In [1]:

```
import tensorflow as tf
from tensorflow.keras import layers, models
from tensorflow.keras.datasets import mnist
from tensorflow.keras.utils import to_categorical
from tensorflow.keras.regularizers import l2

# Load and preprocess MNIST dataset
(train_images, train_labels), (test_images, test_labels) = mnist.load_data()
train_images = train_images.reshape((60000, 28, 28, 1)).astype('float32') / 255
test_images = test_images.reshape((10000, 28, 28, 1)).astype('float32') / 255

train_labels = to_categorical(train_labels)
test_labels = to_categorical(test_labels)

# Define CNN model with regularization and dropout
model = models.Sequential([
    layers.Conv2D(32, (3, 3), activation='relu', kernel_regularizer=l2(0.01), input_shape=(28, 28, 1)),
    layers.MaxPooling2D((2, 2)),
    layers.Conv2D(64, (3, 3), activation='relu', kernel_regularizer=l2(0.01)),
    layers.MaxPooling2D((2, 2)),
    layers.Conv2D(64, (3, 3), activation='relu', kernel_regularizer=l2(0.01)),
    layers.Flatten(),
    layers.Dense(64, activation='relu', kernel_regularizer=l2(0.01)),
    layers.Dropout(0.5),
    layers.Dense(10, activation='softmax')
])

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

# Train the model
history = model.fit(train_images, train_labels, epochs=10, batch_size=64, validation_split=0.2)

# Evaluate the model on the test set
test_loss, test_acc = model.evaluate(test_images, test_labels)
print(f'Test accuracy: {test_acc}')

# Plot training history
import matplotlib.pyplot as plt
```

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plt.plot(history.history['accuracy'], label='Training Accuracy')
plt.plot(history.history['val_accuracy'], label='Validation Accuracy')
plt.xlabel('Epochs')
plt.ylabel('Accuracy')
plt.legend()
plt.show()
```

```
WARNING:tensorflow:From C:\Users\91707\anaconda3\lib\site-packages\keras\src\losses.py:2976: The name tf.losses.sparse_softmax_cross_entropy is deprecated. Please use tf.compat.v1.losses.sparse_softmax_cross_entropy instead.

WARNING:tensorflow:From C:\Users\91707\anaconda3\lib\site-packages\keras\src\backend.py:873: The name tf.get_default_graph is deprecated. Please use tf.compat.v1.get_default_graph instead.

WARNING:tensorflow:From C:\Users\91707\anaconda3\lib\site-packages\keras\src\layers\pooling\max_pooling2d.py:161: The name tf.nn.max_pool is deprecated. Please use tf.nn.max_pool2d instead.

WARNING:tensorflow:From C:\Users\91707\anaconda3\lib\site-packages\keras\src\optimizers\__init__.py:309: The name tf.train.Optimizer is deprecated. Please use tf.compat.v1.train.Optimizer instead.

Epoch 1/10
WARNING:tensorflow:From C:\Users\91707\anaconda3\lib\site-packages\keras\src\utils\tf_utils.py:492: The name tf.ragged.RaggedTensorValue is deprecated. Please use tf.compat.v1.ragged.RaggedTensorValue instead.

WARNING:tensorflow:From C:\Users\91707\anaconda3\lib\site-packages\keras\src\engine\base_layer_utils.py:384: The name tf.executing_eagerly_outside_functions is deprecated. Please use tf.compat.v1.executing_eagerly_outside_functions instead.

750/750 [==============================] - 9s 11ms/step - loss: 1.0104 - accuracy: 0.8430 - val_loss: 0.4412 - val_accuracy: 0.9604
Epoch 2/10
750/750 [==============================] - 8s 11ms/step - loss: 0.5194 - accuracy: 0.9309 - val_loss: 0.3836 - val_accuracy: 0.9658
Epoch 3/10
750/750 [==============================] - 10s 14ms/step - loss: 0.4674 - accuracy: 0.9401 - val_loss: 0.3818 - val_accuracy: 0.9603
Epoch 4/10
750/750 [==============================] - 9s 12ms/step - loss: 0.4428 - accuracy: 0.9432 - val_loss: 0.3330 - val_accuracy: 0.9712
Epoch 5/10
750/750 [==============================] - 9s 11ms/step - loss: 0.4182 - accuracy: 0.9470 - val_loss: 0.3315 - val_accuracy: 0.9683
Epoch 6/10
750/750 [==============================] - 8s 11ms/step - loss: 0.4022 - accuracy: 0.9491 - val_loss: 0.3151 - val_accuracy: 0.9712
Epoch 7/10
750/750 [==============================] - 8s 10ms/step - loss: 0.3873 - accuracy: 0.9501 - val_loss: 0.3040 - val_accuracy: 0.9712
Epoch 8/10
750/750 [==============================] - 7s 10ms/step - loss: 0.3773 - accuracy: 0.9507 - val_loss: 0.3123 - val_accuracy: 0.9692
Epoch 9/10
750/750 [==============================] - 7s 10ms/step - loss: 0.3665 - accuracy: 0.9527 - val_loss: 0.2823 - val_accuracy: 0.9
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Epoch 10/10
750/750 [==============================] - 7s 10ms/step - loss: 0.3567 - accuracy: 0.9534 - val_loss: 0.2717 - val_accuracy: 0.9
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313/313 [==============================] - 1s 3ms/step - loss: 0.2618 - accuracy: 0.9778
Test accuracy: 0.9778000116348267
```