Detection-of-Manipulated-and-Authentic-Images

Dataset Summary: Link

The dataset is divided into three sets: training, testing, and validation. Each set contains 'real' and 'fake' images.

Here is a breakdown of the number of images in each category:

Set	Type	Count
Training	Fake	20001
Training	Real	20001
Total Training		**40002**
------------	------	-------
Validation	Fake	6161
Validation	Real	6199
Total Validation		**12360**
------------	------	-------
Testing	Fake	2623
Testing	Real	2604
Total Testing		**5227**
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Grand Total		**57589**

2. Project Requirements

2.1 Data Preparation

- Choose a dataset containing both real and fake samples in the selected media type. ▯
- Split the dataset into training, validation, and testing sets. ▯

```python
import tensorflow as tf
import os
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.metrics import classification_report, confusion_matrix

os.chdir(r'D:\Projects\Software_Engineering\Artificial_Intelligence\
Detection-of-Manipulated-and-Authentic-Images\Dataset')
```

- Perform necessary preprocessing steps (e.g., resizing, normalization, noise removal, feature extraction).

```python
# Define image size and batch size
IMG_SIZE = (256, 256)
```

```python
BATCH_SIZE = 16
AUTOTUNE = tf.data.AUTOTUNE

# Load train dataset
train_dataset = tf.keras.utils.image_dataset_from_directory(
    'train',
    labels='inferred',
    label_mode='binary',
    image_size=IMG_SIZE,
    interpolation='nearest',
    batch_size=BATCH_SIZE,
    shuffle=True
)

# Load validation dataset
validation_dataset = tf.keras.utils.image_dataset_from_directory(
    'validation',
    labels='inferred',
    label_mode='binary',
    image_size=IMG_SIZE,
    interpolation='nearest',
    batch_size=BATCH_SIZE,
    shuffle=False
)

# Load test dataset
test_dataset = tf.keras.utils.image_dataset_from_directory(
    'test',
    labels='inferred',
    label_mode='binary',
    image_size=IMG_SIZE,
    interpolation='nearest',
    batch_size=BATCH_SIZE,
    shuffle=False
)
```

```
Found 40002 files belonging to 2 classes.
Found 12360 files belonging to 2 classes.
Found 5227 files belonging to 2 classes.
```

