

# Optimizing the MNIST Data Set Classification

This is a problem taken from Chapter 10 of Geron

Train a deep MLP on the MNIST dataset (you can load it using `keras.datasets.mnist.load_data()`). See if you can get over 98% precision. Try searching for the optimal learning rate by using the approach presented in this chapter (i.e., by growing the learning rate exponentially, plotting the loss, and finding the point where the loss shoots up). Try adding all the bells and whistles—save checkpoints, use early stopping, and plot learning curves using TensorBoard.

You can also use a 2D Convnet model, as discussed in class

Try to get to 98% without using Convolution layers, then see how far you can go with them.

You could start with the `CNN_MNIST_fashion` example file, use tactics from the "Functional\_Keras\_Approach" file

```
In [1]: import tensorflow as tf  
from tensorflow import keras
```

```
In [2]: fashion_mnist = keras.datasets.fashion_mnist  
(X_train_full, y_train_full), (X_test, y_test) = fashion_mnist.load_data()
```

```
In [3]: fashion_mnist = keras.datasets.fashion_mnist  
(X_train_full, y_train_full), (X_test, y_test) = fashion_mnist.load_data()
```

```
In [4]: class_names = ["T-shirt/top", "Trouser", "Pullover", "Dress", "Coat",  
"Sandal", "Shirt", "Sneaker", "Bag", "Ankle boot"]
```

```
In [5]: model = keras.models.Sequential()  
model.add(keras.layers.Flatten(input_shape=[28, 28]))  
model.add(keras.layers.Dense(300, activation="relu"))  
model.add(keras.layers.Dense(100, activation="relu"))  
model.add(keras.layers.Dense(10, activation="softmax"))
```

```
/usr/local/lib/python3.10/dist-packages/keras/src/layers/reshaping/flatten.py:37: Use  
rWarning: Do not pass an `input_shape`/`input_dim` argument to a layer. When using Se  
quential models, prefer using an `Input(shape)` object as the first layer in the mode  
l instead.  
super().__init__(**kwargs)
```

```
In [6]: model.summary()
```

Model: "sequential"

Layer (type)	Output Shape	Params
flatten (Flatten)	(None, 784)	
dense (Dense)	(None, 300)	23,400
dense_1 (Dense)	(None, 100)	3,000
dense_2 (Dense)	(None, 10)	100

Total params: 266,610 (1.02 MB)

Trainable params: 266,610 (1.02 MB)

```
In [7]: hidden1 = model.layers[1]
```

```
In [8]: weights, biases = hidden1.get_weights()
```

```
In [9]: model.compile(loss="sparse_categorical_crossentropy",
                    optimizer="sgd",
                    metrics=["accuracy"])
```

```
In [10]: X_valid, X_train = X_train_full[:5000] / 255.0, X_train_full[5000:] / 255.0
y_valid, y_train = y_train_full[:5000], y_train_full[5000:]
X_test = X_test / 255.0
```

```
In [11]: from tensorflow.keras.callbacks import TensorBoard
```

```
In [12]: import os
root_logdir = os.path.join(os.curdir, "my_logs")

def get_run_logdir():
    import time
    run_id = time.strftime("run_%Y_%m_%d-%H_%M_%S")
    return os.path.join(root_logdir, run_id)

run_logdir = get_run_logdir()
```

```
In [13]: tensorboard_cb = keras.callbacks.TensorBoard(run_logdir)

history = model.fit(X_train, y_train, epochs=30,
                     validation_data=(X_valid, y_valid), callbacks=[tensorboard_cb])
```

Epoch 1/30  
**1719/1719** 6s 3ms/step - accuracy: 0.6797 - loss: 1.0000 - val\_accuracy: 0.8254 - val\_loss: 0.5125  
Epoch 2/30  
**1719/1719** 4s 2ms/step - accuracy: 0.8257 - loss: 0.5070 - val\_accuracy: 0.8464 - val\_loss: 0.4491  
Epoch 3/30  
**1719/1719** 4s 2ms/step - accuracy: 0.8444 - loss: 0.4487 - val\_accuracy: 0.8580 - val\_loss: 0.4231  
Epoch 4/30  
**1719/1719** 4s 2ms/step - accuracy: 0.8507 - loss: 0.4204 - val\_accuracy: 0.8672 - val\_loss: 0.3952  
Epoch 5/30  
**1719/1719** 4s 2ms/step - accuracy: 0.8580 - loss: 0.4030 - val\_accuracy: 0.8334 - val\_loss: 0.4357  
Epoch 6/30  
**1719/1719** 4s 2ms/step - accuracy: 0.8651 - loss: 0.3785 - val\_accuracy: 0.8692 - val\_loss: 0.3895  
Epoch 7/30  
**1719/1719** 4s 2ms/step - accuracy: 0.8684 - loss: 0.3708 - val\_accuracy: 0.8750 - val\_loss: 0.3589  
Epoch 8/30  
**1719/1719** 4s 2ms/step - accuracy: 0.8746 - loss: 0.3549 - val\_accuracy: 0.8732 - val\_loss: 0.3629  
Epoch 9/30  
**1719/1719** 4s 2ms/step - accuracy: 0.8778 - loss: 0.3447 - val\_accuracy: 0.8766 - val\_loss: 0.3454  
Epoch 10/30  
**1719/1719** 4s 2ms/step - accuracy: 0.8807 - loss: 0.3356 - val\_accuracy: 0.8782 - val\_loss: 0.3473  
Epoch 11/30  
**1719/1719** 4s 2ms/step - accuracy: 0.8834 - loss: 0.3214 - val\_accuracy: 0.8834 - val\_loss: 0.3304  
Epoch 12/30  
**1719/1719** 4s 2ms/step - accuracy: 0.8875 - loss: 0.3188 - val\_accuracy: 0.8820 - val\_loss: 0.3386  
Epoch 13/30  
**1719/1719** 4s 2ms/step - accuracy: 0.8879 - loss: 0.3120 - val\_accuracy: 0.8802 - val\_loss: 0.3380  
Epoch 14/30  
**1719/1719** 4s 2ms/step - accuracy: 0.8897 - loss: 0.3073 - val\_accuracy: 0.8840 - val\_loss: 0.3275  
Epoch 15/30  
**1719/1719** 4s 2ms/step - accuracy: 0.8913 - loss: 0.3029 - val\_accuracy: 0.8866 - val\_loss: 0.3164  
Epoch 16/30  
**1719/1719** 4s 2ms/step - accuracy: 0.8962 - loss: 0.2878 - val\_accuracy: 0.8856 - val\_loss: 0.3202  
Epoch 17/30  
**1719/1719** 4s 2ms/step - accuracy: 0.8985 - loss: 0.2877 - val\_accuracy: 0.8808 - val\_loss: 0.3257  
Epoch 18/30  
**1719/1719** 4s 2ms/step - accuracy: 0.9021 - loss: 0.2752 - val\_accuracy: 0.8828 - val\_loss: 0.3349  
Epoch 19/30  
**1719/1719** 4s 2ms/step - accuracy: 0.9034 - loss: 0.2717 - val\_accuracy: 0.8922 - val\_loss: 0.3072  
Epoch 20/30  
**1719/1719** 4s 2ms/step - accuracy: 0.9022 - loss: 0.2691 - val\_accuracy: 0.8866 - val\_loss: 0.3181

```
Epoch 21/30
1719/1719 4s 2ms/step - accuracy: 0.9096 - loss: 0.2585 - val_accuracy: 0.8896 - val_loss: 0.3106
Epoch 22/30
1719/1719 4s 2ms/step - accuracy: 0.9056 - loss: 0.2602 - val_accuracy: 0.8696 - val_loss: 0.3479
Epoch 23/30
1719/1719 4s 2ms/step - accuracy: 0.9097 - loss: 0.2515 - val_accuracy: 0.8916 - val_loss: 0.3022
Epoch 24/30
1719/1719 4s 2ms/step - accuracy: 0.9127 - loss: 0.2461 - val_accuracy: 0.8876 - val_loss: 0.3027
Epoch 25/30
1719/1719 4s 2ms/step - accuracy: 0.9126 - loss: 0.2451 - val_accuracy: 0.8904 - val_loss: 0.3101
Epoch 26/30
1719/1719 4s 2ms/step - accuracy: 0.9139 - loss: 0.2388 - val_accuracy: 0.8912 - val_loss: 0.3127
Epoch 27/30
1719/1719 4s 2ms/step - accuracy: 0.9174 - loss: 0.2309 - val_accuracy: 0.8924 - val_loss: 0.2904
Epoch 28/30
1719/1719 4s 2ms/step - accuracy: 0.9167 - loss: 0.2305 - val_accuracy: 0.8898 - val_loss: 0.3057
Epoch 29/30
1719/1719 4s 2ms/step - accuracy: 0.9191 - loss: 0.2288 - val_accuracy: 0.8828 - val_loss: 0.3145
Epoch 30/30
1719/1719 4s 2ms/step - accuracy: 0.9203 - loss: 0.2225 - val_accuracy: 0.8874 - val_loss: 0.3019
```

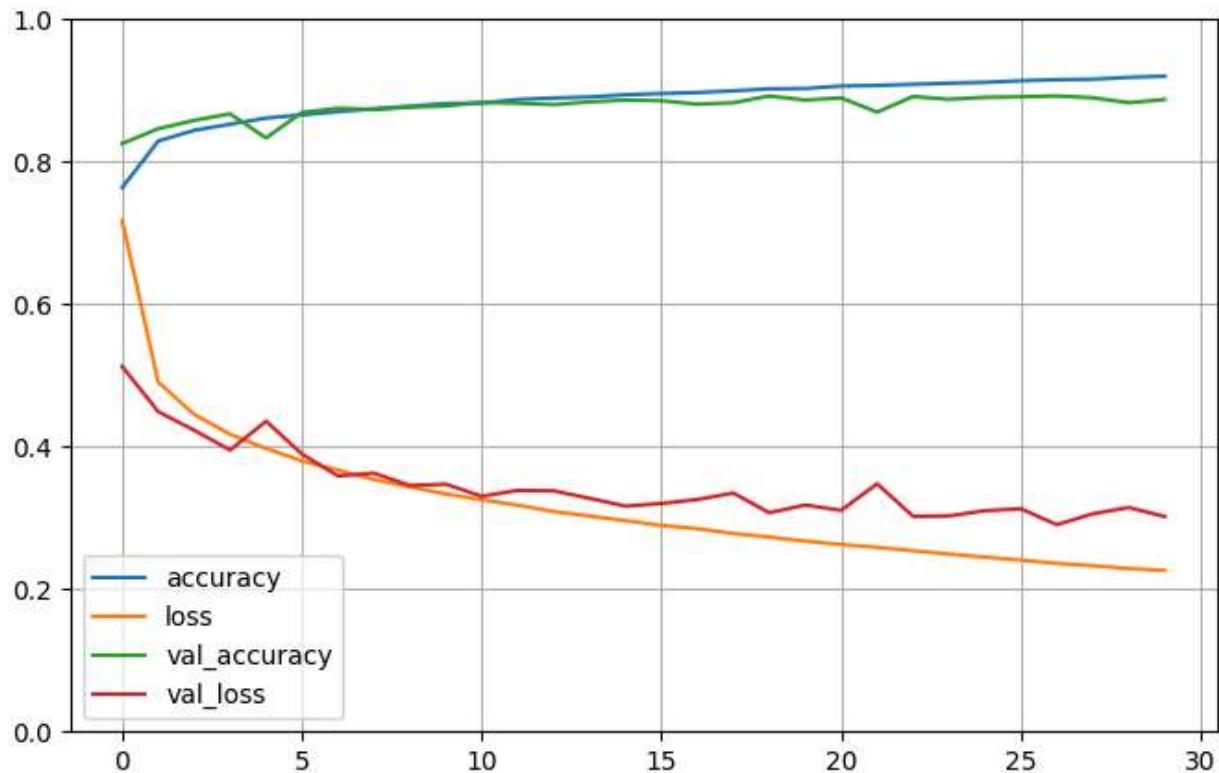
In [15]: `model.evaluate(X_test, y_test)`

