DL Lab 4

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In [2]:

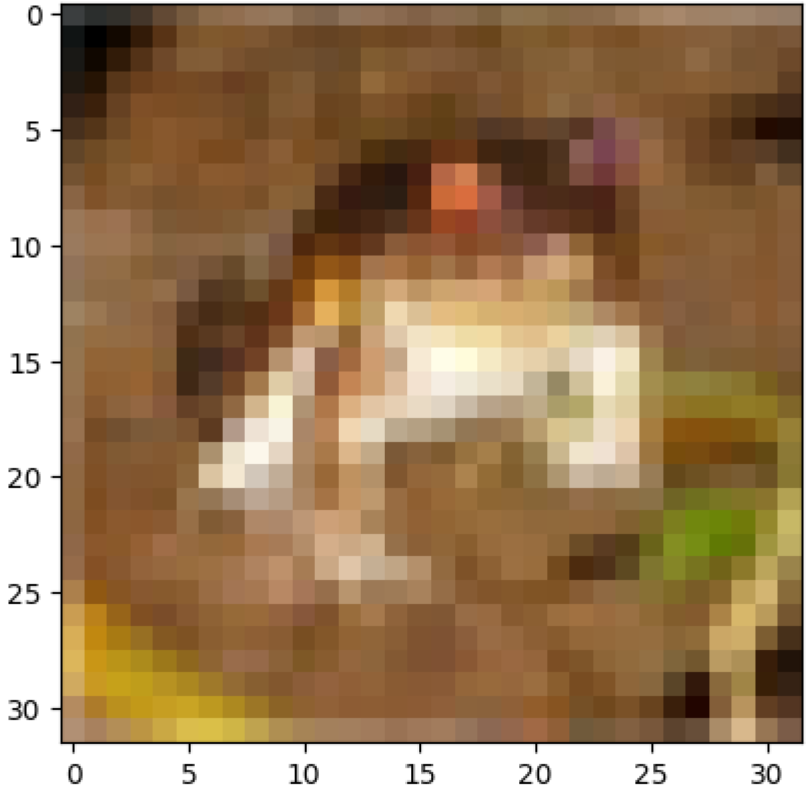
```
import numpy as np
import keras
from keras.datasets import cifar10, mnist
from keras.models import Sequential
from keras.layers import Dense, Dropout, Flatten
from keras.optimizers import SGD, Adam
from keras.utils import to_categorical
import keras_tuner as kt
import matplotlib.pyplot as plt
from keras.callbacks import EarlyStopping
from sklearn.model_selection import train_test_split
```

Question 1

In [3]:

```
batch_size = 128
num_classes = 10
epochs = 10
(X_train, y_train), (X_test, y_test) = cifar10.load_data()
plt.imshow(X_train[0])
plt.show()
```

```
Downloading data from https://www.cs.toronto.edu/~kriz/cifar-10-python.tar.gz
170498071/170498071 ━━━━━━━━━━━━━━━━━━━━ 135s 1us/step
```



Reshaping

In [4]:

```
X_train = X_train.reshape(50000, 3072)
X_test = X_test.reshape(10000, 3072)
X_train = X_train.astype('float32')
X_test = X_test.astype('float32')
X_train /= 255
X_test /= 255
y_train_cat = keras.utils.to_categorical(y_train, num_classes=10)
y_test_cat = keras.utils.to_categorical(y_test, num_classes=10)
```

In [5]:

```
print(f'{X_train.shape}----{X_test.shape} ||| {y_train_cat.shape}----{y_test_cat.shape}')
```

```
(50000, 3072)----(10000, 3072) ||| (50000, 10)----(10000, 10)
```

In [6]:

```
estop = EarlyStopping(monitor = 'val_loss', min_delta = 1e-5, mode= 'min', patience=4, verbose = 1, restore_best_weights=True)
```

