Lesson 3 Exercise
Name: Harrison Mondragon – 30088805
Class ENEL 525

1. **My entire code running without errors (terminal output):**
   PS C:\Users\Harry\Desktop\ENEL525\enel-525\project\lesson3exercise> python .\lesson3ex2.py
   2023-12-08 16:25:48.484128: I tensorflow/core/util/port.cc:113] oneDNN custom operations are on. You may see slightly different numerical results due to floating-point round-off errors from different computation orders. To turn them off, set the environment variable `TF_ENABLE_ONEDNN_OPTS=0`.
   WARNING:tensorflow:From C:\Users\Harry\AppData\Local\Programs\Python\Python311\Lib\site-packages\keras\src\losses.py:2976: The name tf.losses.sparse_softmax_cross_entropy is deprecated. Please use tf.compat.v1.losses.sparse_softmax_cross_entropy instead.

   2023-12-08 16:26:10.717223: I tensorflow/core/platform/cpu_feature_guard.cc:182] This TensorFlow binary is optimized to use available CPU instructions in performance-critical operations.
   To enable the following instructions: SSE SSE2 SSE3 SSE4.1 SSE4.2 AVX2 FMA, in other operations, rebuild TensorFlow with the appropriate compiler flags.
   2023-12-08 16:28:01.390706: W tensorflow/core/kernels/data/cache_dataset_ops.cc:858] The calling iterator did not fully read the dataset being cached. In order to avoid unexpected truncation of the dataset, the partially cached contents of the dataset will be discarded. This can happen if you have an input pipeline similar to `dataset.cache().take(k).repeat()`. You should use `dataset.take(k).cache().repeat()` instead.
   WARNING:tensorflow:From C:\Users\Harry\AppData\Local\Programs\Python\Python311\Lib\site-packages\keras\src\backend.py:873: The name tf.get_default_graph is deprecated. Please use tf.compat.v1.get_default_graph instead.

   WARNING:tensorflow:From C:\Users\Harry\AppData\Local\Programs\Python\Python311\Lib\site-packages\keras\src\backend.py:873: The name tf.get_default_graph is deprecated. Please use tf.compat.v1.get_default_graph instead.

   Epoch 1/6
   WARNING:tensorflow:From C:\Users\Harry\AppData\Local\Programs\Python\Python311\Lib\site-packages\keras\src\utils\tf_utils.py:492: The name tf.ragged.RaggedTensorValue is deprecated. Please use tf.compat.v1.ragged.RaggedTensorValue instead.

   WARNING:tensorflow:From C:\Users\Harry\AppData\Local\Programs\Python\Python311\Lib\site-

packages\keras\src\utils\tf_utils.py:492: The name tf.ragged.RaggedTensorValue is deprecated. Please use tf.compat.v1.ragged.RaggedTensorValue instead.

469/469 [==============================] - 7s 7ms/step - loss: 0.3522 - sparse_categorical_accuracy: 0.9033 - val_loss: 0.1869 - val_sparse_categorical_accuracy: 0.9448Epoch 2/6
469/469 [==============================] - 2s 4ms/step - loss: 0.1635 - sparse_categorical_accuracy: 0.9529 - val_loss: 0.1373 - val_sparse_categorical_accuracy: 0.9582Epoch 3/6
469/469 [==============================] - 2s 3ms/step - loss: 0.1177 - sparse_categorical_accuracy: 0.9661 - val_loss: 0.1136 - val_sparse_categorical_accuracy: 0.9659Epoch 4/6
469/469 [==============================] - 2s 3ms/step - loss: 0.0919 - sparse_categorical_accuracy: 0.9735 - val_loss: 0.0946 - val_sparse_categorical_accuracy: 0.9694Epoch 5/6
469/469 [==============================] - 2s 3ms/step - loss: 0.0743 - sparse_categorical_accuracy: 0.9783 - val_loss: 0.0896 - val_sparse_categorical_accuracy: 0.9712Epoch 6/6
469/469 [==============================] - 2s 3ms/step - loss: 0.0618 - sparse_categorical_accuracy: 0.9823 - val_loss: 0.0809 - val_sparse_categorical_accuracy: 0.9730Model: "sequential"