**313/313** 0s 1ms/step - accuracy: 0.8816 - loss: 0.3390

Out[15]: `[0.3352793753147125, 0.8802000284194946]`

In [16]: `import pandas as pd  
import matplotlib.pyplot as plt`

```
pd.DataFrame(history.history).plot(figsize=(8, 5))
plt.grid(True)
plt.gca().set_ylim(0, 1) # set the vertical range to [0-1]
plt.show()
```



```
In [17]: import tensorflow.keras as keras

def create_model(hidden_units=300, learning_rate=0.01):
    model = keras.models.Sequential([
        keras.layers.Flatten(input_shape=[28, 28]),
        keras.layers.Dense(hidden_units, activation="relu"),
        keras.layers.Dense(100, activation="relu"),
        keras.layers.Dense(10, activation="softmax")
    ])
    optimizer = keras.optimizers.Adam(learning_rate=learning_rate)
    model.compile(loss="sparse_categorical_crossentropy",
                  optimizer=optimizer,
                  metrics=["accuracy"])
    return model
```

```
In [45]: !pip install scikeras
```

```

Collecting scikeras
  Downloading scikeras-0.13.0-py3-none-any.whl (26 kB)
Collecting keras>=3.2.0 (from scikeras)
  Downloading keras-3.3.3-py3-none-any.whl (1.1 MB)
    _____ 1.1/1.1 MB 22.7 MB/s eta 0:00:00
Collecting scikit-learn>=1.4.2 (from scikeras)
  Downloading scikit_learn-1.4.2-cp310-cp310-manylinux_2_17_x86_64.manylinux2014_x86_
64.whl (12.1 MB)
    _____ 12.1/12.1 MB 94.5 MB/s eta 0:00:00
Requirement already satisfied: absl-py in /usr/local/lib/python3.10/dist-packages (fr
om keras>=3.2.0->scikeras) (1.4.0)
Requirement already satisfied: numpy in /usr/local/lib/python3.10/dist-packages (from
keras>=3.2.0->scikeras) (1.25.2)
Requirement already satisfied: rich in /usr/local/lib/python3.10/dist-packages (from
keras>=3.2.0->scikeras) (13.7.1)
Collecting namex (from keras>=3.2.0->scikeras)
  Downloading namex-0.0.8-py3-none-any.whl (5.8 kB)
Requirement already satisfied: h5py in /usr/local/lib/python3.10/dist-packages (from
keras>=3.2.0->scikeras) (3.9.0)
Collecting optree (from keras>=3.2.0->scikeras)
  Downloading optree-0.11.0-cp310-cp310-manylinux_2_17_x86_64.manylinux2014_x86_64.wh
l (311 kB)
    _____ 311.2/311.2 kB 37.5 MB/s eta 0:00:00
Requirement already satisfied: ml-dtypes in /usr/local/lib/python3.10/dist-packages
(from keras>=3.2.0->scikeras) (0.2.0)
Requirement already satisfied: scipy>=1.6.0 in /usr/local/lib/python3.10/dist-package
s (from scikit-learn>=1.4.2->scikeras) (1.11.4)
Requirement already satisfied: joblib>=1.2.0 in /usr/local/lib/python3.10/dist-package
s (from scikit-learn>=1.4.2->scikeras) (1.4.0)
Requirement already satisfied: threadpoolctl>=2.0.0 in /usr/local/lib/python3.10/dist
-packages (from scikit-learn>=1.4.2->scikeras) (3.4.0)
Requirement already satisfied: typing-extensions>=4.0.0 in /usr/local/lib/python3.10/
dist-packages (from optree->keras>=3.2.0->scikeras) (4.11.0)
Requirement already satisfied: markdown-it-py>=2.2.0 in /usr/local/lib/python3.10/dis
t-packages (from rich->keras>=3.2.0->scikeras) (3.0.0)
Requirement already satisfied: pygments<3.0.0,>=2.13.0 in /usr/local/lib/python3.10/d
ist-packages (from rich->keras>=3.2.0->scikeras) (2.16.1)
Requirement already satisfied: mdurl~0.1 in /usr/local/lib/python3.10/dist-packages
(from markdown-it-py>=2.2.0->rich->keras>=3.2.0->scikeras) (0.1.2)
Installing collected packages: namex, optree, scikit-learn, keras, scikeras
  Attempting uninstall: scikit-learn
    Found existing installation: scikit-learn 1.2.2
    Uninstalling scikit-learn-1.2.2:
      Successfully uninstalled scikit-learn-1.2.2
  Attempting uninstall: keras
    Found existing installation: keras 2.15.0
    Uninstalling keras-2.15.0:
      Successfully uninstalled keras-2.15.0
ERROR: pip's dependency resolver does not currently take into account all the package
s that are installed. This behaviour is the source of the following dependency confli
cts.
tensorflow 2.15.0 requires keras<2.16,>=2.15.0, but you have keras 3.3.3 which is inc
ompatible.
Successfully installed keras-3.3.3 namex-0.0.8 optree-0.11.0 scikeras-0.13.0 scikit-l
earn-1.4.2

```

In [19]:

```

from scipy.stats import reciprocal
from sklearn.model_selection import RandomizedSearchCV
from scikeras.wrappers import KerasClassifier

```

```
param_distrib = {
    "hidden_units": [100, 200, 300],
    "learning_rate": reciprocal(3e-4, 3e-2),
}
```

```
In [25]: keras_class = KerasClassifier(create_model)
```

```
In [26]: keras_class.fit(X_train, y_train, epochs=100,
                      validation_data=(X_valid, y_valid),
                      callbacks=[keras.callbacks.EarlyStopping(patience=10)])
#mse_test = keras_class.score(X_test, y_test)
#y_pred = keras_class.predict(X_new)
```

```
/usr/local/lib/python3.10/dist-packages/keras/src/layers/reshaping/flatten.py:37: UserWarning: Do not pass an `input_shape`/`input_dim` argument to a layer. When using Sequential models, prefer using an `Input(shape)` object as the first layer in the model instead.
super().__init__(**kwargs)
```

Epoch 1/100  
**1719/1719** 6s 3ms/step - accuracy: 0.7546 - loss: 0.7100 - val\_accuracy: 0.8344 - val\_loss: 0.4615  
Epoch 2/100  
**1719/1719** 3s 1ms/step - accuracy: 0.8351 - loss: 0.4597 - val\_accuracy: 0.8498 - val\_loss: 0.4181  
Epoch 3/100  
**1719/1719** 3s 1ms/step - accuracy: 0.8470 - loss: 0.4254 - val\_accuracy: 0.8552 - val\_loss: 0.4233  
Epoch 4/100  
**1719/1719** 3s 1ms/step - accuracy: 0.8539 - loss: 0.4107 - val\_accuracy: 0.8500 - val\_loss: 0.4358  
Epoch 5/100  
**1719/1719** 3s 1ms/step - accuracy: 0.8605 - loss: 0.3894 - val\_accuracy: 0.8430 - val\_loss: 0.4340  
Epoch 6/100  
**1719/1719** 3s 2ms/step - accuracy: 0.8611 - loss: 0.3889 - val\_accuracy: 0.8570 - val\_loss: 0.4346  
Epoch 7/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8630 - loss: 0.3899 - val\_accuracy: 0.8588 - val\_loss: 0.4253  
Epoch 8/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8656 - loss: 0.3817 - val\_accuracy: 0.8650 - val\_loss: 0.4196  
Epoch 9/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8633 - loss: 0.3802 - val\_accuracy: 0.8584 - val\_loss: 0.4529  
Epoch 10/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8626 - loss: 0.3810 - val\_accuracy: 0.8646 - val\_loss: 0.4154  
Epoch 11/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8708 - loss: 0.3647 - val\_accuracy: 0.8690 - val\_loss: 0.3897  
Epoch 12/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8710 - loss: 0.3591 - val\_accuracy: 0.8564 - val\_loss: 0.5049  
Epoch 13/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8717 - loss: 0.3611 - val\_accuracy: 0.8652 - val\_loss: 0.4145  
Epoch 14/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8744 - loss: 0.3510 - val\_accuracy: 0.8640 - val\_loss: 0.4276  
Epoch 15/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8744 - loss: 0.3515 - val\_accuracy: 0.8622 - val\_loss: 0.4223  
Epoch 16/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8764 - loss: 0.3444 - val\_accuracy: 0.8630 - val\_loss: 0.4496  
Epoch 17/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8758 - loss: 0.3513 - val\_accuracy: 0.8552 - val\_loss: 0.4486  
Epoch 18/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8797 - loss: 0.3363 - val\_accuracy: 0.8610 - val\_loss: 0.4262  
Epoch 19/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8749 - loss: 0.3458 - val\_accuracy: 0.8598 - val\_loss: 0.4434  
Epoch 20/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8770 - loss: 0.3421 - val\_accuracy: 0.8728 - val\_loss: 0.4285

Epoch 21/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8800 - loss: 0.3347 - val\_accuracy: 0.8672 - val\_loss: 0.4482  
Epoch 22/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8776 - loss: 0.3453 - val\_accuracy: 0.8690 - val\_loss: 0.5114  
Epoch 23/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8788 - loss: 0.3348 - val\_accuracy: 0.8638 - val\_loss: 0.4562  
Epoch 24/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8789 - loss: 0.3393 - val\_accuracy: 0.8606 - val\_loss: 0.4861  
Epoch 25/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8782 - loss: 0.3473 - val\_accuracy: 0.8658 - val\_loss: 0.4438  
Epoch 26/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8824 - loss: 0.3242 - val\_accuracy: 0.8718 - val\_loss: 0.4460  
Epoch 27/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8834 - loss: 0.3311 - val\_accuracy: 0.8674 - val\_loss: 0.4565  
Epoch 28/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8852 - loss: 0.3207 - val\_accuracy: 0.8738 - val\_loss: 0.4402  
Epoch 29/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8791 - loss: 0.3438 - val\_accuracy: 0.8718 - val\_loss: 0.4647  
Epoch 30/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8827 - loss: 0.3269 - val\_accuracy: 0.8696 - val\_loss: 0.4678  
Epoch 31/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8855 - loss: 0.3231 - val\_accuracy: 0.8684 - val\_loss: 0.4632  
Epoch 32/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8829 - loss: 0.3339 - val\_accuracy: 0.8526 - val\_loss: 0.4957  
Epoch 33/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8794 - loss: 0.3405 - val\_accuracy: 0.8752 - val\_loss: 0.4966  
Epoch 34/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8876 - loss: 0.3181 - val\_accuracy: 0.8626 - val\_loss: 0.4669  
Epoch 35/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8860 - loss: 0.3125 - val\_accuracy: 0.8568 - val\_loss: 0.5390  
Epoch 36/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8868 - loss: 0.3162 - val\_accuracy: 0.8636 - val\_loss: 0.5297  
Epoch 37/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8872 - loss: 0.3224 - val\_accuracy: 0.8638 - val\_loss: 0.5551  
Epoch 38/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8833 - loss: 0.3336 - val\_accuracy: 0.8628 - val\_loss: 0.5688  
Epoch 39/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8894 - loss: 0.3107 - val\_accuracy: 0.8596 - val\_loss: 0.5706  
Epoch 40/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8863 - loss: 0.3219 - val\_accuracy: 0.8676 - val\_loss: 0.4944

Epoch 41/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8880 - loss: 0.3135 - val\_accuracy: 0.8590 - val\_loss: 0.6178  
Epoch 42/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8880 - loss: 0.3197 - val\_accuracy: 0.8664 - val\_loss: 0.5274  
Epoch 43/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8886 - loss: 0.3181 - val\_accuracy: 0.8648 - val\_loss: 0.5523  
Epoch 44/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8888 - loss: 0.3176 - val\_accuracy: 0.8600 - val\_loss: 0.4836  
Epoch 45/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8930 - loss: 0.2991 - val\_accuracy: 0.8660 - val\_loss: 0.5112  
Epoch 46/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8900 - loss: 0.3166 - val\_accuracy: 0.8730 - val\_loss: 0.5003  
Epoch 47/100  
**1719/1719** 3s 1ms/step - accuracy: 0.8915 - loss: 0.3057 - val\_accuracy: 0.8722 - val\_loss: 0.5240  
Epoch 48/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8896 - loss: 0.3127 - val\_accuracy: 0.8632 - val\_loss: 0.7026  
Epoch 49/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8797 - loss: 0.3339 - val\_accuracy: 0.8680 - val\_loss: 0.4864  
Epoch 50/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8927 - loss: 0.3036 - val\_accuracy: 0.8642 - val\_loss: 0.4935  
Epoch 51/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8878 - loss: 0.3119 - val\_accuracy: 0.8630 - val\_loss: 0.5511  
Epoch 52/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8876 - loss: 0.3124 - val\_accuracy: 0.8684 - val\_loss: 0.5222  
Epoch 53/100  
**1719/1719** 3s 1ms/step - accuracy: 0.8928 - loss: 0.3040 - val\_accuracy: 0.8734 - val\_loss: 0.6659  
Epoch 54/100  
**1719/1719** 3s 1ms/step - accuracy: 0.8808 - loss: 0.3388 - val\_accuracy: 0.8742 - val\_loss: 0.4795  
Epoch 55/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8903 - loss: 0.3008 - val\_accuracy: 0.8662 - val\_loss: 0.5936  
Epoch 56/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8942 - loss: 0.3053 - val\_accuracy: 0.8688 - val\_loss: 0.6923  
Epoch 57/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8898 - loss: 0.3208 - val\_accuracy: 0.8694 - val\_loss: 0.6218  
Epoch 58/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8915 - loss: 0.3111 - val\_accuracy: 0.8676 - val\_loss: 0.6245  
Epoch 59/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8926 - loss: 0.3005 - val\_accuracy: 0.8662 - val\_loss: 0.6740  
Epoch 60/100  
**1719/1719** 3s 1ms/step - accuracy: 0.8943 - loss: 0.3057 - val\_accuracy: 0.8740 - val\_loss: 0.5401

Epoch 61/100  
**1719/1719** 3s 1ms/step - accuracy: 0.8900 - loss: 0.3080 - val\_accuracy: 0.8750 - val\_loss: 0.5737  
Epoch 62/100  
**1719/1719** 3s 1ms/step - accuracy: 0.8928 - loss: 0.3071 - val\_accuracy: 0.8688 - val\_loss: 0.6433  
Epoch 63/100  
**1719/1719** 3s 1ms/step - accuracy: 0.8919 - loss: 0.3113 - val\_accuracy: 0.8562 - val\_loss: 0.5919  
Epoch 64/100  
**1719/1719** 3s 1ms/step - accuracy: 0.8884 - loss: 0.3185 - val\_accuracy: 0.8652 - val\_loss: 0.7347  
Epoch 65/100  
**1719/1719** 3s 1ms/step - accuracy: 0.8896 - loss: 0.3113 - val\_accuracy: 0.8750 - val\_loss: 0.6085  
Epoch 66/100  
**1719/1719** 3s 1ms/step - accuracy: 0.8942 - loss: 0.3077 - val\_accuracy: 0.8712 - val\_loss: 0.5643  
Epoch 67/100  
**1719/1719** 3s 2ms/step - accuracy: 0.8930 - loss: 0.3094 - val\_accuracy: 0.8722 - val\_loss: 0.6102  
Epoch 68/100  
**1719/1719** 3s 1ms/step - accuracy: 0.8951 - loss: 0.3043 - val\_accuracy: 0.8700 - val\_loss: 0.4944  
Epoch 69/100  
**1719/1719** 3s 1ms/step - accuracy: 0.8957 - loss: 0.2892 - val\_accuracy: 0.8736 - val\_loss: 0.5635  
Epoch 70/100  
**1719/1719** 3s 1ms/step - accuracy: 0.8956 - loss: 0.3009 - val\_accuracy: 0.8578 - val\_loss: 0.6736  
Epoch 71/100  
**1719/1719** 3s 1ms/step - accuracy: 0.8906 - loss: 0.3193 - val\_accuracy: 0.8682 - val\_loss: 0.6212  
Epoch 72/100  
**1719/1719** 3s 1ms/step - accuracy: 0.8940 - loss: 0.3017 - val\_accuracy: 0.8572 - val\_loss: 0.7827  
Epoch 73/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8918 - loss: 0.3102 - val\_accuracy: 0.8652 - val\_loss: 0.5911  
Epoch 74/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8920 - loss: 0.3015 - val\_accuracy: 0.8636 - val\_loss: 0.6271  
Epoch 75/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8912 - loss: 0.3169 - val\_accuracy: 0.8648 - val\_loss: 0.7113  
Epoch 76/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8953 - loss: 0.2993 - val\_accuracy: 0.8656 - val\_loss: 0.6483  
Epoch 77/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8923 - loss: 0.3029 - val\_accuracy: 0.8710 - val\_loss: 0.6845  
Epoch 78/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8960 - loss: 0.2901 - val\_accuracy: 0.8622 - val\_loss: 0.6430  
Epoch 79/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8934 - loss: 0.2988 - val\_accuracy: 0.8548 - val\_loss: 0.6796  
Epoch 80/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8975 - loss: 0.2923 - val\_accuracy: 0.8626 - val\_loss: 0.7256