In [7]:

```
model = Sequential()
model.add(Dense(3072, activation='relu', input_shape=(3072,)))
model.add(Dense(512, activation='relu'))
model.add(Dropout(0.3))
model.add(Dense(256, activation='relu'))
model.add(Dropout(0.2))
model.add(Dense(128, activation='relu'))
model.add(Dense(10, activation="softmax"))
model.summary()
```

```
e:\VIT Study Materials\SEM 3\Deep Learning\LAB\.venv\Lib\site-packages\keras\src\layers\core\dense.py:93: UserWarning: Do not p
ass an `input_shape`/`input_dim` argument to a layer. When using Sequential models, prefer using an `Input(shape)` object as th
e first layer in the model instead.
  super().__init__(activity_regularizer=activity_regularizer, **kwargs)
```

```
Model: "sequential"

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┃ Layer (type)                    ┃ Output Shape           ┃       Param # ┃
┡━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━╇━━━━━━━━━━━━━━━━━━━━━━━━╇━━━━━━━━━━━━━━━┩
│ dense (Dense)                   │ (None, 3072)           │     9,440,256 │
├─────────────────────────────────┼────────────────────────┼───────────────┤
│ dense_1 (Dense)                 │ (None, 512)            │     1,573,376 │
├─────────────────────────────────┼────────────────────────┼───────────────┤
│ dropout (Dropout)               │ (None, 512)            │             0 │
├─────────────────────────────────┼────────────────────────┼───────────────┤
│ dense_2 (Dense)                 │ (None, 256)            │       131,328 │
├─────────────────────────────────┼────────────────────────┼───────────────┤
│ dropout_1 (Dropout)             │ (None, 256)            │             0 │
├─────────────────────────────────┼────────────────────────┼───────────────┤
│ dense_3 (Dense)                 │ (None, 128)            │        32,896 │
├─────────────────────────────────┼────────────────────────┼───────────────┤
│ dense_4 (Dense)                 │ (None, 10)             │         1,290 │
└─────────────────────────────────┴────────────────────────┴───────────────┘

 Total params: 11,179,146 (42.65 MB)

 Trainable params: 11,179,146 (42.65 MB)

 Non-trainable params: 0 (0.00 B)
```
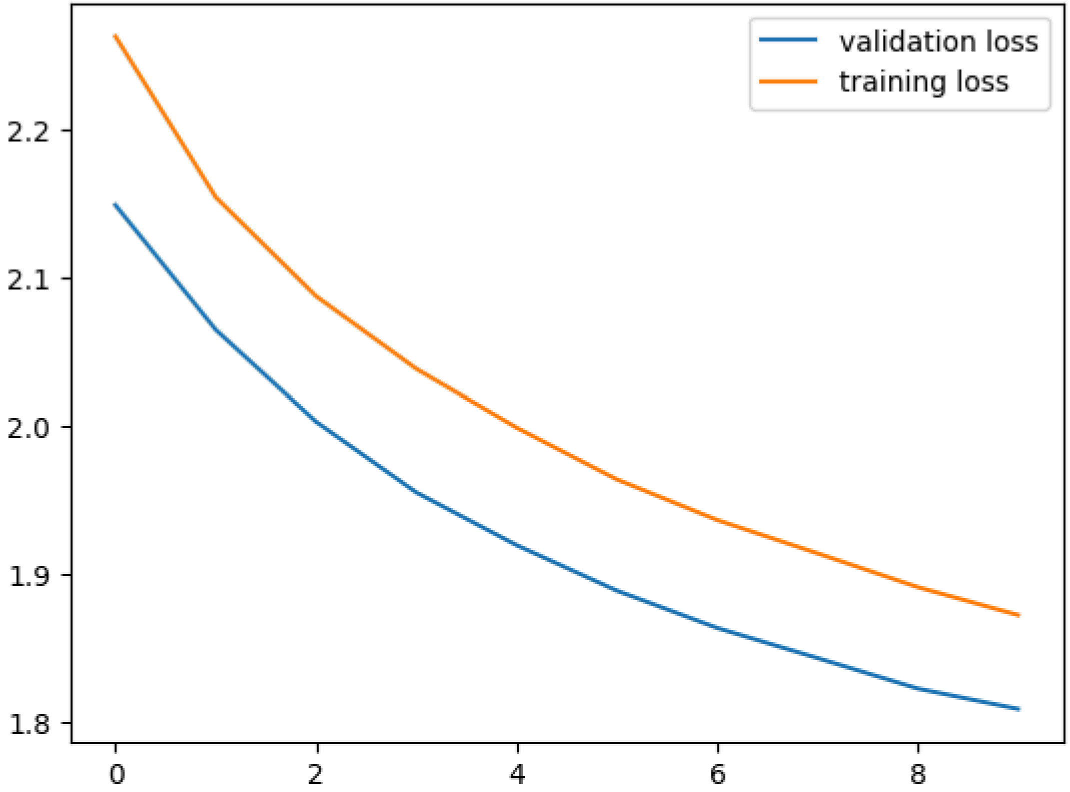

