Handwritten Digit Recognition System using Machine Learning in Python

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Abstract

In pattern recognition applications, handwritten digit recognition is a practical challenge. The goal of this project is to develop an automatic method for recognizing strings of digits written by hand. To begin the recognition task, the digits will be segmented into individual digits. After the digits have been segmented, the handwritten digit string recognition task is finished by using a digit recognition module to label each segment. Applications of digit recognition include sorting mail, processing bank checks, data entry on forms, etc. The most important part of the problem is being able to make a good algorithm that can read handwritten digits from a scanner, tablet, or other digital device.

1. Introduction

The field of artificial intelligence and computer science would be incomplete without the contributions of machine learning and deep learning. Deep learning and machine learning enable reduced human involvement in a wide range of tasks, including recognition, learning, and prediction.

In this project, we use different types of CNN models to evaluate the accuracy of the results. In this instance, we made use of our own dataset by compiling handwritten notes from various people. Machine learning and deep learning techniques are being explored by developers to make machines more intelligent. Humans learn new skills by performing them over and over again until they become established in long-term memory. The neurons in his brain will then automatically fire, allowing them to quickly perform the task they have learned. This is very similar to deep learning.

Handwritten digit recognition refers to computers' ability to recognize human handwritten digits. Because handwritten digits are not standardized and can be made in a wide variety of styles, the machine has difficulty with the task. The solution to this issue is handwritten digit recognition, which takes an image of a digit and identifies that digit.

2. Literature Review

1. “Improved Handwritten Digit Recognition Using Convolutional Neural Networks (CNN)” by Savita Ahlawat

This research paper discusses how convolutional neural networks (CNNs) are the best method for solving handwriting recognition problems because they are able to precisely understand the structure of handwritten characters and words. The goal of this research was to enhance the efficiency of handwritten-digit recognition by investigating potential design directions and evaluating different SGD optimization algorithms. They proposed a CNN architecture that outperforms existing ensemble architectures in terms of accuracy while also being simpler and cheaper to operate. The experimental recognition accuracy for the MNIST dataset has reached 99.87%.

2. "Handwritten Digit Recognition Using Convolutional Neural Networks" by Haider A. Alwzwazy

   This research paper discusses about the use of handwritten digit recognition in machine learning and computer vision is raising the way it is used. Although Arabic digits are more difficult to recognize than English patterns, a robust deep convolutional neural network was able to classify 45,000 samples from the Challenge Arabic Handwritten Digits dataset.

3. "Offline Handwritten Numeral Recognition Using Convolution Neural Network" by Abhisek Sethy

   When it comes to offline handwritten characters, character recognition (CR) is a particularly difficult subfield of pattern recognition. This paper focuses on the recognition of multiple handwritten digits in the Odia and Bangla scripts and proposes a state-of-the-art CNN-based approach. In order to construct an automatic recognition system for handwritten numerals, a high recognition rate is achieved at the simulation level.

3. Dataset Description

The user generated the data. The user's samples (from 0 to 9), sorted by type, are collected and organized into subfolders. There are ten different categories. There's a category represented by each digit here. The process of collecting data from users is very simple. A loop of code will be running, and the user will give his input into the paint program.

4. Methodology

The following are the fundamental steps in building our Machine Learning model:

- Collecting data from users to make a dataset.
- Prepare the data for training.
- Choose a model for train the dataset.
- Then train the model with data.
- Evaluate the model.
- Make predictions with the trained model.

Figure 01: Steps of system development

5. Result and Analysis

The different Keras models are used to train the machine. The models return different results for the dataset. The models are ResNet50, VGG16, InceptionV3, Xception. Also the models are tested with three difference types. The types are base line, transfer-learning, fine-tuning.

ResNet50 return accuracy 99%. VGG16 return accuracy 76%. InceptionV3 return accuracy 23%. Xception return accuracy 61%.

Here ResNet50 gives the best output for our data.

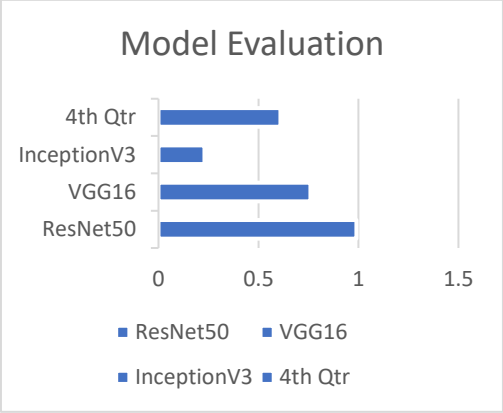

Figure 02: Model analysis

6. Stakeholders

There are several stakeholders involved in collecting data to make a digit recognition dataset, including:

- There are people who gather the data for the dataset. They could be unpaid volunteers, paid employees, or even robots.
- These individuals need to examine the information and make sure it's correct and reliable.
- The end users who use the dataset. These maybe developers or researchers.
- The funders who provide financial support to collect the data and analysis.

7. Issues Encountered

The several issues faced during the work:

- Poor quality of data can affect the result so we use paint application for better result.
- We need a large amount of data but that was time consuming. So, try to collect the data from students by using a python program. Although it took about 2 to 3 minutes collect one’s data.
- Labeling the data is necessary that’s why use separate the data into difference subfolders according to their class. The task was not so easy by doing manually that’s why we used python program to separate data when we collecting them.

8. Conclusion, Limitations and Future Recommendations

In this project, we developed a handwritten digit recognition system using machine learning techniques in Python. We trained four models on our own handwritten digit dataset: ResNet50, VGG16, InceptionV3, and Xception. The results showed that all four models performed well on the test set, with the ResNet50 model performing the best.

One limitation of this project is the use of a personal dataset, which may not be representative of the variability in handwriting styles that exist in the real world. Another limitation is the focus on only four models, which may not be the best models for handwritten digit recognition in general. The project could be expanded by incorporating additional datasets and testing a wider variety of models.

In future work, we could improve the system by incorporating more advanced techniques such as data augmentation, transfer learning, and ensemble methods. We could also explore the use of different neural network architectures and evaluate their performance on the task of handwritten digit recognition. Additionally, we could consider extending the system to recognize other types of handwritten characters, such as letters and symbols, which would make the system more versatile and useful in real-world applications.

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Appendix

Attainment of Complex Engineering Problem (CP)

S.L.	CP No.	Attainment	Remarks
1.	P1: Depth of Knowledge Required		K3(Engineering Fundamentals): Required knowledge of Convolutional Neural Network

			K4 (Engineering Specialization): Required knowledge of Python Libraries and Artificial Neural Network (ANN)
			K5 (Design): Methodology shows solution design.
			K6 (Technology): Python Libraries, jupyter notebook, Google Colab, Image Processing Paint, Keras Applications
			K8 (Research): Studied related research paper to understand the pervious works.
2.	P2: Range of Conflicting Requirements	Yes	Dataset Collection
3.	P3: Depth of Analysis Required	Yes	Image processing using CNN
4.	P4: Familiarity of Issues	No	
5.	P5: Extent of Applicable Codes	Yes	Python
6.	P6: Extent of Stakeholder Involvement and Conflicting Requirements	No	
7.	P7: Interdependence	No	

Mapping of Complex Engineering Activities (CA)

S.L.	CA No.	Attainment	Remarks
1.	A1: Range of resources	Yes	The range of the resources. Described on Art No:[1][2][3]
2.	A2: Level of interaction	No	
3.	A3: Innovation	No	
4.	A4: Consequences for Society and the Environment	Yes	Deep Learning
5.	A5: Familiarity	Yes	Image processing