2.2 Model Design

- Build a neural network manually
- Clearly define the architecture:
  - Number of layers
  - Activation functions
  - Loss function
  - Optimization method
  - Hyperparameters (learning rate, batch size, epochs, etc.)

```
inputs = tf.keras.Input(shape=(IMG_SIZE[0], IMG_SIZE[1], 3))

# Data Augmentation
x = tf.keras.layers.RandomFlip("horizontal")(inputs)
x = tf.keras.layers.RandomRotation(0.1)(x)
x = tf.keras.layers.RandomZoom(0.1)(x)

# Rescaling
x = tf.keras.layers.Rescaling(1./255)(x)

# Block 1
x = tf.keras.layers.Conv2D(32, 3, padding='same', activation='relu')
(x)
x = tf.keras.layers.BatchNormalization()(x)
x = tf.keras.layers.MaxPooling2D()(x)
x = tf.keras.layers.Dropout(0.2)(x)

# Block 2
x = tf.keras.layers.Conv2D(64, 3, padding='same', activation='relu')
(x)
x = tf.keras.layers.BatchNormalization()(x)
x = tf.keras.layers.MaxPooling2D()(x)
x = tf.keras.layers.Dropout(0.2)(x)

# Block 3
x = tf.keras.layers.Conv2D(128, 3, padding='same', activation='relu')
(x)
x = tf.keras.layers.BatchNormalization()(x)
x = tf.keras.layers.MaxPooling2D()(x)
x = tf.keras.layers.Dropout(0.3)(x)

# Block 4
x = tf.keras.layers.Conv2D(256, 3, padding='same', activation='relu')
(x)
x = tf.keras.layers.BatchNormalization()(x)
x = tf.keras.layers.MaxPooling2D()(x)
x = tf.keras.layers.Dropout(0.4)(x)

# Flatten and Dense
x = tf.keras.layers.Flatten()(x)
x = tf.keras.layers.Dense(512, activation='relu')(x)
x = tf.keras.layers.BatchNormalization()(x)
x = tf.keras.layers.Dropout(0.5)(x)
outputs = tf.keras.layers.Dense(1, activation='sigmoid')(x)

model = tf.keras.Model(inputs, outputs)

model.compile(
    optimizer='adam',
    loss='binary_crossentropy',
    metrics=['accuracy']
)

epochs = 20
callbacks = [
    tf.keras.callbacks.EarlyStopping(monitor='val_loss', patience=5,
restore_best_weights=True),
    tf.keras.callbacks.ReduceLROnPlateau(monitor='val_loss',
factor=0.2, patience=3, min_lr=1e-6)
]

history = model.fit(
    train_dataset,
    validation_data=validation_dataset,
    epochs=epochs,
    callbacks=callbacks
)
```

```
Epoch 1/20
2501/2501 ━━━━━━━━━━━━━━━━━━━━ 3413s 1s/step - accuracy: 0.6032 -
loss: 0.7580 - val_accuracy: 0.6545 - val_loss: 0.6247 -
learning_rate: 0.0010
Epoch 2/20
2501/2501 ━━━━━━━━━━━━━━━━━━━━ 4202s 2s/step - accuracy: 0.6872 -
loss: 0.5877 - val_accuracy: 0.7304 - val_loss: 0.5690 -
learning_rate: 0.0010
Epoch 3/20
2501/2501 ━━━━━━━━━━━━━━━━━━━━ 4270s 2s/step - accuracy: 0.7576 -
loss: 0.4898 - val_accuracy: 0.8531 - val_loss: 0.3377 -
learning_rate: 0.0010
Epoch 4/20
2501/2501 ━━━━━━━━━━━━━━━━━━━━ 4258s 2s/step - accuracy: 0.8426 -
loss: 0.3554 - val_accuracy: 0.8626 - val_loss: 0.3188 -
learning_rate: 0.0010
