# Image Segmentation of Handwritten Digits

Introduction:

The goal of this project is to perform image segmentation on handwritten digits using the M2NIST dataset. Image segmentation involves dividing an image into different segments, where each segment corresponds to a specific object or region of interest. In this case, the objective is to segment individual handwritten digits in the images.

Dataset:

The dataset used for this project is the M2NIST dataset, which is a multi-digit extension of the MNIST dataset. It contains images of handwritten digits along with pixel-wise label maps indicating the segmentation masks for each digit.

Methodology:

The project employs a Convolutional Neural Network (CNN) for the downsampling path and utilizes an FCN-8 (Fully Convolutional Network) for the upsampling path. The model is trained on the training set of the M2NIST dataset and evaluated using the intersection over union (IOU) and Dice Score metrics. The code utilizes TensorFlow and Keras for building and training the model.

1. Data Preparation:

- The M2NIST dataset is downloaded and extracted from a zip file.

- Training, validation, and test datasets are created and preprocessed using TensorFlow datasets.

2. Model Architecture:

- The model architecture consists of two main parts: the downsampling path (encoder) and the upsampling path (decoder).

- The downsampling path uses a custom CNN with convolutional and pooling layers to extract features from the input images.

- The upsampling path utilizes an FCN-8 decoder to upsample and produce pixel-wise label maps.

3. Training:

- The model is compiled using categorical cross-entropy loss and stochastic gradient descent (SGD) optimizer.

- Training is performed for a specified number of epochs, and the model is evaluated on the validation set.

4. Evaluation:

- The trained model is used to make predictions on the test set.

- Class-wise metrics such as IOU and Dice Score are calculated to evaluate the segmentation performance.

- The average IOU is computed, and a final grade is assigned based on this metric.

5. Results and Visualization:

- The project includes visualization utilities to display images, ground truth, and predicted label maps.

- Class-wise metrics are visualized for a selected image from the test set.

Results and Discussion:

The trained model demonstrates effective segmentation of handwritten digits, as evidenced by high IOU and Dice Score metrics. The class-wise evaluation provides insights into the performance of the model for each digit class. The average IOU is used as a grading metric, ensuring a quantitative measure of segmentation accuracy.

Conclusion:

The image segmentation project successfully achieves the segmentation of handwritten digits using a combination of downsampling and upsampling paths in a CNN architecture. The model's performance is evaluated using rigorous metrics, providing a comprehensive understanding of its segmentation capabilities.

Future Improvements:

Future improvements could involve fine-tuning the model architecture, exploring different optimization techniques, and increasing the diversity and size of the training dataset. Additionally, hyperparameter tuning and experimenting with advanced segmentation architectures may further enhance the model's performance.

In summary, the project delivers a robust solution for image segmentation of handwritten digits, laying the foundation for potential applications in optical character recognition (OCR) and digit localization tasks.