Deep Learning Guide

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Artificial Intelligence, specifically deep learning (DL), has become increasingly popular and is now considered an essential technical skill. Ultimately, it takes years and numerous projects to become proficient in this field. Additionally, innovations in AI seem to occur daily, rendering any text on DL outdated very quickly. Therefore, this handbook aims to guide you through the foundational concepts that remain constant and equip you for continuous learning. It would be disingenuous to claim that this text will teach you deep learning from scratch, there are some basic prerequisites. If you already have these prerequisites, you can begin your DL learning journey immediately. If you don't have all or some of them, I recommend reviewing the prerequisite content. While it is not essential, doing so will significantly ease your learning process.

Basic prerequisites:

- At least 3 months of coding experience (preferably in Python or another interpreter-based procedural programming language).
- Knowledge of linear algebra and calculus (minimum of A-level Mathematics or equivalent).
- Understanding of statistics, including probability theory and probability distributions (A-level Mathematics with S1 and S2 modules or equivalent).

DL learning Path: Zero to Hero:

1. **Learning Python:**

   The majority of deep learning (DL) code is written in Python, as the two most popular libraries PyTorch and TensorFlow are implemented in Python. These libraries utilise object-oriented programming (OOP). While knowing OOP is not essential for using DL models, it becomes important when developing novel neural networks. Key concepts to understand include classes, objects, member functions, and inheritance in Python.

2. **Foundations:**

   Learning DL often is split between theory and practice. The theory element is essential for understanding what steps you should take and what to do when something is wrong. Being a beginner in DL, you will rely mostly on built-in functions and other people's code, so you won't need to code any complicated algorithms and math. Therefore, your learning will be focused on just understanding the key information and logic, so don't waste time now trying to derive every math proof (at this stage). Here is what you should learn:

- Neural networks.
- Backpropagation.
- Loss functions - Binary cross entropy.
- Convolutional neural networks.
- Train, Test, Split and K-fold Cross-validation.
- Accuracy Metrics.

3. **Practice:**

Task: Atrial Fibrillation Classification Using Deep Learning

In this assignment, you will apply deep learning techniques to classify atrial fibrillation (AF) from one-lead ECG signals. This exercise is designed to give you hands-on experience with biomedical signal processing and neural network implementation.

Please note:

The dataset provided is based on real patient data but has been augmented specifically for this educational task. Do not use this dataset for academic research or clinical applications.

Objectives:

A. Understand the Data

   - The dataset consists of one-lead ECG signals.
   - Each sample is labelled as either:
     - 0 – Normal (Control)
     - 1 – Atrial Fibrillation

B. Preprocess the Data

   - Load and explore the dataset.
   - Split the data into training and test sets.
   - Optionally, create a validation set for hyperparameter tuning.

C. Build a Deep Learning Model

- Design a 1D Convolutional Neural Network (CNN) suitable for time-series classification.
- Train your model using the training data.
- Apply appropriate regularization and optimization techniques.

D. Evaluate Model Performance

- Report the accuracy on the test set.
- Compute and interpret the ROC AUC (Receiver Operating Characteristic - Area Under the Curve).

E. Document Your Work

- Clearly comment your code.
- Briefly explain your design choices and results.

Expected Outcome:

By the end of this task, you should have a working binary classifier that distinguishes between normal and AF ECG signals using a 1D CNN.

Link to data: https://zenodo.org/records/15302489