Epoch 5/20
2501/2501 ━━━━━━━━━━━━━━━━━━━━ 4267s 2s/step - accuracy: 0.8695 -
loss: 0.3046 - val_accuracy: 0.8821 - val_loss: 0.2769 -
learning_rate: 0.0010
Epoch 6/20
2501/2501 ━━━━━━━━━━━━━━━━━━━━ 4142s 2s/step - accuracy: 0.8751 -
loss: 0.2911 - val_accuracy: 0.9117 - val_loss: 0.2219 -
learning_rate: 0.0010
Epoch 7/20
2501/2501 ━━━━━━━━━━━━━━━━━━━━ 3220s 1s/step - accuracy: 0.8790 -
loss: 0.2837 - val_accuracy: 0.9118 - val_loss: 0.2116 -
learning_rate: 0.0010
Epoch 8/20
2501/2501 ━━━━━━━━━━━━━━━━━━━━ 3330s 1s/step - accuracy: 0.8850 -
loss: 0.2677 - val_accuracy: 0.9049 - val_loss: 0.2241 -
learning_rate: 0.0010
```

```
Epoch 9/20
2501/2501 ━━━━━━━━━━━━━━━━━━━━ 4201s 2s/step - accuracy: 0.8933 -
loss: 0.2540 - val_accuracy: 0.9028 - val_loss: 0.2433 -
learning_rate: 0.0010
Epoch 10/20
2501/2501 ━━━━━━━━━━━━━━━━━━━━ 4250s 2s/step - accuracy: 0.8816 -
loss: 0.2813 - val_accuracy: 0.9047 - val_loss: 0.2219 -
learning_rate: 0.0010
Epoch 11/20
2501/2501 ━━━━━━━━━━━━━━━━━━━━ 4281s 2s/step - accuracy: 0.9070 -
loss: 0.2227 - val_accuracy: 0.9303 - val_loss: 0.1779 -
learning_rate: 2.0000e-04
Epoch 12/20
2501/2501 ━━━━━━━━━━━━━━━━━━━━ 4237s 2s/step - accuracy: 0.9140 -
loss: 0.2081 - val_accuracy: 0.9290 - val_loss: 0.1787 -
learning_rate: 2.0000e-04
Epoch 13/20
2501/2501 ━━━━━━━━━━━━━━━━━━━━ 4185s 2s/step - accuracy: 0.9193 -
loss: 0.1963 - val_accuracy: 0.9322 - val_loss: 0.1719 -
learning_rate: 2.0000e-04
Epoch 14/20
2501/2501 ━━━━━━━━━━━━━━━━━━━━ 3749s 1s/step - accuracy: 0.9223 -
loss: 0.1949 - val_accuracy: 0.9383 - val_loss: 0.1615 -
learning_rate: 2.0000e-04
Epoch 15/20
2501/2501 ━━━━━━━━━━━━━━━━━━━━ 4105s 2s/step - accuracy: 0.9230 -
loss: 0.1875 - val_accuracy: 0.9396 - val_loss: 0.1557 -
learning_rate: 2.0000e-04
Epoch 16/20
2501/2501 ━━━━━━━━━━━━━━━━━━━━ 4140s 2s/step - accuracy: 0.9263 -
loss: 0.1847 - val_accuracy: 0.9379 - val_loss: 0.1583 -
learning_rate: 2.0000e-04
Epoch 17/20
2501/2501 ━━━━━━━━━━━━━━━━━━━━ 4080s 2s/step - accuracy: 0.9288 -
loss: 0.1782 - val_accuracy: 0.9368 - val_loss: 0.1563 -
learning_rate: 2.0000e-04
Epoch 18/20
2501/2501 ━━━━━━━━━━━━━━━━━━━━ 3958s 2s/step - accuracy: 0.9263 -
loss: 0.1839 - val_accuracy: 0.9375 - val_loss: 0.1560 -
learning_rate: 2.0000e-04
Epoch 19/20
2501/2501 ━━━━━━━━━━━━━━━━━━━━ 3560s 1s/step - accuracy: 0.9287 -
loss: 0.1784 - val_accuracy: 0.9390 - val_loss: 0.1517 -
learning_rate: 4.0000e-05
Epoch 20/20
2501/2501 ━━━━━━━━━━━━━━━━━━━━ 4089s 2s/step - accuracy: 0.9296 -
loss: 0.1718 - val_accuracy: 0.9397 - val_loss: 0.1488 -
learning_rate: 4.0000e-05
```

```
loss, accuracy = model.evaluate(test_dataset)
print(f'Test Loss: {loss}')
print(f'Test Accuracy: {accuracy}')
```

