, historical document digitization, and improving accessibility for those with vision impairments. Furthermore, the investigation of new strategies, including capsule networks, and the ongoing development of neural network topologies show promise for enhancing the reliability and effectiveness of handwritten digit recognition systems.Real-time recognition skills are becoming easier to integrate into gadgets like smartphones and tablets as technology develops, creating new opportunities for applications that are easy for users to utilize.

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