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▼ first we want to read the files

Design and implement a CNN model for digit recognition application

```
import pandas as pd
```

Double-click (or enter) to edit

```
train_data_dir = 'train.csv'
test_data_dir = 'test.csv'
```

```
train_data = pd.read_csv(train_data_dir)
test_data = pd.read_csv(test_data_dir)
```

```
train_data.head()
```

	label	pixel0	pixel1	pixel2	pixel3	pixel4	pixel5	pixel6	pixel7	pixel8	...	pixel774	pixel775	pixel776	pixel777	pixel778	p:
0	1	0	0	0	0	0	0	0	0	0	...	0.0	0.0	0.0	0.0	0.0	
1	0	0	0	0	0	0	0	0	0	0	...	0.0	0.0	0.0	0.0	0.0	
2	1	0	0	0	0	0	0	0	0	0	...	0.0	0.0	0.0	0.0	0.0	
3	4	0	0	0	0	0	0	0	0	0	...	0.0	0.0	0.0	0.0	0.0	
4	0	0	0	0	0	0	0	0	0	0	...	0.0	0.0	0.0	0.0	0.0	

5 rows × 785 columns

▼ Now we want to see some images in the train file

```
import numpy as np
import matplotlib.pyplot as plt
```

Randomly select 5 rows

```
num_samples = 5
selected_rows = train_data.sample(num_samples)
```

Extract the labels and pixel values

```
labels = selected_rows['label']
pixels = selected_rows.drop(columns=['label'])
```

Reshape pixel values into 28x28 images

```
images = pixels.values.reshape(-1, 28, 28)
```

Create a figure to display the images

```
plt.figure(figsize=(12, 5))
```

```
<Figure size 1200x500 with 0 Axes>
<Figure size 1200x500 with 0 Axes>
```

Plot the images

```

for i in range(num_samples):
    plt.subplot(1, num_samples, i + 1)
    plt.imshow(images[i], cmap='copper')
    plt.title(f"Label: {labels.iloc[i]}")
    plt.axis('off')
plt.show()

```



▼ Now we want to Normalize and create model

```

import pandas as pd
import numpy as np
import tensorflow as tf
from tensorflow.keras.preprocessing.image import ImageDataGenerator
from sklearn.model_selection import train_test_split

```

Load our CSV files again

```

train_df = pd.read_csv('train.csv')
test_df = pd.read_csv('test.csv')

```

Extract the pixel values and labels from the data

```

train_pixels = train_df.drop(columns=['label']).values
train_labels = train_df['label'].values

```

Normalize the pixel values to the range [0, 1]

```

train_pixels = train_pixels / 255.0

```

Reshape the pixel values to the appropriate shape for image data

```

train_images = train_pixels.reshape(-1, 28, 28, 1)

```

Split the data into training and validation sets

```

train_images, valid_images, train_labels, valid_labels = train_test_split(
    train_images,
    train_labels,
    test_size=0.2,
    random_state=42
)

```

Set the seed

```

tf.random.set_seed(42)

```

Create an ImageDataGenerator for data augmentation

```

train_datagen = ImageDataGenerator(rescale=1./255)
valid_datagen = ImageDataGenerator(rescale=1./255)

```

Create data generators from the preprocessed data

```

train_data = train_datagen.flow(
    x=train_images,
    y=train_labels,
    batch_size=32,
    seed=42
)
valid_data = valid_datagen.flow(
    x=valid_images,
    y=valid_labels,
    batch_size=32,
    seed=42
)

```

Create CNN model

```

model = tf.keras.models.Sequential([
    tf.keras.layers.Conv2D(filters=10,
                           kernel_size=3,
                           activation="relu",
                           input_shape=(28, 28, 1)),
    tf.keras.layers.Conv2D(10, 3, activation="relu"),
    tf.keras.layers.MaxPool2D(pool_size=2,
                              padding="valid"),
    tf.keras.layers.Conv2D(10, 3, activation="relu"),
    tf.keras.layers.Conv2D(10, 3, activation="relu"),
    tf.keras.layers.MaxPool2D(2),
    tf.keras.layers.Flatten(),
    tf.keras.layers.Dense(10, activation="softmax")
])

```

Compile the model

```

model.compile(loss="sparse_categorical_crossentropy",
              optimizer=tf.keras.optimizers.Adam(),
              metrics=["accuracy"])

```

Fit the model

```

history = model.fit(train_data,
                    epochs=5,
                    steps_per_epoch=len(train_data),
                    validation_data=valid_data,
                    validation_steps=len(valid_data))

Epoch 1/5
144/144 [=====] - 4s 21ms/step - loss: nan - accuracy: 0.0923 - val_loss: nan - val_accuracy: 0.1081
Epoch 2/5
144/144 [=====] - 4s 27ms/step - loss: nan - accuracy: 0.0951 - val_loss: nan - val_accuracy: 0.1081
Epoch 3/5
144/144 [=====] - 3s 20ms/step - loss: nan - accuracy: 0.0951 - val_loss: nan - val_accuracy: 0.1081
Epoch 4/5
144/144 [=====] - 2s 16ms/step - loss: nan - accuracy: 0.0951 - val_loss: nan - val_accuracy: 0.1081
Epoch 5/5
144/144 [=====] - 2s 16ms/step - loss: nan - accuracy: 0.0951 - val_loss: nan - val_accuracy: 0.1081