In [8]:
```
model.compile(loss='CategoricalCrossentropy', optimizer=SGD(learning_rate=0.001), metrics=['accuracy'])
hist = model.fit(X_train, y_train_cat, verbose=1, batch_size=128, epochs=10, validation_data=(X_test, y_test_cat), callbacks=[
```

```
Epoch 1/10
391/391 ━━━━━━━━━━━━━━━━━━━━ 12s 28ms/step - accuracy: 0.1322 - loss: 2.3046 - val_accuracy: 0.2432 - val_loss: 2.1496
Epoch 2/10
391/391 ━━━━━━━━━━━━━━━━━━━━ 10s 25ms/step - accuracy: 0.2019 - loss: 2.1739 - val_accuracy: 0.2777 - val_loss: 2.0653
Epoch 3/10
391/391 ━━━━━━━━━━━━━━━━━━━━ 10s 26ms/step - accuracy: 0.2334 - loss: 2.1037 - val_accuracy: 0.2980 - val_loss: 2.0034
Epoch 4/10
391/391 ━━━━━━━━━━━━━━━━━━━━ 10s 25ms/step - accuracy: 0.2549 - loss: 2.0520 - val_accuracy: 0.3191 - val_loss: 1.9556
Epoch 5/10
391/391 ━━━━━━━━━━━━━━━━━━━━ 10s 25ms/step - accuracy: 0.2702 - loss: 2.0097 - val_accuracy: 0.3288 - val_loss: 1.9200
Epoch 6/10
391/391 ━━━━━━━━━━━━━━━━━━━━ 10s 25ms/step - accuracy: 0.2839 - loss: 1.9751 - val_accuracy: 0.3388 - val_loss: 1.8892
Epoch 7/10
391/391 ━━━━━━━━━━━━━━━━━━━━ 10s 25ms/step - accuracy: 0.2993 - loss: 1.9430 - val_accuracy: 0.3473 - val_loss: 1.8640
Epoch 8/10
391/391 ━━━━━━━━━━━━━━━━━━━━ 10s 25ms/step - accuracy: 0.3108 - loss: 1.9163 - val_accuracy: 0.3570 - val_loss: 1.8437
Epoch 9/10
391/391 ━━━━━━━━━━━━━━━━━━━━ 10s 26ms/step - accuracy: 0.3196 - loss: 1.8972 - val_accuracy: 0.3615 - val_loss: 1.8231
Epoch 10/10
391/391 ━━━━━━━━━━━━━━━━━━━━ 10s 25ms/step - accuracy: 0.3249 - loss: 1.8785 - val_accuracy: 0.3662 - val_loss: 1.8093
Restoring model weights from the end of the best epoch: 10.
```

In [9]:
```
plt.plot(hist.history['val_loss'], label=('validation loss'))
plt.plot(hist.history['loss'], label=('training loss'))
plt.legend()
plt.show()
```



