```python
#CNN Without regularisation
import tensorflow as tf
from tensorflow import keras
from tensorflow.keras import layers
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.metrics import confusion_matrix

# Load MNIST dataset
(x_train, y_train), (x_test, y_test) =
keras.datasets.mnist.load_data()

# Normalize and reshape data for CNN input
x_train, x_test = x_train / 255.0, x_test / 255.0
x_train = x_train.reshape(-1, 28, 28, 1)
x_test = x_test.reshape(-1, 28, 28, 1)

# Build CNN model (Without Regularization)
model = keras.Sequential([
    layers.Conv2D(32, (3,3), activation='relu',
input_shape=(28,28,1)),
    layers.MaxPooling2D((2,2)),
    layers.Conv2D(64, (3,3), activation='relu'),
    layers.MaxPooling2D((2,2)),
    layers.Flatten(),
    layers.Dense(128, activation='relu'),
    layers.Dense(10, activation='softmax')
])

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

# Train model
history = model.fit(x_train, y_train, epochs=5, batch_size=32,
validation_data=(x_test, y_test))

# Evaluate model
test_loss, test_acc = model.evaluate(x_test, y_test, verbose=2)
print(f"Test Accuracy: {test_acc:.4f}")

# Predict labels
y_pred = np.argmax(model.predict(x_test), axis=1)

# Confusion matrix
cm = confusion_matrix(y_test, y_pred)
```

```
# Plot confusion matrix
plt.figure(figsize=(8,6))
sns.heatmap(cm, annot=True, fmt='d', cmap='Blues',
xticklabels=range(10), yticklabels=range(10))
plt.xlabel("Predicted Label")
plt.ylabel("True Label")
plt.title("Confusion Matrix")
plt.show()

# Training & Validation Plots
plt.figure(figsize=(12, 4))

# Accuracy plot
plt.subplot(1, 2, 1)
plt.plot(history.history['accuracy'], label='Train Accuracy')
plt.plot(history.history['val_accuracy'], label='Validation Accuracy')
plt.xlabel('Epochs')
plt.ylabel('Accuracy')
plt.legend()
plt.title('Training vs Validation Accuracy')

# Loss plot
plt.subplot(1, 2, 2)
plt.plot(history.history['loss'], label='Train Loss')
plt.plot(history.history['val_loss'], label='Validation Loss')
plt.xlabel('Epochs')
plt.ylabel('Loss')
plt.legend()
plt.title('Training vs Validation Loss')

plt.show()
```

```
C:\Newanaconda\Lib\site-packages\keras\src\layers\convolutional\
base_conv.py:107: 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__(activity_regularizer=activity_regularizer,
**kwargs)

Epoch 1/5
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 14s 6ms/step - accuracy: 0.9111 - loss:
0.2815 - val_accuracy: 0.9870 - val_loss: 0.0424
Epoch 2/5
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 13s 7ms/step - accuracy: 0.9880 - loss:
0.0396 - val_accuracy: 0.9855 - val_loss: 0.0426