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Layer (type)	Output Shape	Param #
flatten (Flatten)	(None, 784)	0
dense (Dense)	(None, 128)	100480
dense_1 (Dense)	(None, 10)	1290

===

Total params: 101770 (397.54 KB)
Trainable params: 101770 (397.54 KB)
Non-trainable params: 0 (0.00 Byte)

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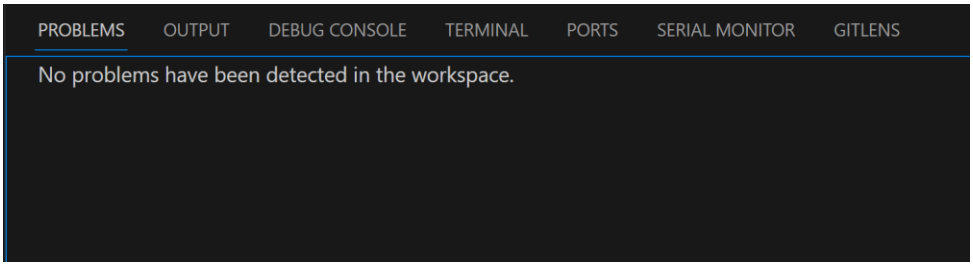
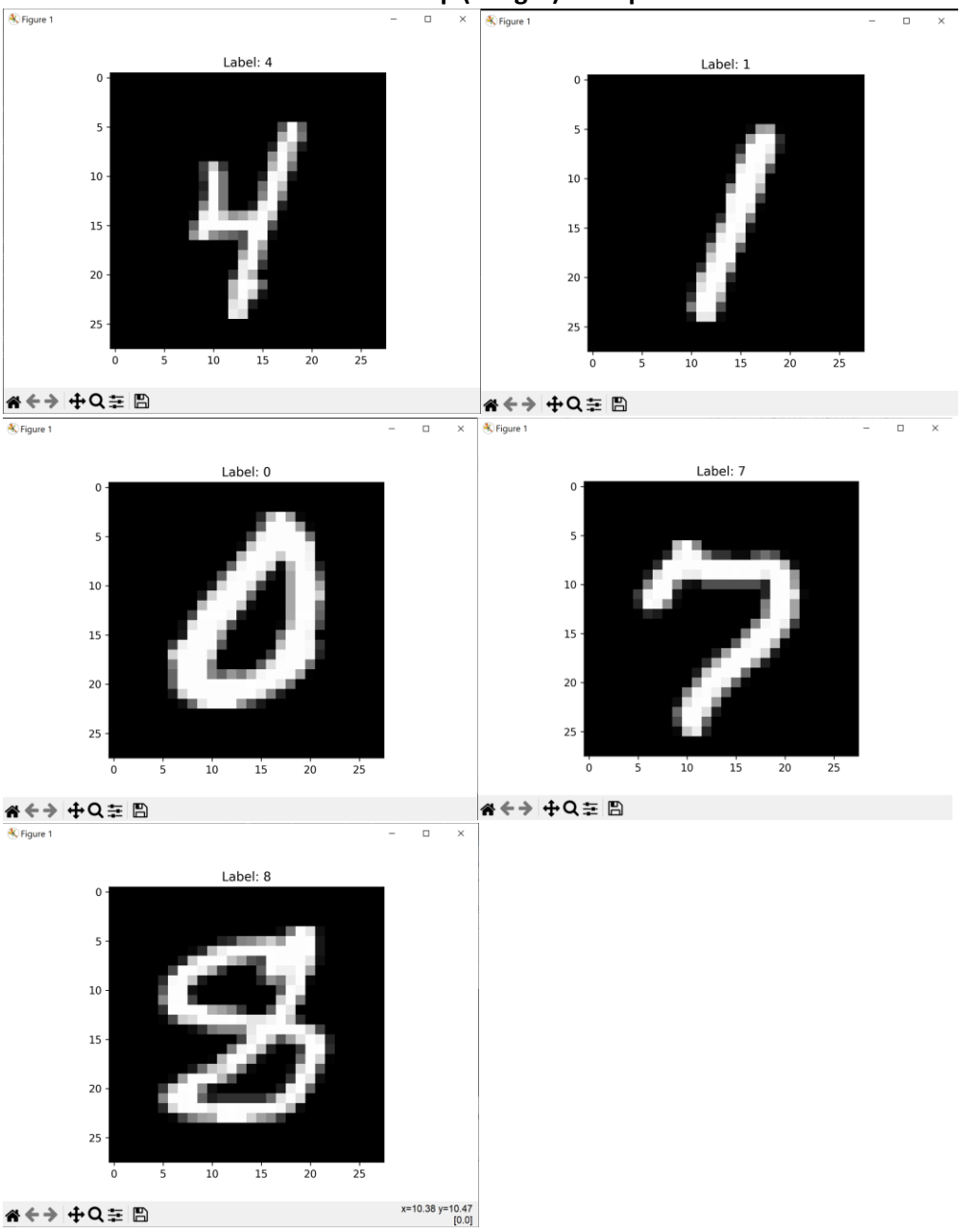
PS C:\Users\Harry\Desktop\ENEL525\enel-525\project\lesson3exercise>