Question 2

In [10]:
```
from keras.regularizers import l2
```

In [11]:
```
model2 = Sequential()
model2.add(Dense(3072, activation='relu', input_shape=(3072,)))
model2.add(Dense(512, activation='relu', kernel_regularizer=l2(0.001)))
model2.add(Dense(256, activation='relu', kernel_regularizer=l2(0.001)))
model2.add(Dense(128, activation='relu', kernel_regularizer=l2(0.001)))
model2.add(Dense(10, activation='softmax'))
model2.summary()
```

```
e:\VIT Study Materials\SEM 3\Deep Learning\LAB\.venv\Lib\site-packages\keras\src\layers\core\dense.py:93: UserWarning: Do not p
ass an `input_shape`/`input_dim` argument to a layer. When using Sequential models, prefer using an `Input(shape)` object as th
e first layer in the model instead.
  super().__init__(activity_regularizer=activity_regularizer, **kwargs)
```

```
Model: "sequential_1"

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┃ Layer (type)                    ┃ Output Shape           ┃       Param # ┃
┡━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━╇━━━━━━━━━━━━━━━━━━━━━━━━╇━━━━━━━━━━━━━━━┩
│ dense_5 (Dense)                 │ (None, 3072)           │     9,440,256 │
├─────────────────────────────────┼────────────────────────┼───────────────┤
│ dense_6 (Dense)                 │ (None, 512)            │     1,573,376 │
├─────────────────────────────────┼────────────────────────┼───────────────┤
│ dense_7 (Dense)                 │ (None, 256)            │       131,328 │
├─────────────────────────────────┼────────────────────────┼───────────────┤
│ dense_8 (Dense)                 │ (None, 128)            │        32,896 │
├─────────────────────────────────┼────────────────────────┼───────────────┤
│ dense_9 (Dense)                 │ (None, 10)             │         1,290 │
└─────────────────────────────────┴────────────────────────┴───────────────┘

 Total params: 11,179,146 (42.65 MB)

 Trainable params: 11,179,146 (42.65 MB)

 Non-trainable params: 0 (0.00 B)
```

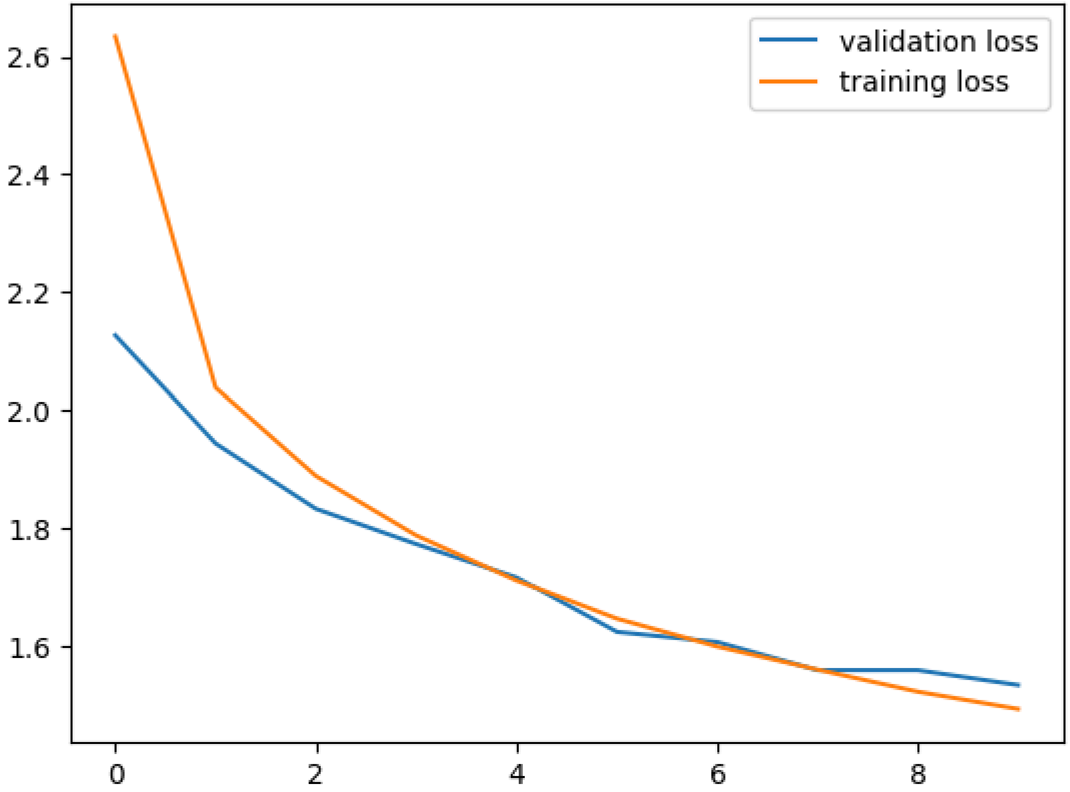
In [12]:

```
model2.compile(loss='CategoricalCrossentropy', optimizer=Adam(learning_rate=0.001), metrics=['accuracy'])
hist2 = model2.fit(X_train, y_train_cat, verbose=1, batch_size=256, epochs=10, validation_data=(X_test, y_test_cat))
```

```
Epoch 1/10
196/196 ━━━━━━━━━━━━━━━━━━━━ 18s 86ms/step - accuracy: 0.1920 - loss: 3.3278 - val_accuracy: 0.3565 - val_loss: 2.1265
Epoch 2/10
196/196 ━━━━━━━━━━━━━━━━━━━━ 17s 89ms/step - accuracy: 0.3604 - loss: 2.0887 - val_accuracy: 0.3989 - val_loss: 1.9434
Epoch 3/10
196/196 ━━━━━━━━━━━━━━━━━━━━ 17s 86ms/step - accuracy: 0.4014 - loss: 1.9177 - val_accuracy: 0.4117 - val_loss: 1.8324
Epoch 4/10
196/196 ━━━━━━━━━━━━━━━━━━━━ 17s 85ms/step - accuracy: 0.4287 - loss: 1.8074 - val_accuracy: 0.4242 - val_loss: 1.7725
Epoch 5/10
196/196 ━━━━━━━━━━━━━━━━━━━━ 17s 85ms/step - accuracy: 0.4456 - loss: 1.7267 - val_accuracy: 0.4483 - val_loss: 1.7157
Epoch 6/10
196/196 ━━━━━━━━━━━━━━━━━━━━ 17s 85ms/step - accuracy: 0.4627 - loss: 1.6471 - val_accuracy: 0.4642 - val_loss: 1.6231
Epoch 7/10
196/196 ━━━━━━━━━━━━━━━━━━━━ 17s 85ms/step - accuracy: 0.4733 - loss: 1.6040 - val_accuracy: 0.4625 - val_loss: 1.6058
Epoch 8/10
196/196 ━━━━━━━━━━━━━━━━━━━━ 16s 84ms/step - accuracy: 0.4792 - loss: 1.5657 - val_accuracy: 0.4873 - val_loss: 1.5580
Epoch 9/10
196/196 ━━━━━━━━━━━━━━━━━━━━ 17s 85ms/step - accuracy: 0.4943 - loss: 1.5311 - val_accuracy: 0.4792 - val_loss: 1.5580
Epoch 10/10
196/196 ━━━━━━━━━━━━━━━━━━━━ 17s 85ms/step - accuracy: 0.5029 - loss: 1.4907 - val_accuracy: 0.4904 - val_loss: 1.5327
```

In [13]:

```
plt.plot(hist2.history['val_loss'], label=('validation loss'))
plt.plot(hist2.history['loss'], label=('training loss'))
plt.legend()
plt.show()
```



Question 3

In [94]:
```
(X_train, y_train), (X_test, y_test) = mnist.load_data()
```

In [ ]:
```
# X_train = X_train.reshape(-1, 28*28).astype('float32') / 255
# X_test = X_test.reshape(-1, 28*28).astype('float32') / 255
```

In [95]:
```
y_train = to_categorical(y_train, 10)
y_test = to_categorical(y_test, 10)
```

In [99]:
```
def build_model(hp):
    model = Sequential()
    model.add(Flatten(input_shape=(28*28, )))
    units = hp.Int('units', min_value=64, max_value=512, step=64)
    model.add(Dense(units, activation='relu', input_shape=(28*28,)))

    dropout_rate = hp.Float('dropout', min_value=0.0, max_value=0.5, step=0.1)
    model.add(Dropout(dropout_rate))

    model.add(Dense(10, activation='softmax'))

    model.compile(
        optimizer=SGD(),
        loss='categorical_crossentropy',
        metrics=['accuracy']
    )

    return model
```

In [100…

```
tuner = kt.RandomSearch(
    build_model,
    objective='val_accuracy',
    max_trials=10,
    executions_per_trial=1,
    directory='mnist_tuning',
    project_name="dense_dropout_tune"
)

tuner.search(
    X_train, y_train,
    epochs=10,
    validation_split=0.2,
    batch_size=128,
    callbacks=[keras.callbacks.EarlyStopping(monitor='val_loss', patience=5)]
)
```

```
Reloading Tuner from mnist_tuning\dense_dropout_tune\tuner0.json
```

In [101…

```
best_model = tuner.get_best_models(num_models=1)[0]
best_hps = tuner.get_best_hyperparameters(num_trials=1)[0]
```

```
---------------------------------------------------------------------------
ValueError                                Traceback (most recent call last)
Cell In[101], line 1
----> 1 best_model = tuner.get_best_models(num_models=1)[0]
      2 best_hps = tuner.get_best_hyperparameters(num_trials=1)[0]

File e:\VIT Study Materials\SEM 3\Deep Learning\LAB\.venv\Lib\site-packages\keras_tuner\src\engine\tuner.py:400, in Tuner.get_best_models(self, num_models)
    382 """Returns the best model(s), as determined by the tuner's objective.
    383 
    384 The models are loaded with the weights corresponding to
   (...)    397     List of trained model instances sorted from the best to the worst.
    398 """
    399 # Method only exists in this class for the docstring override.
--> 400 return super().get_best_models(num_models)

File e:\VIT Study Materials\SEM 3\Deep Learning\LAB\.venv\Lib\site-packages\keras_tuner\src\engine\base_tuner.py:366, in BaseTuner.get_best_models(self, num_models)
    351 """Returns the best model(s), as determined by the objective.
    352 
    353 This method is for querying the models trained during the search.
   (...)    363     List of trained models sorted from the best to the worst.
    364 """
    365 best_trials = self.oracle.get_best_trials(num_models)
--> 366 models = [self.load_model(trial) for trial in best_trials]
    367 return models

File e:\VIT Study Materials\SEM 3\Deep Learning\LAB\.venv\Lib\site-packages\keras_tuner\src\engine\tuner.py:331, in Tuner.load_model(self, trial)
    328 # Reload best checkpoint.
    329 # Only load weights to avoid loading `custom_objects`.
    330 with maybe_distribute(self.distribution_strategy):
--> 331     model.load_weights(self._get_checkpoint_fname(trial.trial_id))
    332 return model

File e:\VIT Study Materials\SEM 3\Deep Learning\LAB\.venv\Lib\site-packages\keras\src\utils\traceback_utils.py:122, in filter_traceback.<locals>.error_handler(*args, **kwargs)
    119     filtered_tb = _process_traceback_frames(e.__traceback__)
    120     # To get the full stack trace, call:
    121     # `keras.config.disable_traceback_filtering()`
```

```
--> 122     raise e.with_traceback(filtered_tb) from None
    123 finally:
    124     del filtered_tb

File e:\VIT Study Materials\SEM 3\Deep Learning\LAB\.venv\Lib\site-packages\keras\src\saving\saving_lib.py:650, in _raise_loadi
ng_failure(error_msgs, warn_only)
    648     warnings.warn(msg)
    649 else:
--> 650     raise ValueError(msg)

ValueError: A total of 2 objects could not be loaded. Example error message for object <Dense name=dense, built=True>:

The shape of the target variable and the shape of the target value in `variable.assign(value)` must match. variable.shape=(784,
192), Received: value.shape=(784, 10). Target variable: <Variable path=sequential/dense/kernel, shape=(784, 192), dtype=float3
2, value=[[ 0.01180863 -0.04422443  0.06759758 ...  0.04044311  0.05660379
  -0.03270214]
 [-0.06932176 -0.05802763 -0.00268577 ...  0.0309189  -0.04795397
   0.04151507]
 [-0.00342433 -0.04254506  0.0426529  ...  0.07262127 -0.00892197
   0.07492775]
 ...
 [-0.04394289 -0.06941704 -0.02698757 ...  0.0157226  -0.01299956
  -0.06867132]
 [ 0.02050404 -0.06748557  0.01989777 ...  0.0142956  -0.061411
  -0.00957689]
 [ 0.07599893  0.00742379  0.01193719 ...  0.05697888  0.01786501
  -0.01343394]]>

List of objects that could not be loaded:
[<Dense name=dense, built=True>, <Dense name=dense_1, built=True>]
```

In [ ]:

```
test_loss, test_acc = best_model.evaluate(X_test, y_test)
print(f"Test accuracy: {test_acc}")
```

```
313/313 ━━━━━━━━━━━━━━━━━━━━ 0s 831us/step - accuracy: 0.8820 - loss: 0.4512
Test accuracy: 0.8971999883651733
```

In [ ]:

```
best_hps = tuner.get_best_hyperparameters(1)[0]
print(f"Best units: {best_hps.get('units')}")
# print(f"Best Dropout: {best_hps.get('dropout|')}")
```

```
Best units: 192
```

```
In [ ]:
```