Solving EMNIST using CNN

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December 31, 2025

Abstract

This article tries to solve EMNIST digit recognition problem using Convolutional Neural Networks which are written in Rust from scratch using State of the Art techniques such as FFT. (Fast Fourier Transform)

1 Introduction

EMNIST [1] is an extension of the classical MNIST dataset for hand written digits (which in turn was an extension for the NIST extension database). This dataset includes more demanding digits which allow for better benchmark for the CNN.

Convolutional Neural Networks [2] which were firstly mentioned when studying the sight of some animals, have proven to be the go-to approach when dealing with image processing.

This article provides a way to understand the whole process involved, from the mathematical foundations to the implementation, showing the intuitive approach and refining solutions to achieve the best possible solution.

2 Convolutions

A convolution. The template uses `i-figured` for labeling equations. Equations will be numbered only if they are labelled. Here is an equation with a label:

$$\sum_{k=1}^{n} k = \frac{n(n+1)}{2} \tag{2.1}$$

We can reference it by `@eq:label` like this: (2.1), i.e., we need to prepend the label with `eq:`. The number of an equation is determined by the section it is in, i.e. the first digit is the section number and the second digit is the equation number within that section.

Here is an equation without a label:

$$\exp(x) = \sum_{n=0}^{\infty} \frac{x^n}{n!}$$

As we can see, it is not numbered.

3 Theorems

The template uses `great-theorems` for theorems. Here is an example of a theorem:

Theorem 3.1. (Example Theorem): *This is an example theorem.*

Proof. This is the proof of the example theorem. □

We also provide `definition`, `lemma`, `remark`, `example`, and `questions` among others. Here is an example of a definition:

Definition 3.2. (Example Definition): *This is an example definition.*

***Question* 3.3.** (Custom mathblock?): How do you define a custom mathblock?

Answer 3.4. *You can define a custom mathblock like this:*

```
#let answer = my-mathblock(
  blocktitle: "Answer",
  bodyfmt: text.with(style: "italic"),
)
```

Similar as for the equations, the numbering of the theorems is determined by the section they are in. We can reference theorems by `@label` like this: Theorem 3.1.

To get a bibliography, we also add a citation

Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magnam aliquam quaerat voluptatem. Ut enim aeque doleamus animo, cum corpore dolemus, fieri tamen permagna accessio potest, si aliquod aeternum et infinitum impendere malum nobis opinemur. Quod idem licet transferre in voluptatem, ut.

Bibliography

[1] G. Cohen, S. Afshar, J. Tapson, and A. van Schaik, "EMNIST: An extension of MNIST to handwritten letters," in *2017 International Joint Conference on Neural Networks (IJCNN)*, 2017, pp. 2921–2926. doi: 10.1109/IJCNN.2017.7966217.

[2] K. O'Shea and R. Nash, "An Introduction to Convolutional Neural Networks," *ArXiv*, 2015, [Online]. Available: https://api.semanticscholar.org/CorpusID:9398408

Appendix A

If you have appendices, you can add them after `#show: appendices`. The appendices are started with an empty heading `=` and will be numbered alphabetically. Any appendix can also have different subsections.

A.1 Appendix section

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