Epoch 3/5
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 13s 7ms/step - accuracy: 0.9911 - loss:
0.0277 - val_accuracy: 0.9920 - val_loss: 0.0258
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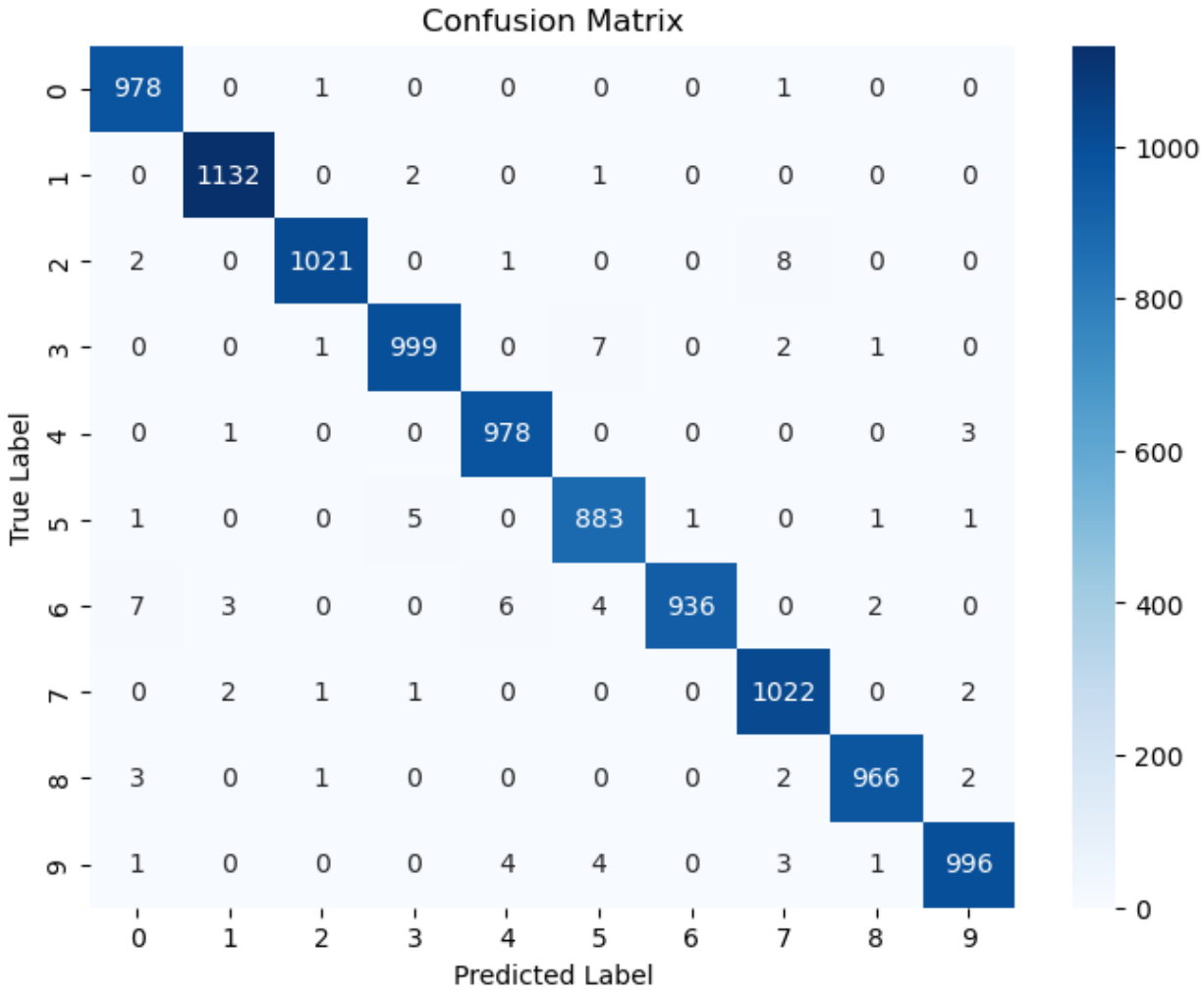
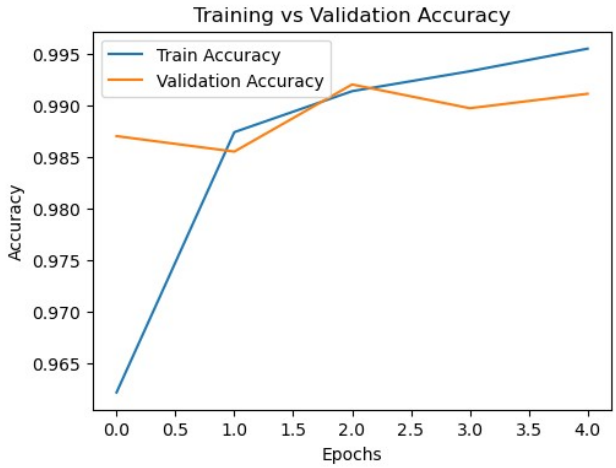
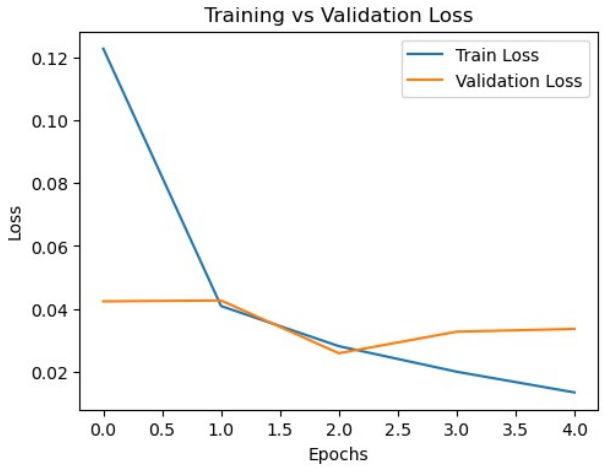
Epoch 4/5
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 13s 7ms/step - accuracy: 0.9945 - loss:
0.0166 - val_accuracy: 0.9897 - val_loss: 0.0327
Epoch 5/5
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 14s 7ms/step - accuracy: 0.9957 - loss:
0.0125 - val_accuracy: 0.9911 - val_loss: 0.0336
313/313 - 1s - 3ms/step - accuracy: 0.9911 - loss: 0.0336
Test Accuracy: 0.9911
313/313 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step
```








```
import tensorflow as tf
from tensorflow import keras
from tensorflow.keras import layers, regularizers
import numpy as np
import matplotlib.pyplot as plt

import seaborn as sns
from sklearn.metrics import confusion_matrix

# Load MNIST dataset
(x_train, y_train), (x_test, y_test) =
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# Normalize and reshape data for CNN input
x_train, x_test = x_train / 255.0, x_test / 255.0
x_train = x_train.reshape(-1, 28, 28, 1)
x_test = x_test.reshape(-1, 28, 28, 1)

# Build CNN model (With L1 & L2 Regularization, Dropout, and Batch
Normalization)
model = keras.Sequential([
    layers.Conv2D(32, (3,3), activation='relu',
                  kernel_regularizer=regularizers.l1_l2(l1=0.001,
l2=0.001),
                  input_shape=(28,28,1)),
    layers.BatchNormalization(),
    layers.MaxPooling2D((2,2)),
    layers.Dropout(0.3),

    layers.Conv2D(64, (3,3), activation='relu',
                  kernel_regularizer=regularizers.l1_l2(l1=0.001,
l2=0.001)),
    layers.BatchNormalization(),
    layers.MaxPooling2D((2,2)),
    layers.Dropout(0.3),
```

```
    layers.Flatten(),
    layers.Dense(128, activation='relu',
                 kernel_regularizer=regularizers.l1_l2(l1=0.001,
l2=0.001)),
    layers.Dropout(0.5),
    layers.Dense(10, activation='softmax')
])

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

# Train model
history = model.fit(x_train, y_train, epochs=10, batch_size=32,
validation_data=(x_test, y_test))

# Evaluate model
test_loss, test_acc = model.evaluate(x_test, y_test, verbose=2)
print(f"Test Accuracy: {test_acc:.4f}")

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sns.heatmap(cm, annot=True, fmt='d', cmap='Blues',
xticklabels=range(10), yticklabels=range(10))