Epoch 81/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8953 - loss: 0.2936 - val\_accuracy: 0.8680 - val\_loss: 0.6034  
Epoch 82/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8972 - loss: 0.2948 - val\_accuracy: 0.8706 - val\_loss: 0.5651  
Epoch 83/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8939 - loss: 0.2993 - val\_accuracy: 0.8712 - val\_loss: 0.6262  
Epoch 84/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8944 - loss: 0.2979 - val\_accuracy: 0.8750 - val\_loss: 0.5897  
Epoch 85/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8968 - loss: 0.2930 - val\_accuracy: 0.8670 - val\_loss: 0.6495  
Epoch 86/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8944 - loss: 0.2915 - val\_accuracy: 0.8650 - val\_loss: 0.6211  
Epoch 87/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8924 - loss: 0.3074 - val\_accuracy: 0.8750 - val\_loss: 0.6947  
Epoch 88/100  
**1719/1719** 2s 1ms/step - accuracy: 0.9003 - loss: 0.2846 - val\_accuracy: 0.8712 - val\_loss: 0.6093  
Epoch 89/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8990 - loss: 0.2883 - val\_accuracy: 0.8586 - val\_loss: 0.7879  
Epoch 90/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8974 - loss: 0.2925 - val\_accuracy: 0.8726 - val\_loss: 0.7825  
Epoch 91/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8992 - loss: 0.2821 - val\_accuracy: 0.8718 - val\_loss: 0.7574  
Epoch 92/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8907 - loss: 0.3232 - val\_accuracy: 0.8682 - val\_loss: 0.7448  
Epoch 93/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8926 - loss: 0.2974 - val\_accuracy: 0.8734 - val\_loss: 0.6578  
Epoch 94/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8950 - loss: 0.3078 - val\_accuracy: 0.8744 - val\_loss: 0.5607  
Epoch 95/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8985 - loss: 0.2818 - val\_accuracy: 0.8660 - val\_loss: 0.6177  
Epoch 96/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8933 - loss: 0.2980 - val\_accuracy: 0.8686 - val\_loss: 0.6595  
Epoch 97/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8976 - loss: 0.2852 - val\_accuracy: 0.8644 - val\_loss: 0.7796  
Epoch 98/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8911 - loss: 0.3170 - val\_accuracy: 0.8738 - val\_loss: 0.7546  
Epoch 99/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8997 - loss: 0.2946 - val\_accuracy: 0.8658 - val\_loss: 0.7851  
Epoch 100/100  
**1719/1719** 2s 1ms/step - accuracy: 0.8967 - loss: 0.2978 - val\_accuracy: 0.8672 - val\_loss: 0.8561

Out[26]:

```
KerasClassifier(  
    model=<function create_model at 0x7b6a3a024af0>  
    build_fn=None  
    warm_start=False  
    random_state=None  
    optimizer=rmsprop  
    loss=None  
    metrics=None  
    batch_size=None  
    validation_batch_size=None  
    verbose=1
```

In [27]:

```
model.evaluate(X_test, y_test)
```

```
313/313 ━━━━━━━━ 0s 1ms/step - accuracy: 0.8816 - loss: 0.3390
```

