**HANDWRITTEN CHARACTER RECOGNITION USING CONVOLUTIONAL NEURAL NETWORKS (CNN)**

**ABSTRACT**

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## **Background**

The capacity to recognize handwritten characters is crucial in various disciplines, including document conversion to digital format, automated form processing, and text recognition. Such applications, beyond simple document recognition, necessitate a dependable technique. Recognizing handwritten characters manually is a laborious and error-prone exercise. Studies reveal that Convolutional Neural Networks (CNNs), a type of Artificial Neural Network, can provide an efficient method for autonomously recognizing handwritten characters. This research uses a CNN model to accomplish reliable and effective recognition of handwritten characters.

## **Introduction**

Recognizing handwritten characters is difficult because of the variety of writing styles and the complexity of each individual's penmanship. The complexities of character recognition present a formidable obstacle to conventional processing techniques. Nevertheless, the latest developments in deep learning, particularly in convolutional neural networks (CNNs), have demonstrated incredible potential for multiple image identification tasks. This study intends to investigate the application of CNNs to developing models to recognize handwritten letters. The objective is to employ CNNs, which specialize in deriving valuable characteristics from images, in addressing the complex nature of handwritten character recognition.

## **Problem Statement**

Recognizing handwritten characters via manual techniques may be very time-consuming and error-prone, frequently resulting in inaccurate results. There is need for an automated program capable of identifying handwritten letters reliably and accurately. Developing a Convolutional Neural Network (CNN) model that is capable of adequately capturing and recognizing the complicated patterns and distinguishing characteristics found in handwritten characters is the primary purpose of this project. This project aims to simplify and improve the procedure of recognizing handwritten characters by drawing on the capabilities of deep learning.

## **Objectives**

To accomplish the major objective of this research, which is to develop a model that is proficient in the automated identification of handwritten characters, the fundamental strategy that will be used is known as "harnessing the power of Convolutional Neural Networks," or "CNNs." The objective is to design a model that is precise and effective in correctly recognizing and deciphering handwritten characters. We hope to unleash the potential for substantial breakthroughs in automatic handwritten character recognition by using CNNs.

## **Methodology**

The dataset was obtained from the following [URL](https://storage.googleapis.com/kaggle-data-sets/9726/17999/compressed/A_Z%20Handwritten%20Data.csv.zip?X-Goog-Algorithm=GOOG4-RSA-SHA256&X-Goog-Credential=gcp-kaggle-com%40kaggle-161607.iam.gserviceaccount.com%2F20230628%2Fauto%2Fstorage%2Fgoog4_request&X-Goog-Date=20230628T120030Z&X-Goog-Expires=259200&X-Goog-SignedHeaders=host&X-Goog-Signature=). It contains 372450 images of handwritten characters represented as arrays of shape (785,) where the actual image has a shape of (784,) and the extra column represents the label for that image. The dataset will be labeled with categories of characters corresponding to the associated IDs (the labels are encoded as integers from 0 through 25 representing the letters A to Z). A convolutional neural network (CNN) will be built, and it will have layers tailored to be as efficient as possible for the goal of character recognition. The effectiveness of the trained model will be evaluated using appropriate metrics to measure its accuracy and adaptability.

**Sample Input Pattern**

The below shows an array of a sample input image:

0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,32,215,235,43,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,130,255,255,107,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,14,227,255,255,107,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,152,255,255,255,162,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,91,255,255,255,255,190,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,47,237,255,212,188,255,190,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,113,255,255,97,136,255,190,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,43,235,255,158,0,136,255,107,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,107,255,255,75,0,136,255,107,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,67,233,255,255,255,212,215,255,206,170,170,142,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,156,255,255,255,255,255,255,255,255,255,255,255,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,40,255,255,255,243,128,156,188,255,255,176,117,57,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,67,255,255,142,0,0,0,53,255,190,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,4,229,255,239,20,0,0,0,53,255,190,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,89,255,255,176,0,0,0,0,53,255,233,12,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,227,255,249,71,0,0,0,0,0,225,255,18,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,144,223,130,0,0,0,0,0,0,170,255,101,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,142,255,184,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,59,255,255,12,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,59,255,152,4,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0

**Performance Optimization and Graphical User Interface (GUI)**

To improve the performance of the model, the following techniques will be added to the architecture of the Convolutional Neural Network:

* **Batch Normalization:** Batch normalization is a mechanism that accelerates and stabilizes training by normalizing the activation functions in a neural network layer. For each mini-batch, it normalizes the activations with zero mean and unit variance thereby addressing the “internal covariate shift” issue. Higher learning rates, faster convergence, and reduced sensitivity to weight initialization are achieved as a result. Batch Normalization acts as a form of regularization, enabling deeper networks and reducing the reliance on dropout.
* **Hyper-parameter tuning:** It is the process of finding the best configuration settings (hyper-parameters) for a machine learning model. By default, these hyper-parameters are fixed before training. Altering them to suit the specific needs for a neural network can greatly improve its performance. Techniques such as random search, grid search, Bayesian optimization, automated machine learning (AutoML), and genetic algorithms can be used to leverage the power of hyper-parameter tuning in boosting the model’s performance. Maximizing performance on the validation set while avoiding overfitting on the test set is the end goal.

Moreover, this research project will not only lead to the development of a classifier for handwritten characters but also building of a Graphical User Interface (GUI). The GUI will enable users to interact with the model at a higher level abstracting the inner details of how the model works. It will allow for users to upload an image of a handwritten character and have the model predict what class it belong to. The GUI will be built using Tkinter.

In conclusion, employing convolutional neural networks (CNNs) for automatic identification of handwritten characters has tremendous promise for various uses. These applications include document processing, text recognition, and optical character recognition (OCR). Employing Convolutional Neural Network (CNN) models, this study aims to develop a productive and precise system for recognizing handwritten characters. Our objective is to improve the preciseness and effectiveness of handwritten character identification by using advanced methodologies and deep learning. This will have a favorable influence on a variety of industries and the general productivity of businesses.