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# Training & Validation Plots
plt.figure(figsize=(12, 4))

# Accuracy plot
plt.subplot(1, 2, 1)
plt.plot(history.history['accuracy'], label='Train Accuracy')
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plt.xlabel('Epochs')
plt.ylabel('Accuracy')
plt.legend()
plt.title('Training vs Validation Accuracy')

# Loss plot
```

```
plt.subplot(1, 2, 2)
plt.plot(history.history['loss'], label='Train Loss')
plt.plot(history.history['val_loss'], label='Validation Loss')
plt.xlabel('Epochs')
plt.ylabel('Loss')
plt.legend()
plt.title('Training vs Validation Loss')

plt.show()
```

```
C:\Newanaconda\Lib\site-packages\keras\src\layers\convolutional\
base_conv.py:107: 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__(activity_regularizer=activity_regularizer,
**kwargs)

Epoch 1/10
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 28s 13ms/step - accuracy: 0.8171 -
loss: 3.8357 - val_accuracy: 0.9757 - val_loss: 1.0343
Epoch 2/10
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 26s 14ms/step - accuracy: 0.9412 -
loss: 1.0958 - val_accuracy: 0.9780 - val_loss: 0.9483
Epoch 3/10
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 27s 14ms/step - accuracy: 0.9458 -
loss: 1.0038 - val_accuracy: 0.9718 - val_loss: 0.8445
Epoch 4/10
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 29s 15ms/step - accuracy: 0.9482 -
loss: 0.9075 - val_accuracy: 0.9814 - val_loss: 0.7289
Epoch 5/10
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 26s 14ms/step - accuracy: 0.9513 -
loss: 0.8368 - val_accuracy: 0.9810 - val_loss: 0.7227
Epoch 6/10
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 27s 14ms/step - accuracy: 0.9506 -
loss: 0.8176 - val_accuracy: 0.9821 - val_loss: 0.6631
Epoch 7/10
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 25s 13ms/step - accuracy: 0.9515 -
loss: 0.7890 - val_accuracy: 0.9821 - val_loss: 0.6501
Epoch 8/10
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 25s 13ms/step - accuracy: 0.9541 -
loss: 0.7465 - val_accuracy: 0.9781 - val_loss: 0.6953
Epoch 9/10
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 27s 14ms/step - accuracy: 0.9515 -
loss: 0.7622 - val_accuracy: 0.9843 - val_loss: 0.6539
Epoch 10/10
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 29s 16ms/step - accuracy: 0.9539 -
loss: 0.7479 - val_accuracy: 0.9808 - val_loss: 0.6703
313/313 - 1s - 4ms/step - accuracy: 0.9808 - loss: 0.6703
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Test Accuracy: 0.9808
313/313 ━━━━━━━━━━━━━━━━━━━━ 2s 5ms/step
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