Out[27]:

```
from scipy.stats import reciprocal  
from sklearn.model_selection import RandomizedSearchCV  
  
param_distributions = {  
    "optimizer": [keras.optimizers.Adam(learning_rate=lr) for lr in reciprocal(3e-4, 3)]  
  
    # Create a KerasClassifier instance  
    keras_clf = KerasClassifier(build_fn=create_model)  
  
    # Perform Randomized Search  
    rnd_search_cv = RandomizedSearchCV(keras_clf, param_distributions, n_iter=10, cv=3)  
    rnd_search_cv.fit(X_train, y_train, epochs=10, validation_data=(X_valid, y_valid))
```

```
/usr/local/lib/python3.10/dist-packages/scikeras/wrappers.py:925: UserWarning: ``build_fn`` will be renamed to ``model`` in a future release, at which point use of ``build_fn`` will raise an Error instead.  
    X, y = self._initialize(X, y)  
/usr/local/lib/python3.10/dist-packages/keras/src/layers/reshaping/flatten.py:37: UserWarning: Do not pass an `input_shape`/`input_dim` argument to a layer. When using Sequential models, prefer using an `Input(shape)` object as the first layer in the model instead.  
    super().__init__(**kwargs)
```

```
Epoch 1/10
1146/1146 6s 4ms/step - accuracy: 0.7396 - loss: 0.7783 - val_accuracy: 0.8164 - val_loss: 0.5686
Epoch 2/10
1146/1146 2s 1ms/step - accuracy: 0.8298 - loss: 0.4856 - val_accuracy: 0.8492 - val_loss: 0.4342
Epoch 3/10
1146/1146 2s 1ms/step - accuracy: 0.8422 - loss: 0.4449 - val_accuracy: 0.8548 - val_loss: 0.4082
Epoch 4/10
1146/1146 2s 1ms/step - accuracy: 0.8532 - loss: 0.4177 - val_accuracy: 0.8650 - val_loss: 0.3834
Epoch 5/10
1146/1146 2s 1ms/step - accuracy: 0.8586 - loss: 0.3922 - val_accuracy: 0.8466 - val_loss: 0.4356
Epoch 6/10
1146/1146 2s 1ms/step - accuracy: 0.8545 - loss: 0.4001 - val_accuracy: 0.8542 - val_loss: 0.4310
Epoch 7/10
1146/1146 2s 1ms/step - accuracy: 0.8610 - loss: 0.3900 - val_accuracy: 0.8630 - val_loss: 0.4292
Epoch 8/10
1146/1146 2s 2ms/step - accuracy: 0.8736 - loss: 0.3698 - val_accuracy: 0.8614 - val_loss: 0.4111
Epoch 9/10
1146/1146 2s 1ms/step - accuracy: 0.8688 - loss: 0.3754 - val_accuracy: 0.8584 - val_loss: 0.4433
Epoch 10/10
1146/1146 2s 1ms/step - accuracy: 0.8714 - loss: 0.3646 - val_accuracy: 0.8668 - val_loss: 0.4230
573/573 1s 1ms/step
```

```
/usr/local/lib/python3.10/dist-packages/scikeras/wrappers.py:925: UserWarning: ``build_fn`` will be renamed to ``model`` in a future release, at which point use of ``build_fn`` will raise an Error instead.
```

```
    X, y = self._initialize(X, y)
```

```
/usr/local/lib/python3.10/dist-packages/keras/src/layers/reshaping/flatten.py:37: UserWarning: Do not pass an `input_shape`/`input_dim` argument to a layer. When using Sequential models, prefer using an `Input(shape)` object as the first layer in the model instead.
```

```
    super().__init__(**kwargs)
```

```
Epoch 1/10
1146/1146 5s 3ms/step - accuracy: 0.7358 - loss: 0.7719 - val_accuracy: 0.8404 - val_loss: 0.4762
Epoch 2/10
1146/1146 2s 1ms/step - accuracy: 0.8342 - loss: 0.4603 - val_accuracy: 0.8562 - val_loss: 0.4451
Epoch 3/10
1146/1146 2s 1ms/step - accuracy: 0.8451 - loss: 0.4280 - val_accuracy: 0.8532 - val_loss: 0.4124
Epoch 4/10
1146/1146 2s 1ms/step - accuracy: 0.8547 - loss: 0.4150 - val_accuracy: 0.8534 - val_loss: 0.4512
Epoch 5/10
1146/1146 2s 1ms/step - accuracy: 0.8584 - loss: 0.4045 - val_accuracy: 0.8618 - val_loss: 0.4102
Epoch 6/10
1146/1146 2s 1ms/step - accuracy: 0.8605 - loss: 0.3907 - val_accuracy: 0.8608 - val_loss: 0.4014
Epoch 7/10
1146/1146 2s 1ms/step - accuracy: 0.8604 - loss: 0.3933 - val_accuracy: 0.8638 - val_loss: 0.4270
Epoch 8/10
1146/1146 2s 1ms/step - accuracy: 0.8628 - loss: 0.3910 - val_accuracy: 0.8602 - val_loss: 0.4380
Epoch 9/10
1146/1146 2s 1ms/step - accuracy: 0.8684 - loss: 0.3633 - val_accuracy: 0.8546 - val_loss: 0.4424
Epoch 10/10
1146/1146 2s 1ms/step - accuracy: 0.8684 - loss: 0.3718 - val_accuracy: 0.8576 - val_loss: 0.4694
573/573 1s 1ms/step
```

```
/usr/local/lib/python3.10/dist-packages/scikeras/wrappers.py:925: UserWarning: ``build_fn`` will be renamed to ``model`` in a future release, at which point use of ``build_fn`` will raise an Error instead.
```

```
    X, y = self._initialize(X, y)
```

```
/usr/local/lib/python3.10/dist-packages/keras/src/layers/reshaping/flatten.py:37: UserWarning: Do not pass an `input_shape`/`input_dim` argument to a layer. When using Sequential models, prefer using an `Input(shape)` object as the first layer in the model instead.
```

```
    super().__init__(**kwargs)
```

```
Epoch 1/10
1146/1146 4s 3ms/step - accuracy: 0.7381 - loss: 0.7644 - val_accuracy: 0.8492 - val_loss: 0.4530
Epoch 2/10
1146/1146 2s 1ms/step - accuracy: 0.8358 - loss: 0.4600 - val_accuracy: 0.8586 - val_loss: 0.4377
Epoch 3/10
1146/1146 2s 1ms/step - accuracy: 0.8505 - loss: 0.4188 - val_accuracy: 0.8502 - val_loss: 0.4192
Epoch 4/10
1146/1146 2s 1ms/step - accuracy: 0.8506 - loss: 0.4136 - val_accuracy: 0.8370 - val_loss: 0.5054
Epoch 5/10
1146/1146 2s 1ms/step - accuracy: 0.8560 - loss: 0.4043 - val_accuracy: 0.8516 - val_loss: 0.4464
Epoch 6/10
1146/1146 2s 1ms/step - accuracy: 0.8648 - loss: 0.3828 - val_accuracy: 0.8582 - val_loss: 0.4265
Epoch 7/10
1146/1146 2s 1ms/step - accuracy: 0.8625 - loss: 0.3955 - val_accuracy: 0.8630 - val_loss: 0.4227
Epoch 8/10
1146/1146 2s 1ms/step - accuracy: 0.8662 - loss: 0.3746 - val_accuracy: 0.8622 - val_loss: 0.3924
Epoch 9/10
1146/1146 2s 1ms/step - accuracy: 0.8702 - loss: 0.3660 - val_accuracy: 0.8442 - val_loss: 0.4638
Epoch 10/10
1146/1146 2s 1ms/step - accuracy: 0.8684 - loss: 0.3758 - val_accuracy: 0.8646 - val_loss: 0.4190
573/573 1s 1ms/step
```

```
/usr/local/lib/python3.10/dist-packages/scikeras/wrappers.py:925: UserWarning: ``build_fn`` will be renamed to ``model`` in a future release, at which point use of ``build_fn`` will raise an Error instead.
```

```
    X, y = self._initialize(X, y)
```

```
/usr/local/lib/python3.10/dist-packages/keras/src/layers/reshaping/flatten.py:37: UserWarning: Do not pass an `input_shape`/`input_dim` argument to a layer. When using Sequential models, prefer using an `Input(shape)` object as the first layer in the model instead.
```

```
    super().__init__(**kwargs)
```

```
Epoch 1/10
1146/1146 5s 3ms/step - accuracy: 0.7407 - loss: 0.7703 - val_accuracy: 0.8442 - val_loss: 0.4635
Epoch 2/10
1146/1146 2s 1ms/step - accuracy: 0.8256 - loss: 0.4880 - val_accuracy: 0.8560 - val_loss: 0.4052
Epoch 3/10
1146/1146 2s 2ms/step - accuracy: 0.8517 - loss: 0.4181 - val_accuracy: 0.8550 - val_loss: 0.4137
Epoch 4/10
1146/1146 2s 1ms/step - accuracy: 0.8541 - loss: 0.3990 - val_accuracy: 0.8568 - val_loss: 0.4111
Epoch 5/10
1146/1146 2s 1ms/step - accuracy: 0.8578 - loss: 0.4043 - val_accuracy: 0.8660 - val_loss: 0.4143
Epoch 6/10
1146/1146 2s 1ms/step - accuracy: 0.8648 - loss: 0.3769 - val_accuracy: 0.8620 - val_loss: 0.4147
Epoch 7/10
1146/1146 2s 1ms/step - accuracy: 0.8654 - loss: 0.3775 - val_accuracy: 0.8512 - val_loss: 0.4549
Epoch 8/10
1146/1146 2s 1ms/step - accuracy: 0.8659 - loss: 0.3747 - val_accuracy: 0.8682 - val_loss: 0.3908
Epoch 9/10
1146/1146 2s 1ms/step - accuracy: 0.8746 - loss: 0.3638 - val_accuracy: 0.8472 - val_loss: 0.4592
Epoch 10/10
1146/1146 2s 1ms/step - accuracy: 0.8693 - loss: 0.3748 - val_accuracy: 0.8622 - val_loss: 0.3878
573/573 1s 1ms/step
```

```
/usr/local/lib/python3.10/dist-packages/scikeras/wrappers.py:925: UserWarning: ``build_fn`` will be renamed to ``model`` in a future release, at which point use of ``build_fn`` will raise an Error instead.
```

```
    X, y = self._initialize(X, y)
```

```
/usr/local/lib/python3.10/dist-packages/keras/src/layers/reshaping/flatten.py:37: UserWarning: Do not pass an `input_shape`/`input_dim` argument to a layer. When using Sequential models, prefer using an `Input(shape)` object as the first layer in the model instead.
```

```
    super().__init__(**kwargs)
```

```
Epoch 1/10
1146/1146 4s 3ms/step - accuracy: 0.7334 - loss: 0.7913 - val_accuracy: 0.8136 - val_loss: 0.4854
Epoch 2/10
1146/1146 2s 1ms/step - accuracy: 0.8330 - loss: 0.4641 - val_accuracy: 0.8456 - val_loss: 0.4597
Epoch 3/10
1146/1146 2s 2ms/step - accuracy: 0.8434 - loss: 0.4335 - val_accuracy: 0.8580 - val_loss: 0.3987
Epoch 4/10
1146/1146 2s 1ms/step - accuracy: 0.8486 - loss: 0.4180 - val_accuracy: 0.8590 - val_loss: 0.4158
Epoch 5/10
1146/1146 2s 1ms/step - accuracy: 0.8570 - loss: 0.3884 - val_accuracy: 0.8562 - val_loss: 0.4470
Epoch 6/10
1146/1146 2s 1ms/step - accuracy: 0.8557 - loss: 0.4052 - val_accuracy: 0.8558 - val_loss: 0.4323
Epoch 7/10
1146/1146 2s 1ms/step - accuracy: 0.8590 - loss: 0.3850 - val_accuracy: 0.8546 - val_loss: 0.4569
Epoch 8/10
1146/1146 2s 1ms/step - accuracy: 0.8623 - loss: 0.3872 - val_accuracy: 0.8486 - val_loss: 0.4395
Epoch 9/10
1146/1146 2s 1ms/step - accuracy: 0.8617 - loss: 0.3797 - val_accuracy: 0.8538 - val_loss: 0.4531
Epoch 10/10
1146/1146 2s 1ms/step - accuracy: 0.8640 - loss: 0.3787 - val_accuracy: 0.8550 - val_loss: 0.4356
573/573 1s 1ms/step
```

```
/usr/local/lib/python3.10/dist-packages/scikeras/wrappers.py:925: UserWarning: ``build_fn`` will be renamed to ``model`` in a future release, at which point use of ``build_fn`` will raise an Error instead.
```

```
    X, y = self._initialize(X, y)
```

```
/usr/local/lib/python3.10/dist-packages/keras/src/layers/reshaping/flatten.py:37: UserWarning: Do not pass an `input_shape`/`input_dim` argument to a layer. When using Sequential models, prefer using an `Input(shape)` object as the first layer in the model instead.
```

```
    super().__init__(**kwargs)
```

```
Epoch 1/10
1146/1146 4s 3ms/step - accuracy: 0.7280 - loss: 0.7789 - val_accuracy: 0.7870 - val_loss: 0.5628
Epoch 2/10
1146/1146 2s 1ms/step - accuracy: 0.8284 - loss: 0.4750 - val_accuracy: 0.8382 - val_loss: 0.4447
Epoch 3/10
1146/1146 2s 1ms/step - accuracy: 0.8467 - loss: 0.4284 - val_accuracy: 0.8550 - val_loss: 0.4107
Epoch 4/10
1146/1146 2s 1ms/step - accuracy: 0.8553 - loss: 0.4023 - val_accuracy: 0.8572 - val_loss: 0.4211
Epoch 5/10
1146/1146 2s 1ms/step - accuracy: 0.8571 - loss: 0.3917 - val_accuracy: 0.8582 - val_loss: 0.4370
Epoch 6/10
1146/1146 2s 1ms/step - accuracy: 0.8582 - loss: 0.3958 - val_accuracy: 0.8562 - val_loss: 0.4303
Epoch 7/10
1146/1146 2s 1ms/step - accuracy: 0.8625 - loss: 0.3932 - val_accuracy: 0.8700 - val_loss: 0.3819
Epoch 8/10
1146/1146 2s 1ms/step - accuracy: 0.8711 - loss: 0.3632 - val_accuracy: 0.8578 - val_loss: 0.4653
Epoch 9/10
1146/1146 2s 1ms/step - accuracy: 0.8629 - loss: 0.3869 - val_accuracy: 0.8602 - val_loss: 0.4347
Epoch 10/10
1146/1146 2s 2ms/step - accuracy: 0.8734 - loss: 0.3461 - val_accuracy: 0.8722 - val_loss: 0.3978
573/573 1s 1ms/step
```

```
/usr/local/lib/python3.10/dist-packages/scikeras/wrappers.py:925: UserWarning: ``build_fn`` will be renamed to ``model`` in a future release, at which point use of ``build_fn`` will raise an Error instead.
```

```
    X, y = self._initialize(X, y)
```

```
/usr/local/lib/python3.10/dist-packages/keras/src/layers/reshaping/flatten.py:37: UserWarning: Do not pass an `input_shape`/`input_dim` argument to a layer. When using Sequential models, prefer using an `Input(shape)` object as the first layer in the model instead.
```

```
    super().__init__(**kwargs)
```

```
Epoch 1/10
1146/1146 5s 3ms/step - accuracy: 0.7391 - loss: 0.7622 - val_accuracy: 0.7954 - val_loss: 0.5627
Epoch 2/10
1146/1146 2s 1ms/step - accuracy: 0.8315 - loss: 0.4720 - val_accuracy: 0.8262 - val_loss: 0.5042
Epoch 3/10
1146/1146 2s 1ms/step - accuracy: 0.8453 - loss: 0.4363 - val_accuracy: 0.8430 - val_loss: 0.4648
Epoch 4/10
1146/1146 2s 1ms/step - accuracy: 0.8540 - loss: 0.4018 - val_accuracy: 0.8508 - val_loss: 0.4613
Epoch 5/10
1146/1146 2s 1ms/step - accuracy: 0.8509 - loss: 0.4078 - val_accuracy: 0.8542 - val_loss: 0.4262
Epoch 6/10
1146/1146 2s 1ms/step - accuracy: 0.8585 - loss: 0.3922 - val_accuracy: 0.8434 - val_loss: 0.4471
Epoch 7/10
1146/1146 2s 1ms/step - accuracy: 0.8629 - loss: 0.3754 - val_accuracy: 0.8660 - val_loss: 0.4185
Epoch 8/10
1146/1146 2s 1ms/step - accuracy: 0.8602 - loss: 0.3897 - val_accuracy: 0.8490 - val_loss: 0.4825
Epoch 9/10
1146/1146 2s 1ms/step - accuracy: 0.8666 - loss: 0.3696 - val_accuracy: 0.8612 - val_loss: 0.4249
Epoch 10/10
1146/1146 2s 1ms/step - accuracy: 0.8666 - loss: 0.3689 - val_accuracy: 0.8596 - val_loss: 0.4387
573/573 1s 1ms/step
```

```
/usr/local/lib/python3.10/dist-packages/scikeras/wrappers.py:925: UserWarning: ``build_fn`` will be renamed to ``model`` in a future release, at which point use of ``build_fn`` will raise an Error instead.
```

```
    X, y = self._initialize(X, y)
```

```
/usr/local/lib/python3.10/dist-packages/keras/src/layers/reshaping/flatten.py:37: UserWarning: Do not pass an `input_shape`/`input_dim` argument to a layer. When using Sequential models, prefer using an `Input(shape)` object as the first layer in the model instead.
```

```
    super().__init__(**kwargs)
```

```
Epoch 1/10
1146/1146 5s 3ms/step - accuracy: 0.7427 - loss: 0.7475 - val_accuracy: 0.8250 - val_loss: 0.4946
Epoch 2/10
1146/1146 2s 1ms/step - accuracy: 0.8329 - loss: 0.4624 - val_accuracy: 0.8454 - val_loss: 0.4369
Epoch 3/10
1146/1146 2s 1ms/step - accuracy: 0.8409 - loss: 0.4446 - val_accuracy: 0.8368 - val_loss: 0.4384