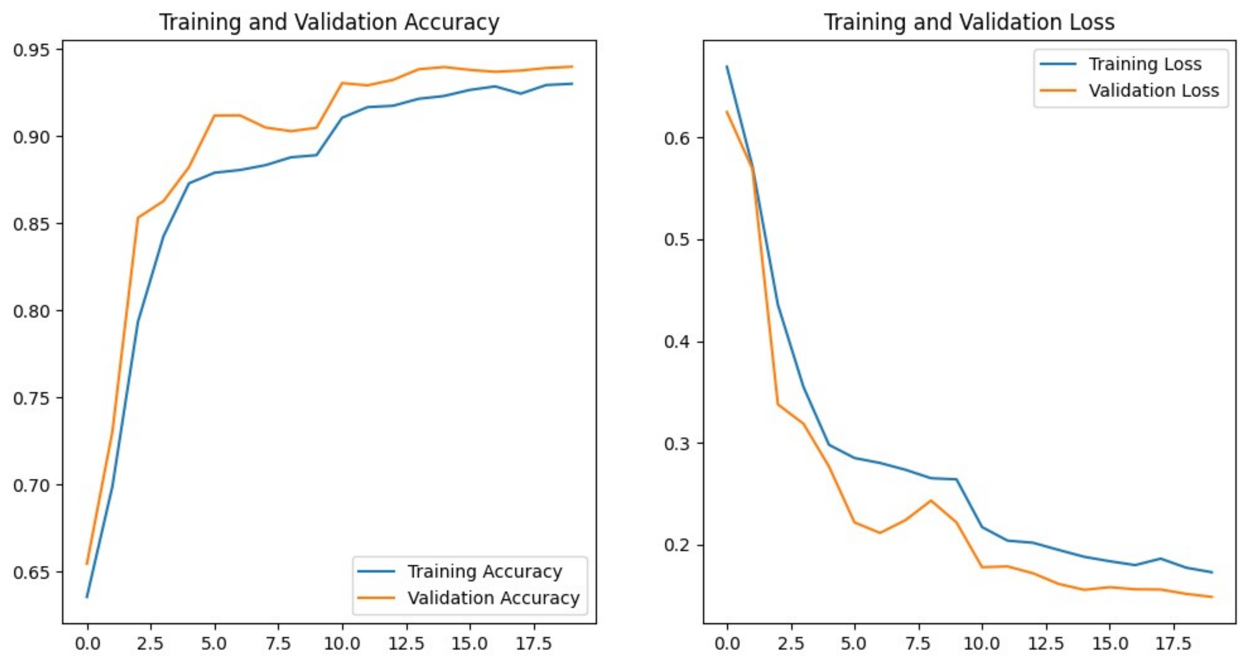
```
327/327 ━━━━━━━━━━━━━━━━━━━━ 65s 195ms/step - accuracy: 0.7933 - loss:
0.4992
Test Loss: 0.6715439558029175
Test Accuracy: 0.757604718208313
```

```
acc = history.history['accuracy']
val_acc = history.history['val_accuracy']
loss = history.history['loss']
val_loss = history.history['val_loss']

epochs_range = range(epochs)

plt.figure(figsize=(12, 6))
plt.subplot(1, 2, 1)
plt.plot(epochs_range, acc, label='Training Accuracy')
plt.plot(epochs_range, val_acc, label='Validation Accuracy')
plt.legend(loc='lower right')
plt.title('Training and Validation Accuracy')

plt.subplot(1, 2, 2)
plt.plot(epochs_range, loss, label='Training Loss')
plt.plot(epochs_range, val_loss, label='Validation Loss')
plt.legend(loc='upper right')
plt.title('Training and Validation Loss')
plt.show()
```



