Classification of Handwritten Digits using Neural Networks

Aysha Talakkal Cosumal (23200212)

Rhema Simon (23200209)

Projects in Math Modelling, MSc Data and Computational Science, University College Dublin

Abstract

Artificial Intelligence (AI) has dramatically transformed numerous fields, with image recognition being one of the most impactful areas. Image recognition has evolved from simple pattern recognition techniques to sophisticated deep learning models. The advent of deep learning, revolutionized the field by enabling models to automatically learn hierarchical features from large datasets. This project is designed to assist in digit recognition systems by leveraging AI technology. We have developed a Neural Network model to classify handwritten numbers from 0 to 9. After extensive training and testing, and going through about four optimizers our model achieves an accuracy of approximately 0.9787.

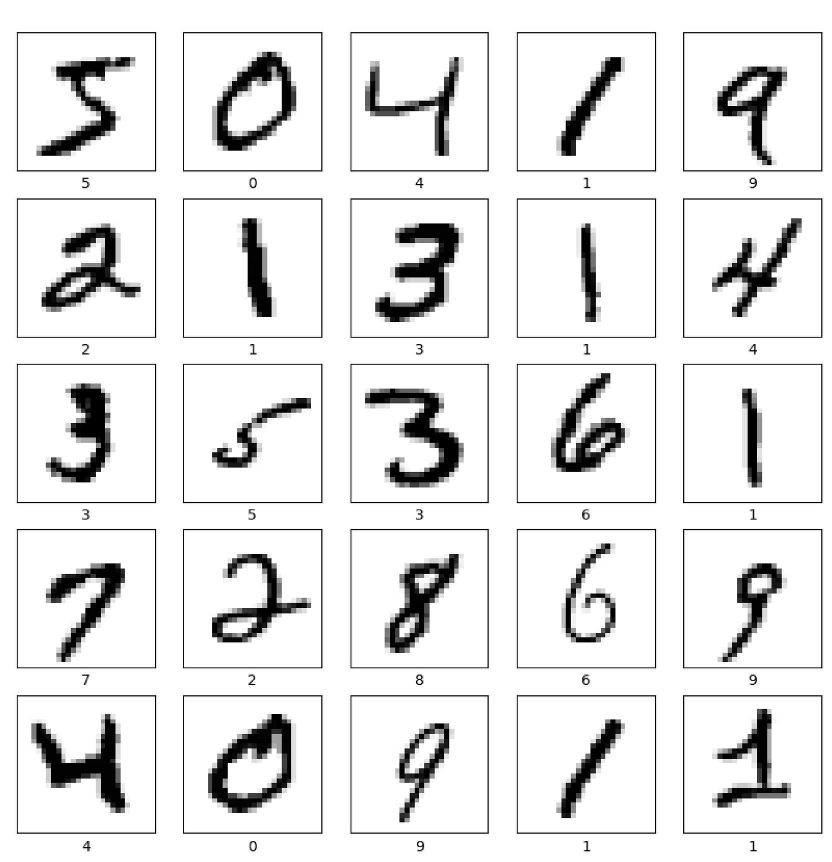
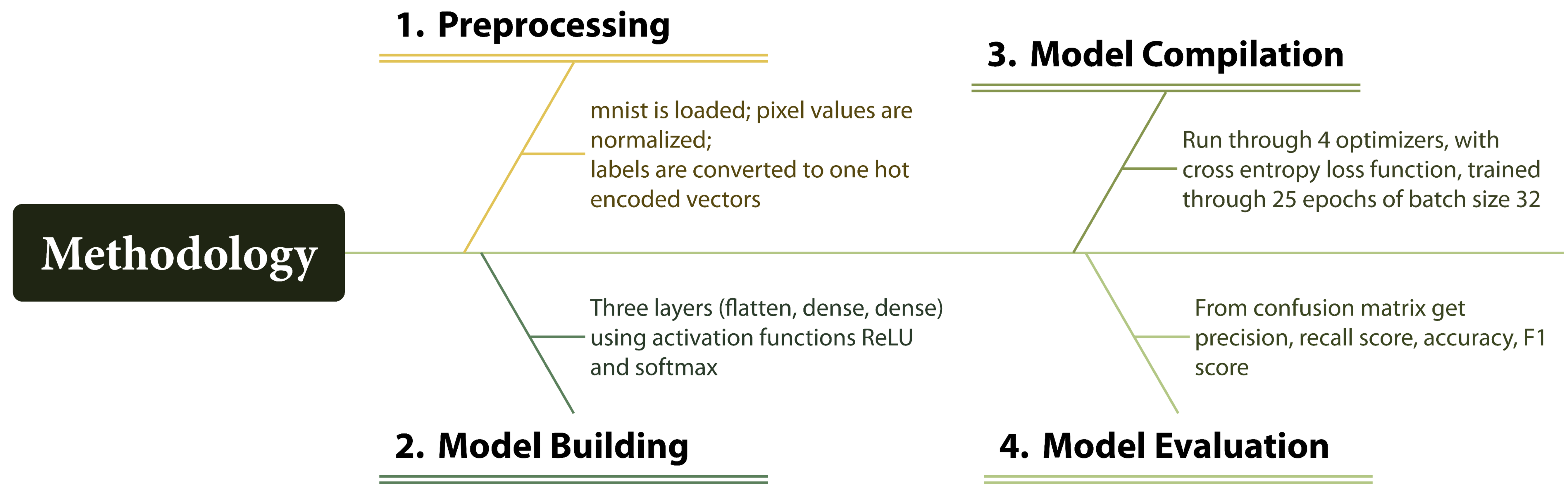