Epoch 4/10
1146/1146 2s 1ms/step - accuracy: 0.8524 - loss: 0.4140 - val_accuracy: 0.8454 - val_loss: 0.4185
Epoch 5/10
1146/1146 2s 2ms/step - accuracy: 0.8583 - loss: 0.3971 - val_accuracy: 0.8670 - val_loss: 0.3915
Epoch 6/10
1146/1146 2s 1ms/step - accuracy: 0.8624 - loss: 0.3907 - val_accuracy: 0.8432 - val_loss: 0.4425
Epoch 7/10
1146/1146 2s 1ms/step - accuracy: 0.8619 - loss: 0.3879 - val_accuracy: 0.8494 - val_loss: 0.4373
Epoch 8/10
1146/1146 2s 2ms/step - accuracy: 0.8628 - loss: 0.3713 - val_accuracy: 0.8582 - val_loss: 0.4158
Epoch 9/10
1146/1146 2s 2ms/step - accuracy: 0.8587 - loss: 0.3815 - val_accuracy: 0.8580 - val_loss: 0.4228
Epoch 10/10
1146/1146 2s 1ms/step - accuracy: 0.8658 - loss: 0.3644 - val_accuracy: 0.8626 - val_loss: 0.4152
573/573 1s 1ms/step
```

```
/usr/local/lib/python3.10/dist-packages/scikeras/wrappers.py:925: UserWarning: ``build_fn`` will be renamed to ``model`` in a future release, at which point use of ``build_fn`` will raise an Error instead.
```

```
    X, y = self._initialize(X, y)
```

```
/usr/local/lib/python3.10/dist-packages/keras/src/layers/reshaping/flatten.py:37: UserWarning: Do not pass an `input_shape`/`input_dim` argument to a layer. When using Sequential models, prefer using an `Input(shape)` object as the first layer in the model instead.
```

```
    super().__init__(**kwargs)
```

```
Epoch 1/10
1146/1146 4s 3ms/step - accuracy: 0.7364 - loss: 0.7540 - val_accuracy: 0.8492 - val_loss: 0.4427
Epoch 2/10
1146/1146 2s 1ms/step - accuracy: 0.8347 - loss: 0.4602 - val_accuracy: 0.8494 - val_loss: 0.4378
Epoch 3/10
1146/1146 2s 1ms/step - accuracy: 0.8467 - loss: 0.4305 - val_accuracy: 0.8530 - val_loss: 0.4217
Epoch 4/10
1146/1146 2s 1ms/step - accuracy: 0.8502 - loss: 0.4215 - val_accuracy: 0.8540 - val_loss: 0.4413
Epoch 5/10
1146/1146 2s 1ms/step - accuracy: 0.8559 - loss: 0.3924 - val_accuracy: 0.8598 - val_loss: 0.3916
Epoch 6/10
1146/1146 2s 1ms/step - accuracy: 0.8536 - loss: 0.4108 - val_accuracy: 0.8448 - val_loss: 0.4506
Epoch 7/10
1146/1146 2s 1ms/step - accuracy: 0.8604 - loss: 0.3857 - val_accuracy: 0.8656 - val_loss: 0.4007
Epoch 8/10
1146/1146 2s 1ms/step - accuracy: 0.8684 - loss: 0.3697 - val_accuracy: 0.8710 - val_loss: 0.3808
Epoch 9/10
1146/1146 2s 1ms/step - accuracy: 0.8663 - loss: 0.3689 - val_accuracy: 0.8640 - val_loss: 0.3831
Epoch 10/10
1146/1146 2s 1ms/step - accuracy: 0.8674 - loss: 0.3692 - val_accuracy: 0.8562 - val_loss: 0.4311
573/573 1s 1ms/step
```

```
/usr/local/lib/python3.10/dist-packages/scikeras/wrappers.py:925: UserWarning: ``build_fn`` will be renamed to ``model`` in a future release, at which point use of ``build_fn`` will raise an Error instead.
```

```
    X, y = self._initialize(X, y)
```

```
/usr/local/lib/python3.10/dist-packages/keras/src/layers/reshaping/flatten.py:37: UserWarning: Do not pass an `input_shape`/`input_dim` argument to a layer. When using Sequential models, prefer using an `Input(shape)` object as the first layer in the model instead.
```

```
    super().__init__(**kwargs)
```

```
Epoch 1/10
1146/1146 5s 3ms/step - accuracy: 0.7294 - loss: 0.8369 - val_accuracy: 0.8352 - val_loss: 0.4597
Epoch 2/10
1146/1146 2s 1ms/step - accuracy: 0.8357 - loss: 0.4668 - val_accuracy: 0.8486 - val_loss: 0.4358
Epoch 3/10
1146/1146 2s 1ms/step - accuracy: 0.8468 - loss: 0.4326 - val_accuracy: 0.8562 - val_loss: 0.4177
Epoch 4/10
1146/1146 2s 1ms/step - accuracy: 0.8482 - loss: 0.4319 - val_accuracy: 0.8672 - val_loss: 0.3945
Epoch 5/10
1146/1146 2s 1ms/step - accuracy: 0.8585 - loss: 0.4010 - val_accuracy: 0.8582 - val_loss: 0.4131
Epoch 6/10
1146/1146 2s 1ms/step - accuracy: 0.8579 - loss: 0.3941 - val_accuracy: 0.8570 - val_loss: 0.4461
Epoch 7/10
1146/1146 2s 1ms/step - accuracy: 0.8606 - loss: 0.3957 - val_accuracy: 0.8530 - val_loss: 0.4386
Epoch 8/10
1146/1146 2s 1ms/step - accuracy: 0.8643 - loss: 0.3833 - val_accuracy: 0.8678 - val_loss: 0.4024
Epoch 9/10
1146/1146 2s 1ms/step - accuracy: 0.8647 - loss: 0.3842 - val_accuracy: 0.8442 - val_loss: 0.4483
Epoch 10/10
1146/1146 2s 1ms/step - accuracy: 0.8658 - loss: 0.3806 - val_accuracy: 0.8620 - val_loss: 0.4170
573/573 1s 1ms/step
```

```
/usr/local/lib/python3.10/dist-packages/scikeras/wrappers.py:925: UserWarning: ``build_fn`` will be renamed to ``model`` in a future release, at which point use of ``build_fn`` will raise an Error instead.
```

```
    X, y = self._initialize(X, y)
```

```
/usr/local/lib/python3.10/dist-packages/keras/src/layers/reshaping/flatten.py:37: UserWarning: Do not pass an `input_shape`/`input_dim` argument to a layer. When using Sequential models, prefer using an `Input(shape)` object as the first layer in the model instead.
```

```
    super().__init__(**kwargs)
```

```
Epoch 1/10
1146/1146 4s 3ms/step - accuracy: 0.7373 - loss: 0.7809 - val_accuracy: 0.8288 - val_loss: 0.4674
Epoch 2/10
1146/1146 2s 1ms/step - accuracy: 0.8304 - loss: 0.4673 - val_accuracy: 0.8502 - val_loss: 0.4241
Epoch 3/10
1146/1146 2s 1ms/step - accuracy: 0.8427 - loss: 0.4347 - val_accuracy: 0.8516 - val_loss: 0.4467
Epoch 4/10
1146/1146 2s 1ms/step - accuracy: 0.8514 - loss: 0.4078 - val_accuracy: 0.8536 - val_loss: 0.4208
Epoch 5/10
1146/1146 2s 1ms/step - accuracy: 0.8523 - loss: 0.4043 - val_accuracy: 0.8540 - val_loss: 0.4152
Epoch 6/10
1146/1146 2s 1ms/step - accuracy: 0.8604 - loss: 0.3835 - val_accuracy: 0.8630 - val_loss: 0.4163
Epoch 7/10
1146/1146 2s 1ms/step - accuracy: 0.8580 - loss: 0.3901 - val_accuracy: 0.8600 - val_loss: 0.4007
Epoch 8/10
1146/1146 2s 1ms/step - accuracy: 0.8591 - loss: 0.3834 - val_accuracy: 0.8638 - val_loss: 0.4217
Epoch 9/10
1146/1146 2s 1ms/step - accuracy: 0.8622 - loss: 0.3747 - val_accuracy: 0.8654 - val_loss: 0.3855
Epoch 10/10
1146/1146 2s 1ms/step - accuracy: 0.8688 - loss: 0.3561 - val_accuracy: 0.8520 - val_loss: 0.4507
573/573 1s 1ms/step
```

```
/usr/local/lib/python3.10/dist-packages/scikeras/wrappers.py:925: UserWarning: ``build_fn`` will be renamed to ``model`` in a future release, at which point use of ``build_fn`` will raise an Error instead.
```

```
    X, y = self._initialize(X, y)
```

```
/usr/local/lib/python3.10/dist-packages/keras/src/layers/reshaping/flatten.py:37: UserWarning: Do not pass an `input_shape`/`input_dim` argument to a layer. When using Sequential models, prefer using an `Input(shape)` object as the first layer in the model instead.
```

```
    super().__init__(**kwargs)
```

```
Epoch 1/10
1146/1146 4s 3ms/step - accuracy: 0.7344 - loss: 0.7883 - val_accuracy: 0.8362 - val_loss: 0.4643
Epoch 2/10
1146/1146 2s 1ms/step - accuracy: 0.8313 - loss: 0.4718 - val_accuracy: 0.8272 - val_loss: 0.4662
Epoch 3/10
1146/1146 2s 2ms/step - accuracy: 0.8415 - loss: 0.4439 - val_accuracy: 0.8414 - val_loss: 0.4809
Epoch 4/10
1146/1146 2s 1ms/step - accuracy: 0.8457 - loss: 0.4280 - val_accuracy: 0.8580 - val_loss: 0.4201
Epoch 5/10
1146/1146 2s 1ms/step - accuracy: 0.8585 - loss: 0.3980 - val_accuracy: 0.8622 - val_loss: 0.4078
Epoch 6/10
1146/1146 2s 1ms/step - accuracy: 0.8652 - loss: 0.3856 - val_accuracy: 0.8530 - val_loss: 0.4409
Epoch 7/10
1146/1146 2s 1ms/step - accuracy: 0.8672 - loss: 0.3848 - val_accuracy: 0.8544 - val_loss: 0.4265
Epoch 8/10
1146/1146 2s 1ms/step - accuracy: 0.8628 - loss: 0.3887 - val_accuracy: 0.8550 - val_loss: 0.4594
Epoch 9/10
1146/1146 2s 1ms/step - accuracy: 0.8696 - loss: 0.3651 - val_accuracy: 0.8502 - val_loss: 0.4202
Epoch 10/10
1146/1146 2s 1ms/step - accuracy: 0.8668 - loss: 0.3652 - val_accuracy: 0.8602 - val_loss: 0.4104
573/573 1s 1ms/step
```

```
/usr/local/lib/python3.10/dist-packages/scikeras/wrappers.py:925: UserWarning: ``build_fn`` will be renamed to ``model`` in a future release, at which point use of ``build_fn`` will raise an Error instead.
```

```
    X, y = self._initialize(X, y)
```

```
/usr/local/lib/python3.10/dist-packages/keras/src/layers/reshaping/flatten.py:37: UserWarning: Do not pass an `input_shape`/`input_dim` argument to a layer. When using Sequential models, prefer using an `Input(shape)` object as the first layer in the model instead.
```

```
    super().__init__(**kwargs)
```

```
Epoch 1/10
1146/1146 5s 3ms/step - accuracy: 0.7355 - loss: 0.7864 - val_accuracy: 0.8438 - val_loss: 0.4346
Epoch 2/10
1146/1146 2s 1ms/step - accuracy: 0.8340 - loss: 0.4667 - val_accuracy: 0.8456 - val_loss: 0.4490
Epoch 3/10
1146/1146 2s 2ms/step - accuracy: 0.8492 - loss: 0.4296 - val_accuracy: 0.8578 - val_loss: 0.4303
Epoch 4/10
1146/1146 2s 1ms/step - accuracy: 0.8549 - loss: 0.4145 - val_accuracy: 0.8522 - val_loss: 0.4339
Epoch 5/10
1146/1146 2s 1ms/step - accuracy: 0.8570 - loss: 0.4019 - val_accuracy: 0.8596 - val_loss: 0.4230
Epoch 6/10
1146/1146 2s 1ms/step - accuracy: 0.8600 - loss: 0.3977 - val_accuracy: 0.8392 - val_loss: 0.4722
Epoch 7/10
1146/1146 2s 1ms/step - accuracy: 0.8621 - loss: 0.3911 - val_accuracy: 0.8662 - val_loss: 0.4231
Epoch 8/10
1146/1146 2s 1ms/step - accuracy: 0.8649 - loss: 0.3760 - val_accuracy: 0.8468 - val_loss: 0.4561
Epoch 9/10
1146/1146 2s 1ms/step - accuracy: 0.8692 - loss: 0.3755 - val_accuracy: 0.8626 - val_loss: 0.4437
Epoch 10/10
1146/1146 2s 1ms/step - accuracy: 0.8676 - loss: 0.3735 - val_accuracy: 0.8674 - val_loss: 0.4122
573/573 1s 1ms/step
```

```
/usr/local/lib/python3.10/dist-packages/scikeras/wrappers.py:925: UserWarning: ``build_fn`` will be renamed to ``model`` in a future release, at which point use of ``build_fn`` will raise an Error instead.
```

```
    X, y = self._initialize(X, y)
```

```
/usr/local/lib/python3.10/dist-packages/keras/src/layers/reshaping/flatten.py:37: UserWarning: Do not pass an `input_shape`/`input_dim` argument to a layer. When using Sequential models, prefer using an `Input(shape)` object as the first layer in the model instead.
```

```
    super().__init__(**kwargs)
```

```
Epoch 1/10
1146/1146 4s 3ms/step - accuracy: 0.7295 - loss: 0.7931 - val_accuracy: 0.8222 - val_loss: 0.4931
Epoch 2/10
1146/1146 2s 1ms/step - accuracy: 0.8342 - loss: 0.4588 - val_accuracy: 0.8442 - val_loss: 0.4423
Epoch 3/10
1146/1146 2s 1ms/step - accuracy: 0.8400 - loss: 0.4441 - val_accuracy: 0.8580 - val_loss: 0.4228
Epoch 4/10
1146/1146 2s 1ms/step - accuracy: 0.8496 - loss: 0.4127 - val_accuracy: 0.8594 - val_loss: 0.3985
Epoch 5/10
1146/1146 2s 1ms/step - accuracy: 0.8581 - loss: 0.3879 - val_accuracy: 0.8566 - val_loss: 0.4064
Epoch 6/10
1146/1146 2s 1ms/step - accuracy: 0.8554 - loss: 0.3980 - val_accuracy: 0.8610 - val_loss: 0.3883
Epoch 7/10
1146/1146 2s 1ms/step - accuracy: 0.8623 - loss: 0.3790 - val_accuracy: 0.8636 - val_loss: 0.3983
Epoch 8/10
1146/1146 2s 1ms/step - accuracy: 0.8597 - loss: 0.3873 - val_accuracy: 0.8632 - val_loss: 0.4089
Epoch 9/10
1146/1146 2s 1ms/step - accuracy: 0.8608 - loss: 0.3769 - val_accuracy: 0.8556 - val_loss: 0.4260
Epoch 10/10
1146/1146 2s 2ms/step - accuracy: 0.8620 - loss: 0.3733 - val_accuracy: 0.8688 - val_loss: 0.4014
573/573 1s 1ms/step
```

```
/usr/local/lib/python3.10/dist-packages/scikeras/wrappers.py:925: UserWarning: ``build_fn`` will be renamed to ``model`` in a future release, at which point use of ``build_fn`` will raise an Error instead.
```

```
    X, y = self._initialize(X, y)
```

```
/usr/local/lib/python3.10/dist-packages/keras/src/layers/reshaping/flatten.py:37: UserWarning: Do not pass an `input_shape`/`input_dim` argument to a layer. When using Sequential models, prefer using an `Input(shape)` object as the first layer in the model instead.
```

```
    super().__init__(**kwargs)
```

```
Epoch 1/10
1146/1146 4s 3ms/step - accuracy: 0.7318 - loss: 0.7825 - val_accuracy: 0.8504 - val_loss: 0.4290
Epoch 2/10
1146/1146 2s 1ms/step - accuracy: 0.8323 - loss: 0.4646 - val_accuracy: 0.8344 - val_loss: 0.4634
Epoch 3/10
1146/1146 2s 1ms/step - accuracy: 0.8393 - loss: 0.4379 - val_accuracy: 0.8534 - val_loss: 0.4208
Epoch 4/10
1146/1146 2s 1ms/step - accuracy: 0.8517 - loss: 0.4097 - val_accuracy: 0.8528 - val_loss: 0.4361
Epoch 5/10
1146/1146 2s 1ms/step - accuracy: 0.8535 - loss: 0.4021 - val_accuracy: 0.8576 - val_loss: 0.4077
Epoch 6/10
1146/1146 2s 1ms/step - accuracy: 0.8601 - loss: 0.3966 - val_accuracy: 0.8518 - val_loss: 0.4524
Epoch 7/10
1146/1146 2s 1ms/step - accuracy: 0.8622 - loss: 0.3880 - val_accuracy: 0.8582 - val_loss: 0.4147
Epoch 8/10
1146/1146 2s 1ms/step - accuracy: 0.8637 - loss: 0.3791 - val_accuracy: 0.8622 - val_loss: 0.4222
Epoch 9/10
1146/1146 2s 1ms/step - accuracy: 0.8668 - loss: 0.3688 - val_accuracy: 0.8640 - val_loss: 0.3975
Epoch 10/10
1146/1146 2s 2ms/step - accuracy: 0.8732 - loss: 0.3523 - val_accuracy: 0.8538 - val_loss: 0.4297
573/573 1s 1ms/step
```

```
/usr/local/lib/python3.10/dist-packages/scikeras/wrappers.py:925: UserWarning: ``build_fn`` will be renamed to ``model`` in a future release, at which point use of ``build_fn`` will raise an Error instead.
```

```
    X, y = self._initialize(X, y)
```

```
/usr/local/lib/python3.10/dist-packages/keras/src/layers/reshaping/flatten.py:37: UserWarning: Do not pass an `input_shape`/`input_dim` argument to a layer. When using Sequential models, prefer using an `Input(shape)` object as the first layer in the model instead.
```

```
    super().__init__(**kwargs)
```