```

Now we want to plot training_loss, val_loss, training_accuracy and val_accuracy

```

import matplotlib.pyplot as plt

def plot_loss_curves(history):
    """
    Returns separate loss curves for training and validation metrics.
    """
    loss = history.history['loss']
    val_loss = history.history['val_loss']

    accuracy = history.history['accuracy']
    val_accuracy = history.history['val_accuracy']

    epochs = range(len(history.history['loss']))

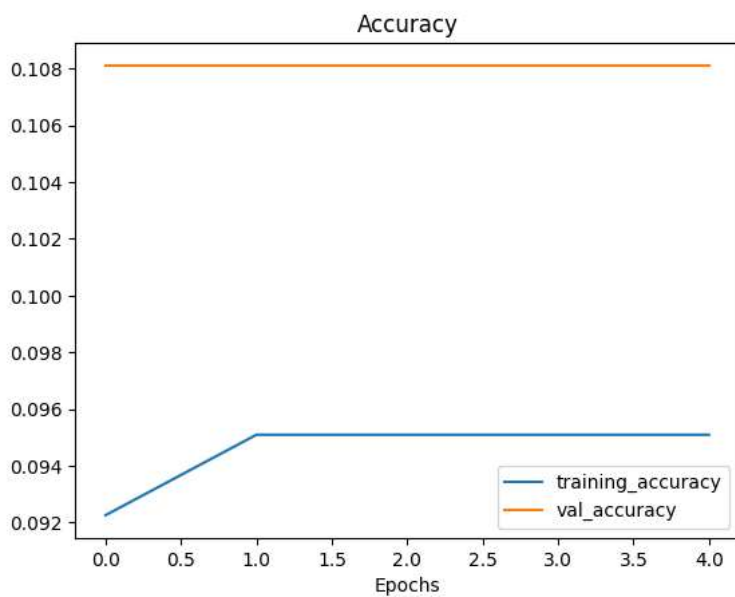
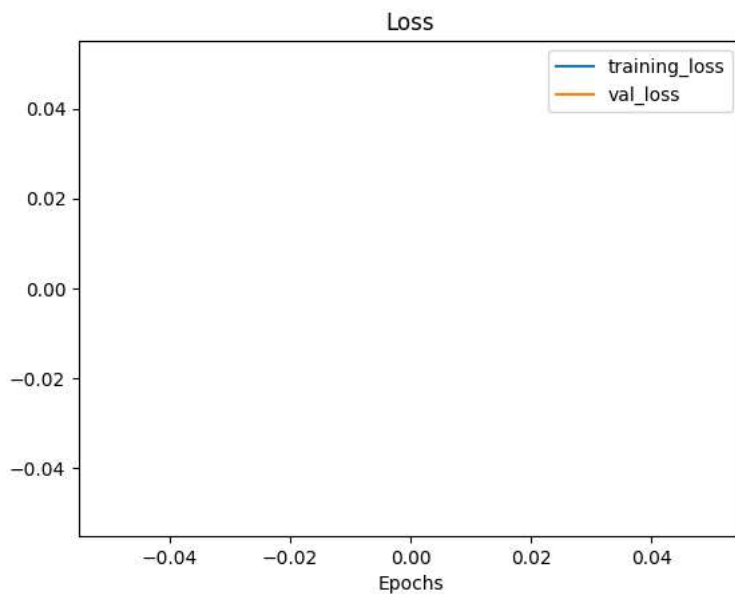
```

```
# Plot loss
plt.plot(epochs, loss, label='training_loss')
plt.plot(epochs, val_loss, label='val_loss')
plt.title('Loss')
plt.xlabel('Epochs')
plt.legend()

# Plot accuracy
plt.figure()
plt.plot(epochs, accuracy, label='training_accuracy')
plt.plot(epochs, val_accuracy, label='val_accuracy')
plt.title('Accuracy')
plt.xlabel('Epochs')
plt.legend();
```

Check out the loss curves of model

```
plot_loss_curves(history)
```



▼ Now we want to predict on test data

Preprocess the test data

```
test_pixels = test_df.values / 255.0 # Normalize the pixel values
test_images = test_pixels.reshape(-1, 28, 28, 1)
```

Use the trained model to make predictions

```
predictions = model.predict(test_images)

162/162 [=====] - 1s 5ms/step
```

Convert the predicted probabilities to class labels

```
predicted_labels = np.argmax(predictions, axis=1)
```

▼ Convert the predicted labels to a DataFrame with 'ImageId' and 'Label' columns

```
image_ids = range(1, len(predicted_labels) + 1)
submission_df = pd.DataFrame({'ImageId': image_ids, 'Label': predicted_labels})
```

Save the DataFrame to a CSV file

```
submission_df.to_csv('submission.csv', index=False)
```

Because of we don't have the actual labels for the test data, we won't be able to calculate traditional evaluation metrics like accuracy, precision, recall, or F1-score, as these metrics require a ground truth for comparison.

However, we can still get an idea of how well your model is performing on the test data by doing **Visual Inspection**

Visual Inspection: Take a look at some of the predicted labels and corresponding images to get a qualitative sense of the model's performance. We can use matplotlib to display the images and predicted labels.

```
import matplotlib.pyplot as plt

# Display some random test images with their predicted labels
num_samples_to_display = 10
random_indices = np.random.choice(len(predicted_labels), num_samples_to_display, replace=False)

for i, idx in enumerate(random_indices):
    plt.subplot(2, 5, i + 1)
    plt.imshow(test_images[idx].reshape(28, 28), cmap='summer')
    plt.title(f'Predicted: {predicted_labels[idx]}')
    plt.axis('off')

plt.tight_layout()
plt.show()
```