2.3 Training and Evaluation

- Train the model using the prepared dataset.
- Validate the model during training to avoid overfitting.
- Evaluate final performance using metrics such as:
  - Accuracy
  - Precision / Recall / F1-Score
  - Confusion Matrix
- Provide a discussion of the results.

```
# Get predictions
y_pred = []
y_true = []
for images, labels in test_dataset:
    y_true.extend(labels.numpy())
    y_pred.extend(model.predict(images).flatten().round()) # Use
extend for lists

print('Classification Report:')
print(classification_report(y_true, y_pred, target_names=['real',
'fake']))

print('Confusion Matrix:')
cm = confusion_matrix(y_true, y_pred)
plt.figure(figsize=(8, 6))
sns.heatmap(cm, annot=True, fmt='d', cmap='Blues',
xticklabels=['real', 'fake'], yticklabels=['real', 'fake'])
plt.xlabel('Predicted')
plt.ylabel('True')
plt.title('Confusion Matrix')
plt.show()
```

```
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 540ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 261ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 232ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 289ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 278ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 246ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 244ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 239ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 260ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 240ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 241ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 227ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 238ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 231ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 254ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 223ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 229ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 232ms/step
```

```
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 231ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 238ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 237ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 236ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 246ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 239ms/step
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1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 242ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 250ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 242ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 295ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 243ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 244ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 255ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 231ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 234ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 233ms/step
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1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 241ms/step
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1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 238ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 240ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 243ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 236ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 237ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 242ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 237ms/step
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1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 238ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 236ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 247ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 315ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 238ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 239ms/step
```

```
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 243ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 248ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 233ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 243ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 232ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 242ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 239ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 230ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 227ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 229ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 238ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 259ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 234ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 229ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 233ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 237ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 232ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 233ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 227ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 241ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 235ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 229ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 235ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 232ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 243ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 231ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 229ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 227ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 230ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 233ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 232ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 264ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 249ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 251ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 239ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 261ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 249ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 233ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 229ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 257ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 260ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 377ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 269ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 273ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 249ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 228ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 247ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 214ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 250ms/step
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1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 230ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 219ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 215ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 212ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 214ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 209ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 211ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 219ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 220ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 238ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 219ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 252ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 215ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 221ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 238ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 239ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 229ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 232ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 234ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 218ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 216ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 217ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 218ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 219ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 225ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 222ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 244ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 223ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 218ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 216ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 216ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 219ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 229ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 241ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 216ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 218ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 225ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 226ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 219ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 213ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 210ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 213ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 220ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 222ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 237ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 236ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 229ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 222ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 216ms/step
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1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 212ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 209ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 215ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 210ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 220ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 218ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 214ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 217ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 217ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 221ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 218ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 229ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 224ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 235ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 215ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 224ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 238ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 226ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 241ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 235ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 237ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 228ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 227ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 215ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 218ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 215ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 223ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 217ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 219ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 218ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 262ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 224ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 215ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 225ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 215ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 217ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 211ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 214ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 230ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 219ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 218ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 210ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 212ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 215ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 219ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 215ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 217ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 214ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 214ms/step
```

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1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 217ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 214ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 220ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 219ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 219ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 213ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 213ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 213ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 217ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 221ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 214ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 218ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 212ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 216ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 216ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 211ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 214ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 218ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 221ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 216ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 212ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 214ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 216ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 215ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 212ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 212ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 213ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 215ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 210ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 219ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 212ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 216ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 214ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 218ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 218ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 230ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 231ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 218ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 214ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 209ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 219ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 213ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 219ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 219ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 218ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 213ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 222ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 226ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 213ms/step
```

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1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 214ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 211ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 211ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 213ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 242ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 212ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 213ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 212ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 214ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 213ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 217ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 215ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 218ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 216ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 217ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 216ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 210ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 217ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 215ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 215ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 216ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 215ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 218ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 214ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 213ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 216ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 217ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 217ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 216ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 216ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 211ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 211ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 211ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 217ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 220ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 215ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 219ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 216ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 213ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 215ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 218ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 214ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 214ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 211ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 237ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 212ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 214ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 211ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 214ms/step
```