```
Epoch 1/10
1146/1146 5s 3ms/step - accuracy: 0.7443 - loss: 0.7679 - val_accuracy: 0.8466 - val_loss: 0.4391
Epoch 2/10
1146/1146 2s 1ms/step - accuracy: 0.8286 - loss: 0.4774 - val_accuracy: 0.8372 - val_loss: 0.4743
Epoch 3/10
1146/1146 2s 1ms/step - accuracy: 0.8475 - loss: 0.4355 - val_accuracy: 0.8450 - val_loss: 0.4384
Epoch 4/10
1146/1146 2s 1ms/step - accuracy: 0.8556 - loss: 0.4151 - val_accuracy: 0.8608 - val_loss: 0.4194
Epoch 5/10
1146/1146 2s 1ms/step - accuracy: 0.8609 - loss: 0.3931 - val_accuracy: 0.8522 - val_loss: 0.4210
Epoch 6/10
1146/1146 2s 1ms/step - accuracy: 0.8620 - loss: 0.3889 - val_accuracy: 0.8640 - val_loss: 0.4065
Epoch 7/10
1146/1146 2s 1ms/step - accuracy: 0.8623 - loss: 0.3823 - val_accuracy: 0.8606 - val_loss: 0.4412
Epoch 8/10
1146/1146 2s 1ms/step - accuracy: 0.8676 - loss: 0.3705 - val_accuracy: 0.8522 - val_loss: 0.4200
Epoch 9/10
1146/1146 2s 1ms/step - accuracy: 0.8712 - loss: 0.3653 - val_accuracy: 0.8672 - val_loss: 0.4090
Epoch 10/10
1146/1146 2s 2ms/step - accuracy: 0.8733 - loss: 0.3638 - val_accuracy: 0.8596 - val_loss: 0.4297
573/573 1s 1ms/step
```

```
/usr/local/lib/python3.10/dist-packages/scikeras/wrappers.py:925: UserWarning: ``build_fn`` will be renamed to ``model`` in a future release, at which point use of ``build_fn`` will raise an Error instead.
```

```
    X, y = self._initialize(X, y)
```

```
/usr/local/lib/python3.10/dist-packages/keras/src/layers/reshaping/flatten.py:37: UserWarning: Do not pass an `input_shape`/`input_dim` argument to a layer. When using Sequential models, prefer using an `Input(shape)` object as the first layer in the model instead.
```

```
    super().__init__(**kwargs)
```

```
Epoch 1/10
1146/1146 5s 3ms/step - accuracy: 0.7427 - loss: 0.7460 - val_accuracy: 0.8360 - val_loss: 0.4510
Epoch 2/10
1146/1146 2s 1ms/step - accuracy: 0.8271 - loss: 0.4841 - val_accuracy: 0.8532 - val_loss: 0.4215
Epoch 3/10
1146/1146 2s 1ms/step - accuracy: 0.8451 - loss: 0.4331 - val_accuracy: 0.8404 - val_loss: 0.4516
Epoch 4/10
1146/1146 2s 1ms/step - accuracy: 0.8492 - loss: 0.4197 - val_accuracy: 0.8594 - val_loss: 0.4259
Epoch 5/10
1146/1146 2s 1ms/step - accuracy: 0.8510 - loss: 0.4109 - val_accuracy: 0.8494 - val_loss: 0.4412
Epoch 6/10
1146/1146 2s 1ms/step - accuracy: 0.8522 - loss: 0.4061 - val_accuracy: 0.8550 - val_loss: 0.4310
Epoch 7/10
1146/1146 2s 1ms/step - accuracy: 0.8594 - loss: 0.3902 - val_accuracy: 0.8468 - val_loss: 0.4582
Epoch 8/10
1146/1146 2s 1ms/step - accuracy: 0.8666 - loss: 0.3695 - val_accuracy: 0.8544 - val_loss: 0.4227
Epoch 9/10
1146/1146 2s 1ms/step - accuracy: 0.8637 - loss: 0.3780 - val_accuracy: 0.8590 - val_loss: 0.4153
Epoch 10/10
1146/1146 2s 1ms/step - accuracy: 0.8711 - loss: 0.3608 - val_accuracy: 0.8644 - val_loss: 0.3933
573/573 1s 1ms/step
```

```
/usr/local/lib/python3.10/dist-packages/scikeras/wrappers.py:925: UserWarning: ``build_fn`` will be renamed to ``model`` in a future release, at which point use of ``build_fn`` will raise an Error instead.
```

```
    X, y = self._initialize(X, y)
```

```
/usr/local/lib/python3.10/dist-packages/keras/src/layers/reshaping/flatten.py:37: UserWarning: Do not pass an `input_shape`/`input_dim` argument to a layer. When using Sequential models, prefer using an `Input(shape)` object as the first layer in the model instead.
```

```
    super().__init__(**kwargs)
```

```
Epoch 1/10
1146/1146 5s 3ms/step - accuracy: 0.7414 - loss: 0.7663 - val_accuracy: 0.8260 - val_loss: 0.4894
Epoch 2/10
1146/1146 2s 2ms/step - accuracy: 0.8383 - loss: 0.4558 - val_accuracy: 0.8504 - val_loss: 0.4560
Epoch 3/10
1146/1146 2s 1ms/step - accuracy: 0.8414 - loss: 0.4483 - val_accuracy: 0.8526 - val_loss: 0.4163
Epoch 4/10
1146/1146 2s 1ms/step - accuracy: 0.8519 - loss: 0.4074 - val_accuracy: 0.8610 - val_loss: 0.4140
Epoch 5/10
1146/1146 2s 1ms/step - accuracy: 0.8504 - loss: 0.4123 - val_accuracy: 0.8448 - val_loss: 0.4166
Epoch 6/10
1146/1146 2s 1ms/step - accuracy: 0.8560 - loss: 0.4013 - val_accuracy: 0.8596 - val_loss: 0.4262
Epoch 7/10
1146/1146 2s 1ms/step - accuracy: 0.8643 - loss: 0.3839 - val_accuracy: 0.8510 - val_loss: 0.4271
Epoch 8/10
1146/1146 2s 1ms/step - accuracy: 0.8611 - loss: 0.3866 - val_accuracy: 0.8482 - val_loss: 0.4419
Epoch 9/10
1146/1146 2s 2ms/step - accuracy: 0.8681 - loss: 0.3726 - val_accuracy: 0.8596 - val_loss: 0.4137
Epoch 10/10
1146/1146 2s 1ms/step - accuracy: 0.8666 - loss: 0.3710 - val_accuracy: 0.8600 - val_loss: 0.4564
573/573 1s 1ms/step
```

```
/usr/local/lib/python3.10/dist-packages/scikeras/wrappers.py:925: UserWarning: ``build_fn`` will be renamed to ``model`` in a future release, at which point use of ``build_fn`` will raise an Error instead.
```

```
    X, y = self._initialize(X, y)
```

```
/usr/local/lib/python3.10/dist-packages/keras/src/layers/reshaping/flatten.py:37: UserWarning: Do not pass an `input_shape`/`input_dim` argument to a layer. When using Sequential models, prefer using an `Input(shape)` object as the first layer in the model instead.
```

```
    super().__init__(**kwargs)
```

```
Epoch 1/10
1146/1146 5s 3ms/step - accuracy: 0.7336 - loss: 0.7940 - val_accuracy: 0.8350 - val_loss: 0.4694
Epoch 2/10
1146/1146 2s 1ms/step - accuracy: 0.8370 - loss: 0.4599 - val_accuracy: 0.8434 - val_loss: 0.4574
Epoch 3/10
1146/1146 2s 1ms/step - accuracy: 0.8415 - loss: 0.4422 - val_accuracy: 0.8416 - val_loss: 0.4375
Epoch 4/10
1146/1146 2s 1ms/step - accuracy: 0.8515 - loss: 0.4151 - val_accuracy: 0.8560 - val_loss: 0.4426
Epoch 5/10
1146/1146 2s 1ms/step - accuracy: 0.8569 - loss: 0.4023 - val_accuracy: 0.8432 - val_loss: 0.4437
Epoch 6/10
1146/1146 2s 1ms/step - accuracy: 0.8619 - loss: 0.3887 - val_accuracy: 0.8542 - val_loss: 0.4187
Epoch 7/10
1146/1146 2s 1ms/step - accuracy: 0.8626 - loss: 0.3820 - val_accuracy: 0.8688 - val_loss: 0.4075
Epoch 8/10
1146/1146 2s 1ms/step - accuracy: 0.8651 - loss: 0.3823 - val_accuracy: 0.8708 - val_loss: 0.3951
Epoch 9/10
1146/1146 2s 1ms/step - accuracy: 0.8706 - loss: 0.3675 - val_accuracy: 0.8636 - val_loss: 0.4219
Epoch 10/10
1146/1146 2s 1ms/step - accuracy: 0.8726 - loss: 0.3692 - val_accuracy: 0.8566 - val_loss: 0.4607
573/573 1s 1ms/step
```

```
/usr/local/lib/python3.10/dist-packages/scikeras/wrappers.py:925: UserWarning: ``build_fn`` will be renamed to ``model`` in a future release, at which point use of ``build_fn`` will raise an Error instead.
```

```
    X, y = self._initialize(X, y)
```

```
/usr/local/lib/python3.10/dist-packages/keras/src/layers/reshaping/flatten.py:37: UserWarning: Do not pass an `input_shape`/`input_dim` argument to a layer. When using Sequential models, prefer using an `Input(shape)` object as the first layer in the model instead.
```

```
    super().__init__(**kwargs)
```

```
Epoch 1/10
1146/1146 5s 3ms/step - accuracy: 0.7289 - loss: 0.8022 - val_accuracy: 0.7940 - val_loss: 0.5781
Epoch 2/10
1146/1146 2s 1ms/step - accuracy: 0.8351 - loss: 0.4606 - val_accuracy: 0.8120 - val_loss: 0.5335
Epoch 3/10
1146/1146 2s 1ms/step - accuracy: 0.8472 - loss: 0.4228 - val_accuracy: 0.8580 - val_loss: 0.4128
Epoch 4/10
1146/1146 2s 1ms/step - accuracy: 0.8505 - loss: 0.4134 - val_accuracy: 0.8298 - val_loss: 0.4750
Epoch 5/10
1146/1146 2s 1ms/step - accuracy: 0.8517 - loss: 0.4047 - val_accuracy: 0.8604 - val_loss: 0.4235
Epoch 6/10
1146/1146 2s 1ms/step - accuracy: 0.8643 - loss: 0.3758 - val_accuracy: 0.8704 - val_loss: 0.3873
Epoch 7/10
1146/1146 2s 1ms/step - accuracy: 0.8681 - loss: 0.3674 - val_accuracy: 0.8350 - val_loss: 0.4651
Epoch 8/10
1146/1146 2s 1ms/step - accuracy: 0.8698 - loss: 0.3686 - val_accuracy: 0.8638 - val_loss: 0.4228
Epoch 9/10
1146/1146 2s 1ms/step - accuracy: 0.8685 - loss: 0.3719 - val_accuracy: 0.8616 - val_loss: 0.4446
Epoch 10/10
1146/1146 2s 1ms/step - accuracy: 0.8689 - loss: 0.3647 - val_accuracy: 0.8754 - val_loss: 0.3958
573/573 1s 1ms/step
```

```
/usr/local/lib/python3.10/dist-packages/scikeras/wrappers.py:925: UserWarning: ``build_fn`` will be renamed to ``model`` in a future release, at which point use of ``build_fn`` will raise an Error instead.
```

```
    X, y = self._initialize(X, y)
```

```
/usr/local/lib/python3.10/dist-packages/keras/src/layers/reshaping/flatten.py:37: UserWarning: Do not pass an `input_shape`/`input_dim` argument to a layer. When using Sequential models, prefer using an `Input(shape)` object as the first layer in the model instead.
```

```
    super().__init__(**kwargs)
```

```
Epoch 1/10
1146/1146 4s 3ms/step - accuracy: 0.7304 - loss: 0.8100 - val_accuracy: 0.8122 - val_loss: 0.5064
Epoch 2/10
1146/1146 2s 1ms/step - accuracy: 0.8330 - loss: 0.4623 - val_accuracy: 0.8498 - val_loss: 0.4137
Epoch 3/10
1146/1146 2s 1ms/step - accuracy: 0.8381 - loss: 0.4434 - val_accuracy: 0.8498 - val_loss: 0.4317
Epoch 4/10
1146/1146 2s 1ms/step - accuracy: 0.8518 - loss: 0.4118 - val_accuracy: 0.8508 - val_loss: 0.4562
Epoch 5/10
1146/1146 2s 1ms/step - accuracy: 0.8518 - loss: 0.4132 - val_accuracy: 0.8334 - val_loss: 0.4940
Epoch 6/10
1146/1146 2s 1ms/step - accuracy: 0.8591 - loss: 0.3966 - val_accuracy: 0.8608 - val_loss: 0.4062
Epoch 7/10
1146/1146 2s 1ms/step - accuracy: 0.8631 - loss: 0.3817 - val_accuracy: 0.8566 - val_loss: 0.4089
Epoch 8/10
1146/1146 2s 1ms/step - accuracy: 0.8671 - loss: 0.3734 - val_accuracy: 0.8564 - val_loss: 0.4181
Epoch 9/10
1146/1146 2s 1ms/step - accuracy: 0.8626 - loss: 0.3737 - val_accuracy: 0.8636 - val_loss: 0.3976
Epoch 10/10
1146/1146 2s 1ms/step - accuracy: 0.8671 - loss: 0.3686 - val_accuracy: 0.8658 - val_loss: 0.3877
573/573 1s 1ms/step
```

```
/usr/local/lib/python3.10/dist-packages/scikeras/wrappers.py:925: UserWarning: ``build_fn`` will be renamed to ``model`` in a future release, at which point use of ``build_fn`` will raise an Error instead.
```

```
    X, y = self._initialize(X, y)
```

```
/usr/local/lib/python3.10/dist-packages/keras/src/layers/reshaping/flatten.py:37: UserWarning: Do not pass an `input_shape`/`input_dim` argument to a layer. When using Sequential models, prefer using an `Input(shape)` object as the first layer in the model instead.
```

```
    super().__init__(**kwargs)
```

```
Epoch 1/10
1146/1146 5s 3ms/step - accuracy: 0.7401 - loss: 0.7904 - val_accuracy: 0.8406 - val_loss: 0.4630
Epoch 2/10
1146/1146 2s 1ms/step - accuracy: 0.8374 - loss: 0.4529 - val_accuracy: 0.8520 - val_loss: 0.4480
Epoch 3/10
1146/1146 2s 1ms/step - accuracy: 0.8508 - loss: 0.4279 - val_accuracy: 0.8394 - val_loss: 0.4316
Epoch 4/10
1146/1146 2s 1ms/step - accuracy: 0.8507 - loss: 0.4261 - val_accuracy: 0.8598 - val_loss: 0.4316
Epoch 5/10
1146/1146 2s 1ms/step - accuracy: 0.8557 - loss: 0.4020 - val_accuracy: 0.8602 - val_loss: 0.4235
Epoch 6/10
1146/1146 2s 1ms/step - accuracy: 0.8594 - loss: 0.4014 - val_accuracy: 0.8576 - val_loss: 0.4095
Epoch 7/10
1146/1146 2s 1ms/step - accuracy: 0.8634 - loss: 0.3900 - val_accuracy: 0.8592 - val_loss: 0.4469
Epoch 8/10
1146/1146 2s 1ms/step - accuracy: 0.8671 - loss: 0.3772 - val_accuracy: 0.8476 - val_loss: 0.4758
Epoch 9/10
1146/1146 2s 2ms/step - accuracy: 0.8661 - loss: 0.3788 - val_accuracy: 0.8666 - val_loss: 0.4289
Epoch 10/10
1146/1146 2s 1ms/step - accuracy: 0.8660 - loss: 0.3755 - val_accuracy: 0.8618 - val_loss: 0.4264
573/573 1s 1ms/step
```

```
/usr/local/lib/python3.10/dist-packages/scikeras/wrappers.py:925: UserWarning: ``build_fn`` will be renamed to ``model`` in a future release, at which point use of ``build_fn`` will raise an Error instead.
```

```
    X, y = self._initialize(X, y)
```

```
/usr/local/lib/python3.10/dist-packages/keras/src/layers/reshaping/flatten.py:37: UserWarning: Do not pass an `input_shape`/`input_dim` argument to a layer. When using Sequential models, prefer using an `Input(shape)` object as the first layer in the model instead.
```

```
    super().__init__(**kwargs)
```

```
Epoch 1/10
1146/1146 5s 3ms/step - accuracy: 0.7318 - loss: 0.7602 - val_accuracy: 0.8314 - val_loss: 0.4553
Epoch 2/10
1146/1146 2s 1ms/step - accuracy: 0.8288 - loss: 0.4738 - val_accuracy: 0.8406 - val_loss: 0.4510
Epoch 3/10
1146/1146 2s 1ms/step - accuracy: 0.8424 - loss: 0.4484 - val_accuracy: 0.8616 - val_loss: 0.4175
Epoch 4/10
1146/1146 2s 1ms/step - accuracy: 0.8522 - loss: 0.4148 - val_accuracy: 0.8338 - val_loss: 0.4805
Epoch 5/10
1146/1146 2s 1ms/step - accuracy: 0.8581 - loss: 0.4019 - val_accuracy: 0.8444 - val_loss: 0.4717
Epoch 6/10
1146/1146 2s 1ms/step - accuracy: 0.8562 - loss: 0.3972 - val_accuracy: 0.8658 - val_loss: 0.4199
Epoch 7/10
1146/1146 2s 1ms/step - accuracy: 0.8561 - loss: 0.3994 - val_accuracy: 0.8502 - val_loss: 0.4449
Epoch 8/10
1146/1146 2s 1ms/step - accuracy: 0.8641 - loss: 0.3821 - val_accuracy: 0.8664 - val_loss: 0.4074
Epoch 9/10
1146/1146 2s 1ms/step - accuracy: 0.8749 - loss: 0.3582 - val_accuracy: 0.8608 - val_loss: 0.3923
Epoch 10/10
1146/1146 2s 1ms/step - accuracy: 0.8684 - loss: 0.3676 - val_accuracy: 0.8510 - val_loss: 0.4755
573/573 1s 1ms/step
```

```
/usr/local/lib/python3.10/dist-packages/scikeras/wrappers.py:925: UserWarning: ``build_fn`` will be renamed to ``model`` in a future release, at which point use of ``build_fn`` will raise an Error instead.
```

```
    X, y = self._initialize(X, y)
```

```