Fig. 1. Handwritten digits of mnist dataset.

Motivation

Handwritten digit recognition has practical applications in fields like postal mail sorting, bank check processing, and form digitization. Improving accuracy in these tasks can have significant real-world benefits. reducing the need for human intervention and decreasing error rates in digit recognition tasks.



Analysis

Running through four different optimizers to get the best results. Shown below are the results from the best and worst of optimizers i.e. Adam and SGD, respectively.

Model: "sequential_7"

Layer (type)	Output Shape	Param #
flatten_7 (Flatten)	(None, 784)	0
dense_14 (Dense)	(None, 128)	100,480
dense_15 (Dense)	(None, 10)	1,290

Total params: 101,770 (397.54 KB)

Trainable params: 101,770 (397.54 KB)

Non-trainable params: 0 (0.00 B)

Fig. 2. Different layers of the model

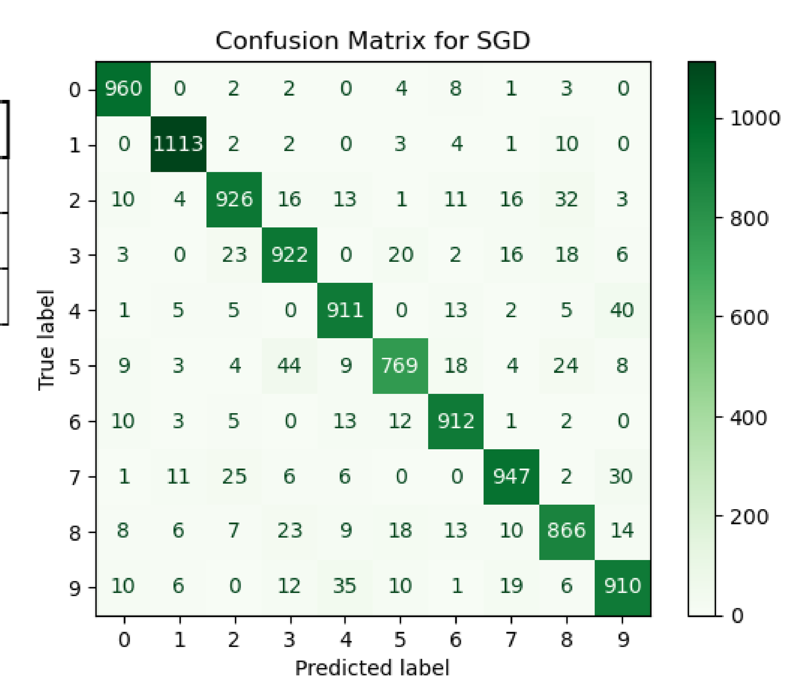