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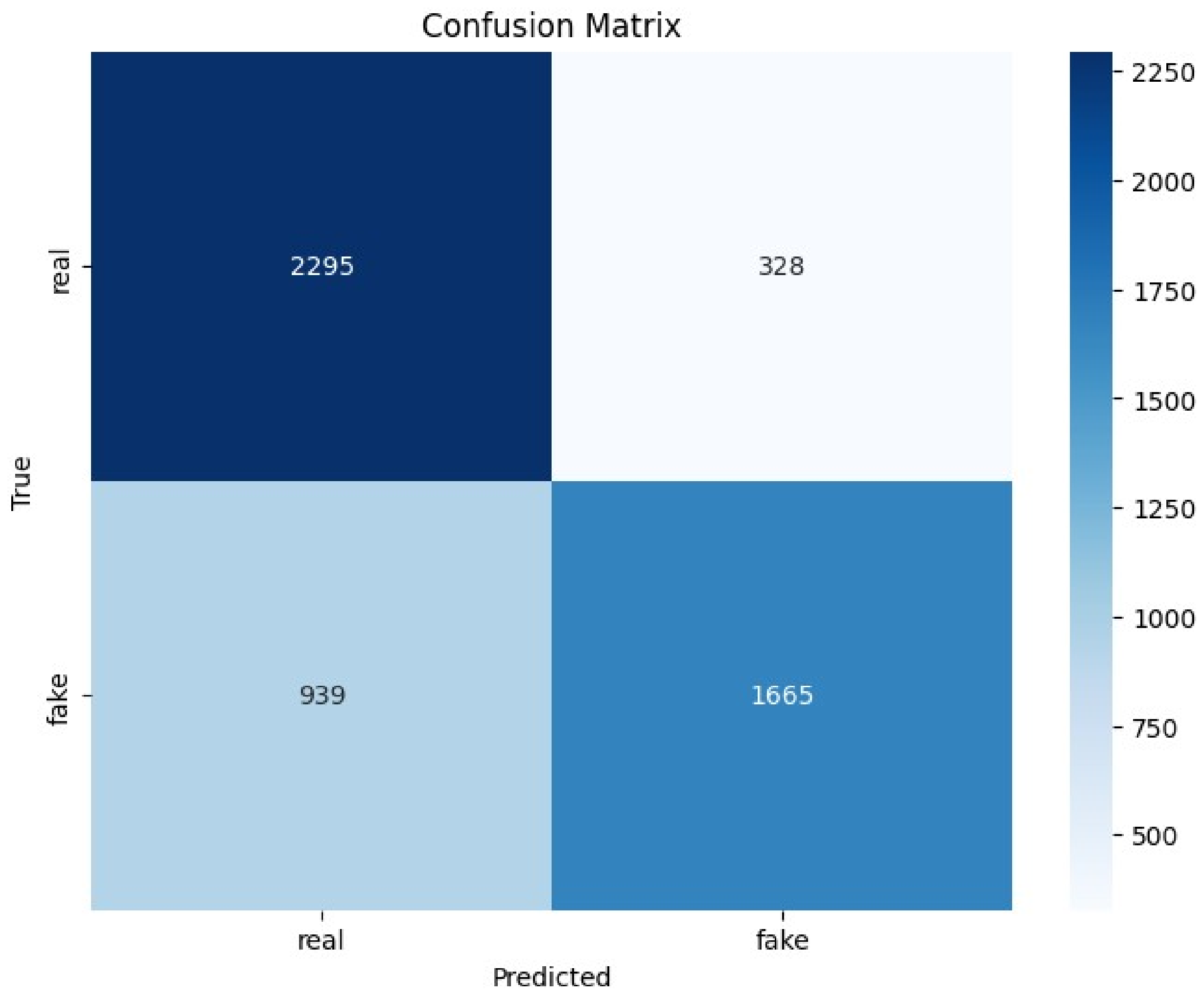
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 216ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 212ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 212ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 214ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 216ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 212ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 207ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 216ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 213ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 225ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 224ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 226ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 224ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 213ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 350ms/step
Classification Report:
              precision    recall  f1-score   support

        real       0.71      0.87      0.78      2623
        fake       0.84      0.64      0.72      2604

    accuracy                           0.76      5227
   macro avg       0.77      0.76      0.75      5227
weighted avg       0.77      0.76      0.75      5227

Confusion Matrix:
```



3. Deliverables

3.1 Source Code

- Complete and clean implementation
- Proper comments and modular structure
- Separate training, testing, and preprocessing scripts if possible

3.2 Presentation

- 5–8 minute presentation summarizing the project
- Slides should highlight the methodology, model structure, and results