/usr/local/lib/python3.10/dist-packages/keras/src/layers/reshaping/flatten.py:37: UserWarning: Do not pass an `input_shape`/`input_dim` argument to a layer. When using Sequential models, prefer using an `Input(shape)` object as the first layer in the model instead.
```

```
    super().__init__(**kwargs)
```

```
Epoch 1/10
1146/1146 5s 3ms/step - accuracy: 0.7327 - loss: 0.7509 - val_accuracy: 0.8392 - val_loss: 0.4477
Epoch 2/10
1146/1146 2s 1ms/step - accuracy: 0.8361 - loss: 0.4613 - val_accuracy: 0.8374 - val_loss: 0.4570
Epoch 3/10
1146/1146 2s 1ms/step - accuracy: 0.8451 - loss: 0.4331 - val_accuracy: 0.8448 - val_loss: 0.4389
Epoch 4/10
1146/1146 2s 1ms/step - accuracy: 0.8503 - loss: 0.4106 - val_accuracy: 0.8538 - val_loss: 0.4427
Epoch 5/10
1146/1146 2s 1ms/step - accuracy: 0.8543 - loss: 0.3996 - val_accuracy: 0.8408 - val_loss: 0.4426
Epoch 6/10
1146/1146 2s 1ms/step - accuracy: 0.8549 - loss: 0.3967 - val_accuracy: 0.8626 - val_loss: 0.4149
Epoch 7/10
1146/1146 2s 1ms/step - accuracy: 0.8646 - loss: 0.3676 - val_accuracy: 0.8674 - val_loss: 0.4067
Epoch 8/10
1146/1146 2s 1ms/step - accuracy: 0.8627 - loss: 0.3808 - val_accuracy: 0.8632 - val_loss: 0.4157
Epoch 9/10
1146/1146 2s 1ms/step - accuracy: 0.8679 - loss: 0.3619 - val_accuracy: 0.8626 - val_loss: 0.4238
Epoch 10/10
1146/1146 2s 1ms/step - accuracy: 0.8738 - loss: 0.3523 - val_accuracy: 0.8646 - val_loss: 0.3888
573/573 1s 1ms/step
```

```
/usr/local/lib/python3.10/dist-packages/scikeras/wrappers.py:925: UserWarning: ``build_fn`` will be renamed to ``model`` in a future release, at which point use of ``build_fn`` will raise an Error instead.
```

```
    X, y = self._initialize(X, y)
```

```
/usr/local/lib/python3.10/dist-packages/keras/src/layers/reshaping/flatten.py:37: UserWarning: Do not pass an `input_shape`/`input_dim` argument to a layer. When using Sequential models, prefer using an `Input(shape)` object as the first layer in the model instead.
```

```
    super().__init__(**kwargs)
```

```
Epoch 1/10
1146/1146 5s 3ms/step - accuracy: 0.7296 - loss: 0.8211 - val_accuracy: 0.8454 - val_loss: 0.4637
Epoch 2/10
1146/1146 2s 1ms/step - accuracy: 0.8375 - loss: 0.4552 - val_accuracy: 0.8444 - val_loss: 0.4421
Epoch 3/10
1146/1146 2s 1ms/step - accuracy: 0.8485 - loss: 0.4315 - val_accuracy: 0.8346 - val_loss: 0.4938
Epoch 4/10
1146/1146 2s 1ms/step - accuracy: 0.8475 - loss: 0.4292 - val_accuracy: 0.8420 - val_loss: 0.4635
Epoch 5/10
1146/1146 2s 1ms/step - accuracy: 0.8558 - loss: 0.4141 - val_accuracy: 0.8578 - val_loss: 0.4174
Epoch 6/10
1146/1146 2s 1ms/step - accuracy: 0.8596 - loss: 0.4022 - val_accuracy: 0.8350 - val_loss: 0.4678
Epoch 7/10
1146/1146 2s 1ms/step - accuracy: 0.8646 - loss: 0.3844 - val_accuracy: 0.8618 - val_loss: 0.4121
Epoch 8/10
1146/1146 2s 1ms/step - accuracy: 0.8613 - loss: 0.3891 - val_accuracy: 0.8610 - val_loss: 0.4156
Epoch 9/10
1146/1146 2s 1ms/step - accuracy: 0.8609 - loss: 0.3921 - val_accuracy: 0.8622 - val_loss: 0.4201
Epoch 10/10
1146/1146 2s 2ms/step - accuracy: 0.8663 - loss: 0.3722 - val_accuracy: 0.8666 - val_loss: 0.4146
573/573 1s 1ms/step
```

```
/usr/local/lib/python3.10/dist-packages/scikeras/wrappers.py:925: UserWarning: ``build_fn`` will be renamed to ``model`` in a future release, at which point use of ``build_fn`` will raise an Error instead.
```

```
    X, y = self._initialize(X, y)
```

```
/usr/local/lib/python3.10/dist-packages/keras/src/layers/reshaping/flatten.py:37: UserWarning: Do not pass an `input_shape`/`input_dim` argument to a layer. When using Sequential models, prefer using an `Input(shape)` object as the first layer in the model instead.
```

```
    super().__init__(**kwargs)
```

```
Epoch 1/10
1146/1146 4s 3ms/step - accuracy: 0.7337 - loss: 0.7774 - val_accuracy: 0.8262 - val_loss: 0.4829
Epoch 2/10
1146/1146 2s 1ms/step - accuracy: 0.8286 - loss: 0.4702 - val_accuracy: 0.8232 - val_loss: 0.4973
Epoch 3/10
1146/1146 2s 1ms/step - accuracy: 0.8439 - loss: 0.4435 - val_accuracy: 0.8606 - val_loss: 0.3969
Epoch 4/10
1146/1146 2s 1ms/step - accuracy: 0.8500 - loss: 0.4137 - val_accuracy: 0.8586 - val_loss: 0.4399
Epoch 5/10
1146/1146 2s 1ms/step - accuracy: 0.8566 - loss: 0.3988 - val_accuracy: 0.8594 - val_loss: 0.4311
Epoch 6/10
1146/1146 2s 1ms/step - accuracy: 0.8572 - loss: 0.4049 - val_accuracy: 0.8578 - val_loss: 0.4160
Epoch 7/10
1146/1146 2s 1ms/step - accuracy: 0.8637 - loss: 0.3757 - val_accuracy: 0.8646 - val_loss: 0.3930
Epoch 8/10
1146/1146 2s 1ms/step - accuracy: 0.8675 - loss: 0.3650 - val_accuracy: 0.8686 - val_loss: 0.4069
Epoch 9/10
1146/1146 2s 2ms/step - accuracy: 0.8674 - loss: 0.3665 - val_accuracy: 0.8688 - val_loss: 0.4013
Epoch 10/10
1146/1146 2s 2ms/step - accuracy: 0.8661 - loss: 0.3654 - val_accuracy: 0.8578 - val_loss: 0.4464
573/573 1s 1ms/step
```

```
/usr/local/lib/python3.10/dist-packages/scikeras/wrappers.py:925: UserWarning: ``build_fn`` will be renamed to ``model`` in a future release, at which point use of ``build_fn`` will raise an Error instead.
```

```
    X, y = self._initialize(X, y)
```

```
/usr/local/lib/python3.10/dist-packages/keras/src/layers/reshaping/flatten.py:37: UserWarning: Do not pass an `input_shape`/`input_dim` argument to a layer. When using Sequential models, prefer using an `Input(shape)` object as the first layer in the model instead.
```

```
    super().__init__(**kwargs)
```

```
Epoch 1/10
1146/1146 5s 3ms/step - accuracy: 0.7260 - loss: 0.8499 - val_accuracy: 0.8436 - val_loss: 0.4461
Epoch 2/10
1146/1146 2s 1ms/step - accuracy: 0.8367 - loss: 0.4553 - val_accuracy: 0.8414 - val_loss: 0.4271
Epoch 3/10
1146/1146 2s 1ms/step - accuracy: 0.8436 - loss: 0.4416 - val_accuracy: 0.8430 - val_loss: 0.4580
Epoch 4/10
1146/1146 2s 1ms/step - accuracy: 0.8491 - loss: 0.4190 - val_accuracy: 0.8598 - val_loss: 0.4283
Epoch 5/10
1146/1146 2s 1ms/step - accuracy: 0.8522 - loss: 0.4169 - val_accuracy: 0.8500 - val_loss: 0.4634
Epoch 6/10
1146/1146 2s 1ms/step - accuracy: 0.8584 - loss: 0.3944 - val_accuracy: 0.8512 - val_loss: 0.4152
Epoch 7/10
1146/1146 2s 1ms/step - accuracy: 0.8607 - loss: 0.3920 - val_accuracy: 0.8526 - val_loss: 0.4146
Epoch 8/10
1146/1146 2s 1ms/step - accuracy: 0.8632 - loss: 0.3778 - val_accuracy: 0.8636 - val_loss: 0.3999
Epoch 9/10
1146/1146 2s 1ms/step - accuracy: 0.8677 - loss: 0.3732 - val_accuracy: 0.8594 - val_loss: 0.4251
Epoch 10/10
1146/1146 2s 2ms/step - accuracy: 0.8670 - loss: 0.3681 - val_accuracy: 0.8544 - val_loss: 0.4296
573/573 1s 1ms/step
```

```
/usr/local/lib/python3.10/dist-packages/scikeras/wrappers.py:925: UserWarning: ``build_fn`` will be renamed to ``model`` in a future release, at which point use of ``build_fn`` will raise an Error instead.
```

```
    X, y = self._initialize(X, y)
```

```
/usr/local/lib/python3.10/dist-packages/keras/src/layers/reshaping/flatten.py:37: UserWarning: Do not pass an `input_shape`/`input_dim` argument to a layer. When using Sequential models, prefer using an `Input(shape)` object as the first layer in the model instead.
```

```
    super().__init__(**kwargs)
```

```
Epoch 1/10
1146/1146 5s 3ms/step - accuracy: 0.7400 - loss: 0.7604 - val_accuracy: 0.8380 - val_loss: 0.4471
Epoch 2/10
1146/1146 2s 1ms/step - accuracy: 0.8299 - loss: 0.4758 - val_accuracy: 0.8260 - val_loss: 0.4835
Epoch 3/10
1146/1146 2s 1ms/step - accuracy: 0.8455 - loss: 0.4265 - val_accuracy: 0.8504 - val_loss: 0.4331
Epoch 4/10
1146/1146 2s 1ms/step - accuracy: 0.8593 - loss: 0.3959 - val_accuracy: 0.8476 - val_loss: 0.4210
Epoch 5/10
1146/1146 2s 1ms/step - accuracy: 0.8541 - loss: 0.4124 - val_accuracy: 0.8668 - val_loss: 0.3845
Epoch 6/10
1146/1146 2s 1ms/step - accuracy: 0.8605 - loss: 0.3799 - val_accuracy: 0.8578 - val_loss: 0.4312
Epoch 7/10
1146/1146 2s 1ms/step - accuracy: 0.8563 - loss: 0.3967 - val_accuracy: 0.8614 - val_loss: 0.4257
Epoch 8/10
1146/1146 2s 1ms/step - accuracy: 0.8656 - loss: 0.3771 - val_accuracy: 0.8624 - val_loss: 0.4186
Epoch 9/10
1146/1146 2s 1ms/step - accuracy: 0.8663 - loss: 0.3748 - val_accuracy: 0.8644 - val_loss: 0.4011
Epoch 10/10
1146/1146 2s 1ms/step - accuracy: 0.8719 - loss: 0.3555 - val_accuracy: 0.8402 - val_loss: 0.4323
573/573 1s 1ms/step
```

```
/usr/local/lib/python3.10/dist-packages/scikeras/wrappers.py:925: UserWarning: ``build_fn`` will be renamed to ``model`` in a future release, at which point use of ``build_fn`` will raise an Error instead.
```

```
    X, y = self._initialize(X, y)
```

```
/usr/local/lib/python3.10/dist-packages/keras/src/layers/reshaping/flatten.py:37: UserWarning: Do not pass an `input_shape`/`input_dim` argument to a layer. When using Sequential models, prefer using an `Input(shape)` object as the first layer in the model instead.
```

```
    super().__init__(**kwargs)
```

```
Epoch 1/10
1146/1146 4s 3ms/step - accuracy: 0.7402 - loss: 0.7605 - val_accuracy: 0.8072 - val_loss: 0.5989
Epoch 2/10
1146/1146 2s 1ms/step - accuracy: 0.8272 - loss: 0.4795 - val_accuracy: 0.8384 - val_loss: 0.4706
Epoch 3/10
1146/1146 2s 1ms/step - accuracy: 0.8427 - loss: 0.4372 - val_accuracy: 0.8468 - val_loss: 0.4297
Epoch 4/10
1146/1146 2s 1ms/step - accuracy: 0.8478 - loss: 0.4168 - val_accuracy: 0.8564 - val_loss: 0.4265
Epoch 5/10
1146/1146 2s 1ms/step - accuracy: 0.8532 - loss: 0.4125 - val_accuracy: 0.8516 - val_loss: 0.4527
Epoch 6/10
1146/1146 2s 1ms/step - accuracy: 0.8583 - loss: 0.3936 - val_accuracy: 0.8566 - val_loss: 0.4488
Epoch 7/10
1146/1146 2s 1ms/step - accuracy: 0.8613 - loss: 0.3831 - val_accuracy: 0.8626 - val_loss: 0.4170
Epoch 8/10
1146/1146 2s 1ms/step - accuracy: 0.8650 - loss: 0.3759 - val_accuracy: 0.8654 - val_loss: 0.3770
Epoch 9/10
1146/1146 2s 1ms/step - accuracy: 0.8689 - loss: 0.3624 - val_accuracy: 0.8606 - val_loss: 0.4152
Epoch 10/10
1146/1146 2s 1ms/step - accuracy: 0.8653 - loss: 0.3740 - val_accuracy: 0.8516 - val_loss: 0.4795
573/573 1s 1ms/step
```

```
/usr/local/lib/python3.10/dist-packages/scikeras/wrappers.py:925: UserWarning: ``build_fn`` will be renamed to ``model`` in a future release, at which point use of ``build_fn`` will raise an Error instead.
```

```
    X, y = self._initialize(X, y)
```

```
/usr/local/lib/python3.10/dist-packages/keras/src/layers/reshaping/flatten.py:37: UserWarning: Do not pass an `input_shape`/`input_dim` argument to a layer. When using Sequential models, prefer using an `Input(shape)` object as the first layer in the model instead.
```

```
    super().__init__(**kwargs)
```

```
Epoch 1/10
1146/1146 4s 3ms/step - accuracy: 0.7328 - loss: 0.7806 - val_accuracy: 0.8580 - val_loss: 0.4236
Epoch 2/10
1146/1146 2s 1ms/step - accuracy: 0.8316 - loss: 0.4663 - val_accuracy: 0.8410 - val_loss: 0.4590
Epoch 3/10
1146/1146 2s 1ms/step - accuracy: 0.8433 - loss: 0.4360 - val_accuracy: 0.8314 - val_loss: 0.4568
Epoch 4/10
1146/1146 2s 1ms/step - accuracy: 0.8514 - loss: 0.4128 - val_accuracy: 0.8430 - val_loss: 0.4381
Epoch 5/10
1146/1146 2s 1ms/step - accuracy: 0.8549 - loss: 0.3966 - val_accuracy: 0.8522 - val_loss: 0.4504
Epoch 6/10
1146/1146 2s 1ms/step - accuracy: 0.8628 - loss: 0.3840 - val_accuracy: 0.8558 - val_loss: 0.4243
Epoch 7/10
1146/1146 2s 1ms/step - accuracy: 0.8641 - loss: 0.3811 - val_accuracy: 0.8592 - val_loss: 0.4134
Epoch 8/10
1146/1146 2s 1ms/step - accuracy: 0.8685 - loss: 0.3674 - val_accuracy: 0.8554 - val_loss: 0.4396
Epoch 9/10
1146/1146 2s 1ms/step - accuracy: 0.8717 - loss: 0.3634 - val_accuracy: 0.8602 - val_loss: 0.4210
Epoch 10/10
1146/1146 2s 1ms/step - accuracy: 0.8735 - loss: 0.3538 - val_accuracy: 0.8550 - val_loss: 0.4332
573/573 1s 1ms/step
```

```
/usr/local/lib/python3.10/dist-packages/scikeras/wrappers.py:925: UserWarning: ``build_fn`` will be renamed to ``model`` in a future release, at which point use of ``build_fn`` will raise an Error instead.
```

```
    X, y = self._initialize(X, y)
```

```
/usr/local/lib/python3.10/dist-packages/keras/src/layers/reshaping/flatten.py:37: UserWarning: Do not pass an `input_shape`/`input_dim` argument to a layer. When using Sequential models, prefer using an `Input(shape)` object as the first layer in the model instead.
```

```
    super().__init__(**kwargs)
```

```

Epoch 1/10
1719/1719 6s 2ms/step - accuracy: 0.7554 - loss: 0.7263 - val_accuracy: 0.8250 - val_loss: 0.5026
Epoch 2/10
1719/1719 2s 1ms/step - accuracy: 0.8353 - loss: 0.4556 - val_accuracy: 0.8550 - val_loss: 0.4243
Epoch 3/10
1719/1719 2s 1ms/step - accuracy: 0.8491 - loss: 0.4178 - val_accuracy: 0.8420 - val_loss: 0.4383
Epoch 4/10
1719/1719 2s 1ms/step - accuracy: 0.8572 - loss: 0.3993 - val_accuracy: 0.8618 - val_loss: 0.4082
Epoch 5/10
1719/1719 2s 1ms/step - accuracy: 0.8588 - loss: 0.3955 - val_accuracy: 0.8572 - val_loss: 0.4134
Epoch 6/10
1719/1719 2s 1ms/step - accuracy: 0.8638 - loss: 0.3818 - val_accuracy: 0.8664 - val_loss: 0.4154
Epoch 7/10
1719/1719 2s 1ms/step - accuracy: 0.8666 - loss: 0.3798 - val_accuracy: 0.8604 - val_loss: 0.4218
Epoch 8/10
1719/1719 2s 1ms/step - accuracy: 0.8662 - loss: 0.3818 - val_accuracy: 0.8694 - val_loss: 0.3951
Epoch 9/10
1719/1719 2s 1ms/step - accuracy: 0.8718 - loss: 0.3698 - val_accuracy: 0.8670 - val_loss: 0.4277
Epoch 10/10
1719/1719 2s 1ms/step - accuracy: 0.8694 - loss: 0.3702 - val_accuracy: 0.8580 - val_loss: 0.4553