Fig. 3. Confusion matrix of SGD optimizer

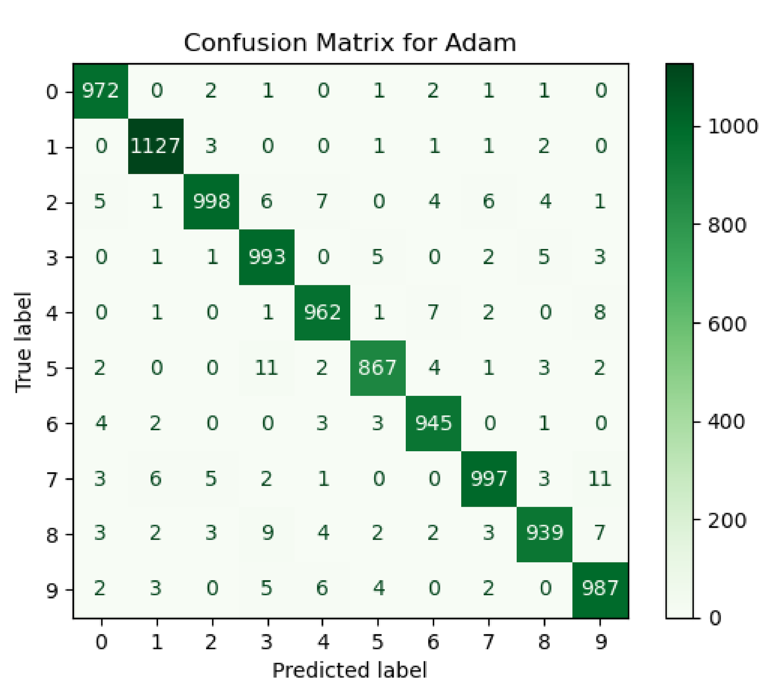


Fig. 4. Confusion matrix of Adam optimizer

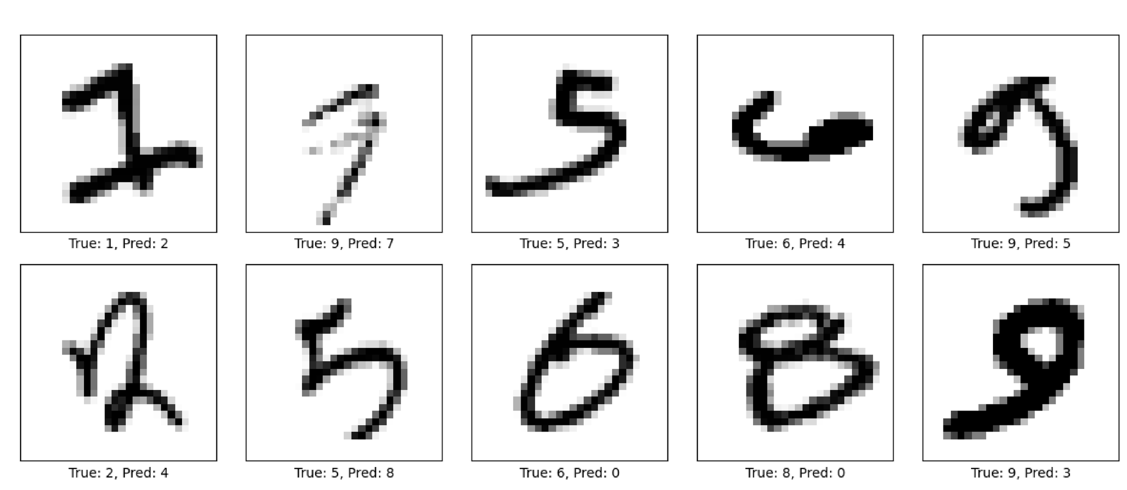


Fig. 5. Misclassified images using Adam optimizer

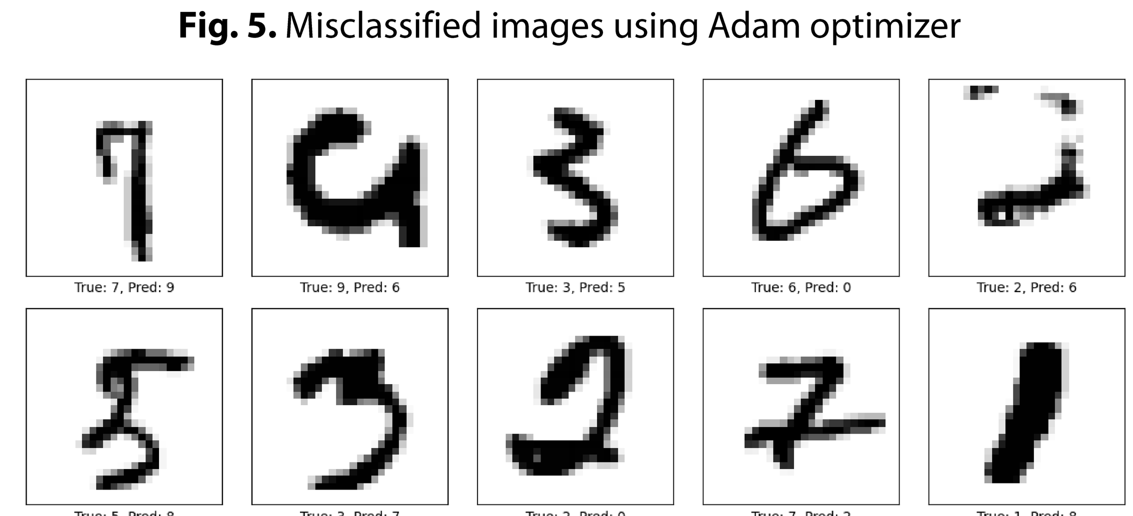


Fig. 6. Misclassified images using SGD optimizer

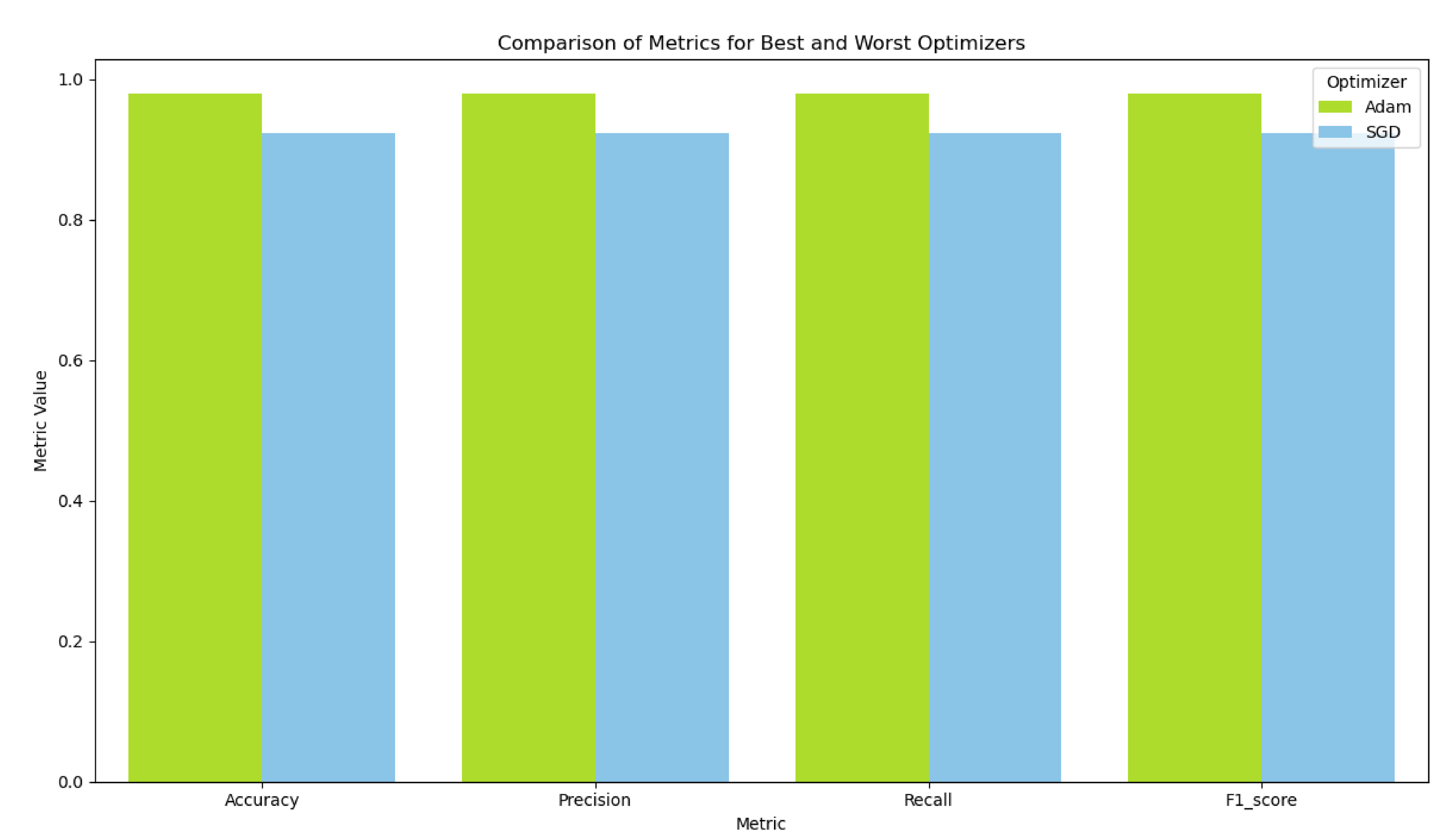


Fig. 7. Bar graph comparing Adam and SGD

Conclusion

We have developed an end-to-end neural network that effectively classifies handwritten digits from the MNIST dataset. The model is a straightforward feedforward neural network that successfully encodes images into a compact representation and predicts the corresponding digit. The model is trained to maximize the accuracy of classification, and its performance is evaluated using various metrics such as precision, recall, accuracy, and F1 score. The results demonstrate that the neural network can reliably classify the digits with high accuracy, making it a powerful tool for digit recognition tasks.

Future work

This work serves as a foundation for further advancements in handwritten digit recognition and broader image classification tasks.

- Include data augmentation techniques like shearing and rotating for more robustness and accuracy of the program.
- Adapting the model to classify different types of handwritten characters, such as letters or symbols.
- Refining the model by exploring advanced techniques such as transfer learning.
- Expanding the model's capabilities to handle more diverse datasets or real-world handwritten samples will further enhance its robustness.

As technology evolves, continuous model refinement and adaptation will be crucial to maintaining accuracy and efficiency in ever-changing environments.