Problems tab in VSCode:



2. **Screenshot of the data verification step (Images). I outputted 5 of them:**



3. **Screenshot of the model summary with dense layers added:**

```
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 flatten (Flatten)           (None, 784)               0

 dense (Dense)               (None, 128)               100480

 dense_1 (Dense)             (None, 10)                1290

=================================================================
Total params: 101770 (397.54 KB)
Trainable params: 101770 (397.54 KB)
Non-trainable params: 0 (0.00 Byte)
```

4. Screenshot of the training epochs with accuracy/loss

```
Epoch 1/6
WARNING:tensorflow:From C:\Users\Harry\AppData\Local\Programs\Python\Python311\Lib\site-packages\keras\src\utils\tf_utils.py:492: The name tf.ragged.RaggedTensorValue i
s deprecated. Please use tf.compat.v1.ragged.RaggedTensorValue instead.

WARNING:tensorflow:From C:\Users\Harry\AppData\Local\Programs\Python\Python311\Lib\site-packages\keras\src\utils\tf_utils.py:492: The name tf.ragged.RaggedTensorValue i
s deprecated. Please use tf.compat.v1.ragged.RaggedTensorValue instead.

469/469 [==============================] - 4s 4ms/step - loss: 0.3631 - sparse_categorical_accuracy: 0.8987 - val_loss: 0.1964 - val_sparse_categorical_accuracy: 0.9447
Epoch 2/6
469/469 [==============================] - 2s 4ms/step - loss: 0.1686 - sparse_categorical_accuracy: 0.9517 - val_loss: 0.1351 - val_sparse_categorical_accuracy: 0.9611
Epoch 3/6
469/469 [==============================] - 2s 4ms/step - loss: 0.1194 - sparse_categorical_accuracy: 0.9647 - val_loss: 0.1111 - val_sparse_categorical_accuracy: 0.9679
Epoch 4/6
469/469 [==============================] - 2s 4ms/step - loss: 0.0932 - sparse_categorical_accuracy: 0.9732 - val_loss: 0.0961 - val_sparse_categorical_accuracy: 0.9722
Epoch 5/6
469/469 [==============================] - 2s 4ms/step - loss: 0.0746 - sparse_categorical_accuracy: 0.9781 - val_loss: 0.0978 - val_sparse_categorical_accuracy: 0.9705
Epoch 6/6
469/469 [==============================] - 2s 3ms/step - loss: 0.0609 - sparse_categorical_accuracy: 0.9823 - val_loss: 0.0851 - val_sparse_categorical_accuracy: 0.9747
```

5. Screenshot of the accuracy/loss plot