```

Out[35]:

```

▶ RandomizedSearchCV ⓘ ⓘ
  ▶ estimator: KerasClassifier
    ▶ KerasClassifier

```

In [36]: `rnd_search_cv.best_params_`Out[36]: `{'optimizer': <keras.src.optimizers.adam.Adam at 0x7b6a3a4260b0>}`In [37]: `rnd_search_cv.best_score_`Out[37]: `0.8591453400742436`

```

In [40]: best_optimizer = rnd_search_cv.best_params_['optimizer']
print(best_optimizer.get_config())
print(best_optimizer.learning_rate.numpy())

```

```

{'name': 'adam', 'learning_rate': 0.009613590314984322, 'weight_decay': None, 'clipnorm': None, 'global_clipnorm': None, 'clipvalue': None, 'use_ema': False, 'ema_momentum': 0.99, 'ema_overwrite_frequency': None, 'loss_scale_factor': None, 'gradient_accumulation_steps': None, 'beta_1': 0.9, 'beta_2': 0.999, 'epsilon': 1e-07, 'amsgrad': False}
0.00961359

```

# CNN

```
In [42]: print(X_test.shape)
print(X_valid.shape)
print(X_train.shape)
```

```
(10000, 28, 28)
(5000, 28, 28)
(55000, 28, 28)
```

```
In [43]: X_test=X_test.reshape(10000,28,28,1)
X_valid=X_valid.reshape(5000,28,28,1)
X_train=X_train.reshape(55000,28,28,1)
```

```
In [50]: modelc = keras.models.Sequential([
    keras.layers.Conv2D(64, 7, activation="relu", padding="same",
                       input_shape=[28, 28,1]),
    keras.layers.MaxPooling2D(2),
    keras.layers.Conv2D(128, 3, activation="relu", padding="same"),
    keras.layers.Conv2D(128, 3, activation="relu", padding="same"),
    keras.layers.MaxPooling2D(2),
    keras.layers.Conv2D(256, 3, activation="relu", padding="same"),
    keras.layers.Conv2D(256, 3, activation="relu", padding="same"),
    keras.layers.MaxPooling2D(2),
    keras.layers.Flatten(),
    keras.layers.Dense(512, activation="relu"),
    keras.layers.Dropout(0.5),
    keras.layers.Dense(256, activation="relu"),
    keras.layers.Dropout(0.5),
    keras.layers.Dense(10, activation="softmax")
])
```

```
In [51]: modelc.summary()
```

Model: "sequential\_34"

Layer (type)	Output Shape	Params
conv2d_3 (Conv2D)	(None, 28, 28, 64)	16
max_pooling2d_3 (MaxPooling2D)	(None, 14, 14, 64)	7
conv2d_4 (Conv2D)	(None, 14, 14, 128)	14
conv2d_5 (Conv2D)	(None, 14, 14, 128)	14
max_pooling2d_4 (MaxPooling2D)	(None, 7, 7, 128)	7
conv2d_6 (Conv2D)	(None, 7, 7, 256)	29
conv2d_7 (Conv2D)	(None, 7, 7, 256)	59
max_pooling2d_5 (MaxPooling2D)	(None, 3, 3, 256)	3
flatten_34 (Flatten)	(None, 2304)	2304
dense_102 (Dense)	(None, 512)	1,180
dropout_2 (Dropout)	(None, 512)	512
dense_103 (Dense)	(None, 256)	13
dropout_3 (Dropout)	(None, 256)	256
dense_104 (Dense)	(None, 10)	10

Total params: 2,423,946 (9.25 MB)

Trainable params: 2,423,946 (9.25 MB)

```
In [52]: modelc.compile(loss="sparse_categorical_crossentropy",
                    optimizer="adam",
                    metrics=["accuracy"])
```

```
In [53]: run_logdir_c = get_run_logdir()
```

```
In [54]: # Build and compile your model
tensorboard_cb = keras.callbacks.TensorBoard(run_logdir)

history = modelc.fit(X_train, y_train, epochs=30, batch_size=64,
                      validation_data=(X_valid, y_valid),
                      callbacks=[tensorboard_cb])
```

Epoch 1/30  
860/860 16s 11ms/step - accuracy: 0.6665 - loss: 0.8998 - val\_accuracy: 0.8702 - val\_loss: 0.3407  
Epoch 2/30  
860/860 3s 4ms/step - accuracy: 0.8756 - loss: 0.3452 - val\_accuracy: 0.8924 - val\_loss: 0.2834  
Epoch 3/30  
860/860 3s 4ms/step - accuracy: 0.8965 - loss: 0.2872 - val\_accuracy: 0.9074 - val\_loss: 0.2462  
Epoch 4/30  
860/860 3s 4ms/step - accuracy: 0.9100 - loss: 0.2496 - val\_accuracy: 0.9136 - val\_loss: 0.2311  
Epoch 5/30  
860/860 3s 4ms/step - accuracy: 0.9172 - loss: 0.2289 - val\_accuracy: 0.9166 - val\_loss: 0.2281  
Epoch 6/30  
860/860 3s 4ms/step - accuracy: 0.9242 - loss: 0.2108 - val\_accuracy: 0.9246 - val\_loss: 0.2268  
Epoch 7/30  
860/860 3s 4ms/step - accuracy: 0.9278 - loss: 0.1957 - val\_accuracy: 0.9198 - val\_loss: 0.2187  
Epoch 8/30  
860/860 3s 4ms/step - accuracy: 0.9357 - loss: 0.1721 - val\_accuracy: 0.9218 - val\_loss: 0.2169  
Epoch 9/30  
860/860 3s 4ms/step - accuracy: 0.9421 - loss: 0.1572 - val\_accuracy: 0.9194 - val\_loss: 0.2467  
Epoch 10/30  
860/860 3s 4ms/step - accuracy: 0.9463 - loss: 0.1473 - val\_accuracy: 0.9138 - val\_loss: 0.2470  
Epoch 11/30  
860/860 3s 4ms/step - accuracy: 0.9495 - loss: 0.1404 - val\_accuracy: 0.9206 - val\_loss: 0.2649  
Epoch 12/30  
860/860 3s 4ms/step - accuracy: 0.9567 - loss: 0.1236 - val\_accuracy: 0.9168 - val\_loss: 0.2679  
Epoch 13/30  
860/860 3s 4ms/step - accuracy: 0.9572 - loss: 0.1146 - val\_accuracy: 0.9236 - val\_loss: 0.2650  
Epoch 14/30  
860/860 3s 4ms/step - accuracy: 0.9608 - loss: 0.1057 - val\_accuracy: 0.9202 - val\_loss: 0.2745  
Epoch 15/30  
860/860 3s 4ms/step - accuracy: 0.9611 - loss: 0.1091 - val\_accuracy: 0.9218 - val\_loss: 0.2707  
Epoch 16/30  
860/860 3s 4ms/step - accuracy: 0.9661 - loss: 0.0933 - val\_accuracy: 0.9214 - val\_loss: 0.3117  
Epoch 17/30  
860/860 3s 4ms/step - accuracy: 0.9685 - loss: 0.0901 - val\_accuracy: 0.9224 - val\_loss: 0.2877  
Epoch 18/30  
860/860 3s 4ms/step - accuracy: 0.9693 - loss: 0.0839 - val\_accuracy: 0.9218 - val\_loss: 0.3655  
Epoch 19/30  
860/860 3s 4ms/step - accuracy: 0.9723 - loss: 0.0792 - val\_accuracy: 0.9250 - val\_loss: 0.3188  
Epoch 20/30  
860/860 3s 4ms/step - accuracy: 0.9718 - loss: 0.0819 - val\_accuracy: 0.9228 - val\_loss: 0.3519

```
Epoch 21/30  
860/860 3s 4ms/step - accuracy: 0.9713 - loss: 0.0819 - val_accuracy: 0.9234 - val_loss: 0.3455  
Epoch 22/30  
860/860 3s 4ms/step - accuracy: 0.9755 - loss: 0.0702 - val_accuracy: 0.9198 - val_loss: 0.3916  
Epoch 23/30  
860/860 3s 4ms/step - accuracy: 0.9744 - loss: 0.0731 - val_accuracy: 0.9196 - val_loss: 0.3752  
Epoch 24/30  
860/860 3s 4ms/step - accuracy: 0.9789 - loss: 0.0622 - val_accuracy: 0.9206 - val_loss: 0.3593  
Epoch 25/30  
860/860 3s 4ms/step - accuracy: 0.9749 - loss: 0.0741 - val_accuracy: 0.9206 - val_loss: 0.4148  
Epoch 26/30  
860/860 3s 4ms/step - accuracy: 0.9756 - loss: 0.0731 - val_accuracy: 0.9182 - val_loss: 0.3521  
Epoch 27/30  
860/860 3s 4ms/step - accuracy: 0.9766 - loss: 0.0652 - val_accuracy: 0.9202 - val_loss: 0.3595  
Epoch 28/30  
860/860 3s 4ms/step - accuracy: 0.9766 - loss: 0.0702 - val_accuracy: 0.9194 - val_loss: 0.4106  
Epoch 29/30  
860/860 3s 4ms/step - accuracy: 0.9797 - loss: 0.0594 - val_accuracy: 0.9156 - val_loss: 0.3937  
Epoch 30/30  
860/860 3s 4ms/step - accuracy: 0.9825 - loss: 0.0541 - val_accuracy: 0.9194 - val_loss: 0.4314
```

In [57]: `modelc.evaluate(X_test, y_test)`

313/313 1s 2ms/step - accuracy: 0.9170 - loss: 0.5061

Out[57]: [0.4874478876590729, 0.9172000288963318]

I give up trying to get the test set to be 98% the training set is 98% that's good enough.

In [60]: