```
import tensorflow as tf
from tensorflow.keras import layers, models
import matplotlib.pyplot as plt
from tensorflow.keras.datasets import fashion_mnist

# Load Fashion MNIST dataset
(x_train, y_train), (x_test, y_test) = fashion_mnist.load_data()

# Normalize the images to be between 0 and 1
x_train, x_test = x_train / 255.0, x_test / 255.0

# Reshape images to be (28, 28, 1) for the CNN input format
x_train = x_train.reshape((x_train.shape[0], 28, 28, 1))
x_test = x_test.reshape((x_test.shape[0], 28, 28, 1))

# Check the shape of the data
print(f"Training data shape: {x_train.shape}")
print(f"Test data shape: {x_test.shape}")
```

```
Downloading data from https://storage.googleapis.com/tensorflow/tf-keras-datasets/train-labels-idx1-ubyte.gz
29515/29515 ━━━━━━━━━━━━━━━━━━━━ 0s 0us/step
Downloading data from https://storage.googleapis.com/tensorflow/tf-keras-datasets/train-images-idx3-ubyte.gz
26421880/26421880 ━━━━━━━━━━━━━━━━━━━━ 0s 0us/step
Downloading data from https://storage.googleapis.com/tensorflow/tf-keras-datasets/t10k-labels-idx1-ubyte.gz
5148/5148 ━━━━━━━━━━━━━━━━━━━━ 0s 0us/step
Downloading data from https://storage.googleapis.com/tensorflow/tf-keras-datasets/t10k-images-idx3-ubyte.gz
4422102/4422102 ━━━━━━━━━━━━━━━━━━━━ 0s 0us/step
Training data shape: (60000, 28, 28, 1)
Test data shape: (10000, 28, 28, 1)
```

```
model = models.Sequential()

# Convolutional Layer 1: 32 filters, 3x3 kernel, ReLU activation
model.add(layers.Conv2D(32, (3, 3), activation='relu', input_shape=(28, 28, 1)))
model.add(layers.MaxPooling2D((2, 2)))

# Convolutional Layer 2: 64 filters, 3x3 kernel, ReLU activation
model.add(layers.Conv2D(64, (3, 3), activation='relu'))
model.add(layers.MaxPooling2D((2, 2)))

# Convolutional Layer 3: 128 filters, 3x3 kernel, ReLU activation
model.add(layers.Conv2D(128, (3, 3), activation='relu'))
model.add(layers.MaxPooling2D((2, 2)))

# Flatten the output from convolutional layers to feed into fully connected layers
model.add(layers.Flatten())

# Fully Connected Layer: 128 neurons, ReLU activation
model.add(layers.Dense(128, activation='relu'))

# Output Layer: 10 neurons for 10 classes, Softmax activation for multi-class classification
model.add(layers.Dense(10, activation='softmax'))

# Compile the model with categorical crossentropy loss, Adam optimizer, and accuracy metric
model.compile(optimizer='adam',
              loss='sparse_categorical_crossentropy',
              metrics=['accuracy'])

model.summary()
```

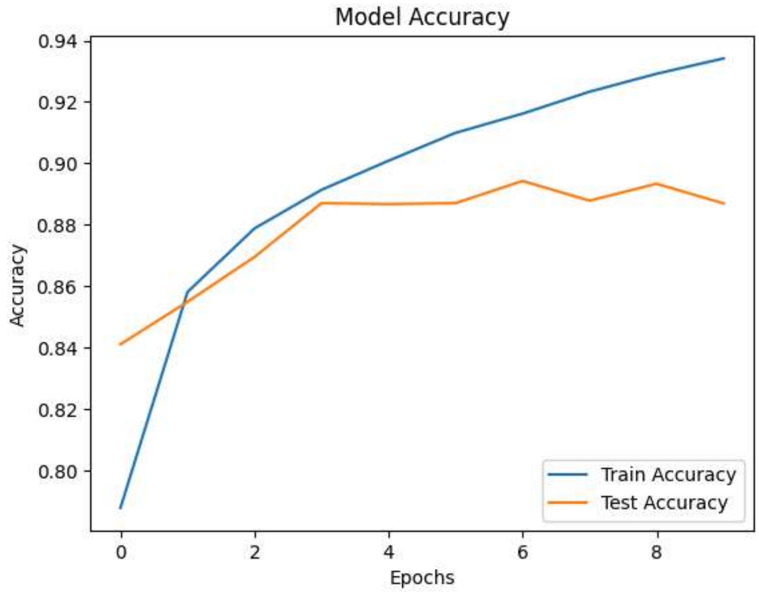
```
/usr/local/lib/python3.11/dist-packages/keras/src/layers/convolutional/base_conv.py:107: UserWarning: Do not pass an `input_shape`/`inpu
  super().__init__(activity_regularizer=activity_regularizer, **kwargs)
Model: "sequential"
┏━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━┳━━━━━━━━━━━━━━━━━━━━━━━━━━━━━┳━━━━━━━━━━━━━━━━━┓
┃ Layer (type)                         ┃ Output Shape                ┃         Param # ┃
┡━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━╇━━━━━━━━━━━━━━━━━━━━━━━━━━━━━╇━━━━━━━━━━━━━━━━━┩
│ conv2d (Conv2D)                      │ (None, 26, 26, 32)          │             320 │
├──────────────────────────────────────┼─────────────────────────────┼─────────────────┤
│ max_pooling2d (MaxPooling2D)         │ (None, 13, 13, 32)          │               0 │
├──────────────────────────────────────┼─────────────────────────────┼─────────────────┤
│ conv2d_1 (Conv2D)                    │ (None, 11, 11, 64)          │          18,496 │
├──────────────────────────────────────┼─────────────────────────────┼─────────────────┤
│ max_pooling2d_1 (MaxPooling2D)       │ (None, 5, 5, 64)            │               0 │
├──────────────────────────────────────┼─────────────────────────────┼─────────────────┤
│ conv2d_2 (Conv2D)                    │ (None, 3, 3, 128)           │          73,856 │
├──────────────────────────────────────┼─────────────────────────────┼─────────────────┤
│ max_pooling2d_2 (MaxPooling2D)       │ (None, 1, 1, 128)           │               0 │
├──────────────────────────────────────┼─────────────────────────────┼─────────────────┤
│ flatten (Flatten)                    │ (None, 128)                 │               0 │
├──────────────────────────────────────┼─────────────────────────────┼─────────────────┤
│ dense (Dense)                        │ (None, 128)                 │          16,512 │
├──────────────────────────────────────┼─────────────────────────────┼─────────────────┤
│ dense_1 (Dense)                      │ (None, 10)                  │           1,290 │
└──────────────────────────────────────┴─────────────────────────────┴─────────────────┘
 Total params: 110,474 (431.54 KB)
 Trainable params: 110,474 (431.54 KB)
```

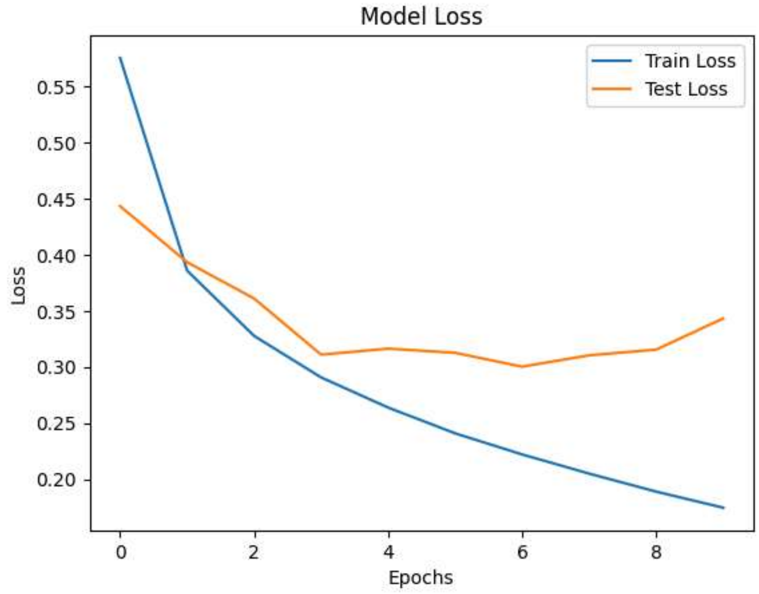
```
# Train the model
history = model.fit(x_train, y_train, epochs=10, validation_data=(x_test, y_test))

# Plot training & validation accuracy
plt.plot(history.history['accuracy'], label='Train Accuracy')
plt.plot(history.history['val_accuracy'], label='Test Accuracy')
plt.title('Model Accuracy')
plt.xlabel('Epochs')
plt.ylabel('Accuracy')
plt.legend(loc='lower right')
plt.show()
```

```
# Plot training & validation loss
plt.plot(history.history['loss'], label='Train Loss')
plt.plot(history.history['val_loss'], label='Test Loss')
plt.title('Model Loss')
plt.xlabel('Epochs')
plt.ylabel('Loss')
plt.legend(loc='upper right')
plt.show()
```

```
Epoch 1/10
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 16s 6ms/step - accuracy: 0.7139 - loss: 0.7808 - val_accuracy: 0.8412 - val_loss: 0.4432
Epoch 2/10
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 14s 4ms/step - accuracy: 0.8546 - loss: 0.3969 - val_accuracy: 0.8550 - val_loss: 0.3933
Epoch 3/10
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 7s 4ms/step - accuracy: 0.8735 - loss: 0.3404 - val_accuracy: 0.8696 - val_loss: 0.3609
Epoch 4/10
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 7s 4ms/step - accuracy: 0.8910 - loss: 0.2942 - val_accuracy: 0.8871 - val_loss: 0.3109
Epoch 5/10
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 10s 3ms/step - accuracy: 0.9025 - loss: 0.2616 - val_accuracy: 0.8868 - val_loss: 0.3163
Epoch 6/10
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 10s 4ms/step - accuracy: 0.9113 - loss: 0.2333 - val_accuracy: 0.8871 - val_loss: 0.3126
Epoch 7/10
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 7s 4ms/step - accuracy: 0.9190 - loss: 0.2137 - val_accuracy: 0.8943 - val_loss: 0.3002
Epoch 8/10
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 10s 4ms/step - accuracy: 0.9243 - loss: 0.1984 - val_accuracy: 0.8879 - val_loss: 0.3104
Epoch 9/10
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 6s 3ms/step - accuracy: 0.9311 - loss: 0.1823 - val_accuracy: 0.8934 - val_loss: 0.3155
Epoch 10/10
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 7s 4ms/step - accuracy: 0.9361 - loss: 0.1698 - val_accuracy: 0.8870 - val_loss: 0.3432
```





```
# Evaluate the model on the test set
test_loss, test_acc = model.evaluate(x_test, y_test, verbose=2)
print(f"Test accuracy: {test_acc}")

# Predict on a test image
predictions = model.predict(x_test)
print(f"Predicted label for first test image: {predictions[0].argmax()}")
print(f"True label for first test image: {y_test[0]}")
```

```
313/313 - 1s - 4ms/step - accuracy: 0.8870 - loss: 0.3432
Test accuracy: 0.8870000243186951
313/313 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step
Predicted label for first test image: 9
True label for first test image: 9
```

```
model = models.Sequential()

# Convolutional Layer 1
model.add(layers.Conv2D(32, (3, 3), activation='relu', input_shape=(28, 28, 1)))
model.add(layers.MaxPooling2D((2, 2)))
model.add(layers.BatchNormalization())

# Convolutional Layer 2
model.add(layers.Conv2D(64, (3, 3), activation='relu'))
model.add(layers.MaxPooling2D((2, 2)))
model.add(layers.BatchNormalization())

# Convolutional Layer 3
model.add(layers.Conv2D(128, (3, 3), activation='relu'))
model.add(layers.MaxPooling2D((2, 2)))
model.add(layers.BatchNormalization())

# Flatten
model.add(layers.Flatten())

# Fully Connected Layer
model.add(layers.Dense(128, activation='relu'))
model.add(layers.Dropout(0.5))  # Dropout layer

# Output Layer
model.add(layers.Dense(10, activation='softmax'))

# Compile the model
model.compile(optimizer='adam',
              loss='sparse_categorical_crossentropy',
              metrics=['accuracy'])

model.summary()
```

```
Model: "sequential_1"
┏━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━┳━━━━━━━━━━━━━━━━━━━━━━━━━━━━━┳━━━━━━━━━━━━━━━━━┓
┃ Layer (type)                         ┃ Output Shape                ┃         Param # ┃
┡━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━╇━━━━━━━━━━━━━━━━━━━━━━━━━━━━━╇━━━━━━━━━━━━━━━━━┩
│ conv2d_3 (Conv2D)                    │ (None, 26, 26, 32)          │             320 │
├──────────────────────────────────────┼─────────────────────────────┼─────────────────┤
│ max_pooling2d_3 (MaxPooling2D)       │ (None, 13, 13, 32)          │               0 │
├──────────────────────────────────────┼─────────────────────────────┼─────────────────┤
│ batch_normalization                  │ (None, 13, 13, 32)          │             128 │
│ (BatchNormalization)                 │                             │                 │
├──────────────────────────────────────┼─────────────────────────────┼─────────────────┤
│ conv2d_4 (Conv2D)                    │ (None, 11, 11, 64)          │          18,496 │
├──────────────────────────────────────┼─────────────────────────────┼─────────────────┤
│ max_pooling2d_4 (MaxPooling2D)       │ (None, 5, 5, 64)            │               0 │
├──────────────────────────────────────┼─────────────────────────────┼─────────────────┤
│ batch_normalization_1                │ (None, 5, 5, 64)            │             256 │
│ (BatchNormalization)                 │                             │                 │
├──────────────────────────────────────┼─────────────────────────────┼─────────────────┤
│ conv2d_5 (Conv2D)                    │ (None, 3, 3, 128)           │          73,856 │
├──────────────────────────────────────┼─────────────────────────────┼─────────────────┤
│ max_pooling2d_5 (MaxPooling2D)       │ (None, 1, 1, 128)           │               0 │
├──────────────────────────────────────┼─────────────────────────────┼─────────────────┤
│ batch_normalization_2                │ (None, 1, 1, 128)           │             512 │
│ (BatchNormalization)                 │                             │                 │
├──────────────────────────────────────┼─────────────────────────────┼─────────────────┤
│ flatten_1 (Flatten)                  │ (None, 128)                 │               0 │
├──────────────────────────────────────┼─────────────────────────────┼─────────────────┤
│ dense_2 (Dense)                      │ (None, 128)                 │          16,512 │
├──────────────────────────────────────┼─────────────────────────────┼─────────────────┤
│ dropout (Dropout)                    │ (None, 128)                 │               0 │
├──────────────────────────────────────┼─────────────────────────────┼─────────────────┤
│ dense_3 (Dense)                      │ (None, 10)                  │           1,290 │
└──────────────────────────────────────┴─────────────────────────────┴─────────────────┘
 Total params: 111,370 (435.04 KB)
 Trainable params: 110,922 (433.29 KB)
```

```
# After training your model, save it to a file
model.save('fashion_mnist_cnn_model.h5')
```

```
WARNING:absl:You are saving your model as an HDF5 file via `model.save()` or `keras.saving.save_model(model)`. This file format is consi
```