Module 9 - Bonus Challenges

§M9: Metrics for Model Evaluation

- Below are open-ended bonus challenges; solving them is not required but can help you better understand ML/AI in the context of engineering, and how to use them in practical cases.
- Bonus points earned in all homework assignments will be averaged (6 bonus points for each assignment) and then directly added to your final score to calculate your final letter grade.

Challenge 1.1. In this bonus question, you will apply a neural network to the MNIST dataset, which consists of images of handwritten digits (0-9). Your task is to predict the corresponding digit labels based on these images, and then use the confusion matrix to identify and visualize some misclassified samples. The MNIST dataset is a classic benchmark in the field of machine learning and is widely used for training image classification systems. You can learn more about this dataset via this link: https://en.wikipedia.org/wiki/MNIST_database.

Although convolutional neural networks (CNNs) are typically used for this task, here we will simplify it by transforming each image into a vector (flattening the image) and predicting the labels from these flattened vectors.

We have provided some starter code in `'m09_bonus.ipynb'` to load the dataset, transform the images into vectors, and a helper function to recover and visualize the original images. Please build your solution on top of the provided starter code and complete the task according to the following instructions: (*6pts*)

1. Fit a neural network model to the training dataset using PyTorch, predict the number label.
2. Predict the digit labels for the test set and evaluate the results by computing and visualizing the confusion matrix.
3. Write a code to automatically identify the largest off-diagonal entry in the confusion matrix, explain its meaning, and visualize the images corresponding to the samples stored in that entry.

4. Write a code to automatically identify the class with the most misclassified samples. Visualize all those misclassified samples, using a figure title to indicate the actual class and the class into which they were misclassified. An example is shown in Figure 1

5. Submit your Jupyter notebook file with necessary comments.

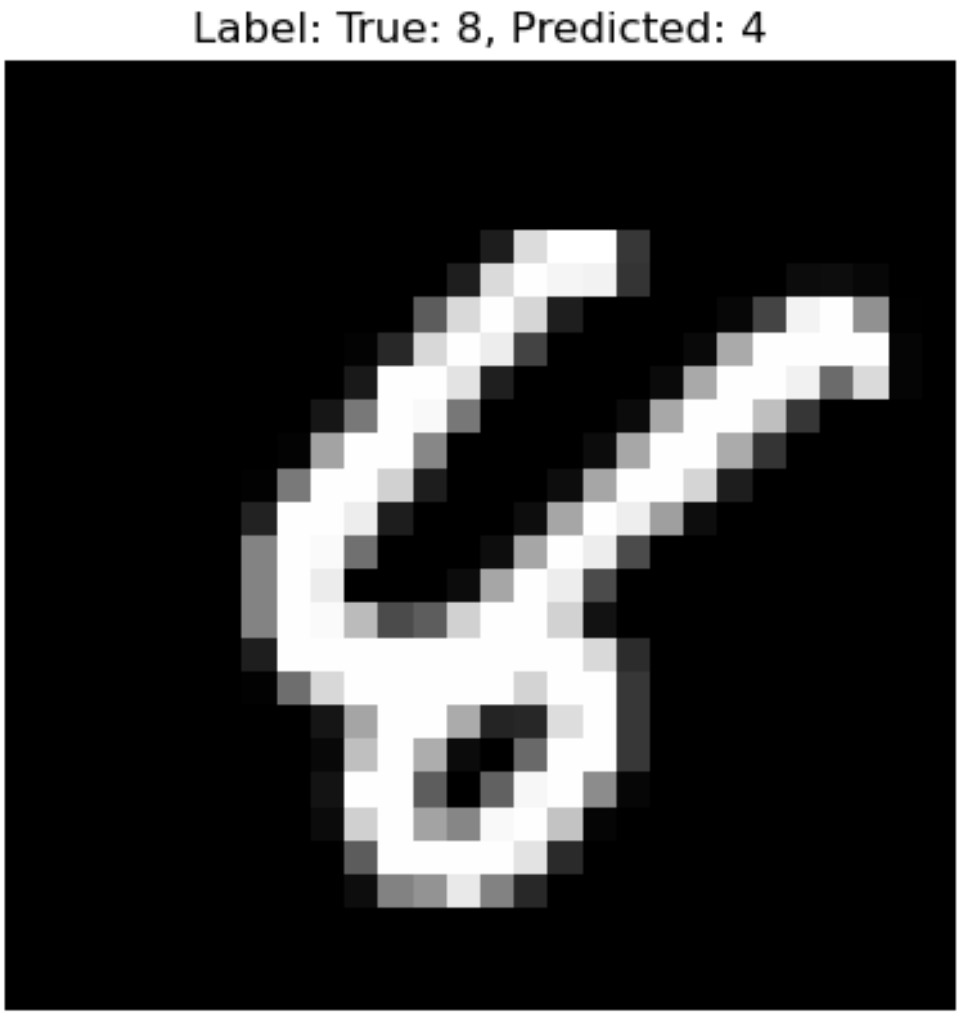

Figure 1: Example of visualization