```python
import tensorflow as tf
from tensorflow.keras import layers, models
from tensorflow.keras.applications import ResNet50, MobileNetV2
from tensorflow.keras.datasets import cifar10
import matplotlib.pyplot as plt
import numpy as np
from sklearn.metrics import confusion_matrix, ConfusionMatrixDisplay
from sklearn.metrics import  classification_report
import seaborn as sns
import os

# Load and preprocess the CIFAR-10 dataset
(x_train, y_train), (x_test, y_test) = cifar10.load_data()

# Normalize the pixel values to the range [0, 1]
x_train = x_train / 255.0
x_test = x_test / 255.0

# Convert class labels to one-hot encoding
y_train = tf.keras.utils.to_categorical(y_train, 10)
y_test = tf.keras.utils.to_categorical(y_test, 10)


# Displaying the shapes of a preprocessed data.
print("Training images shape:", x_train.shape)
print("Training labels shape:", y_train.shape)
print("Test images shape:", x_test.shape)
print("Test labels shape:", y_test.shape)
```

```
Training images shape: (50000, 32, 32, 3)
Training labels shape: (50000, 10)
Test images shape: (10000, 32, 32, 3)
Test labels shape: (10000, 10)
```

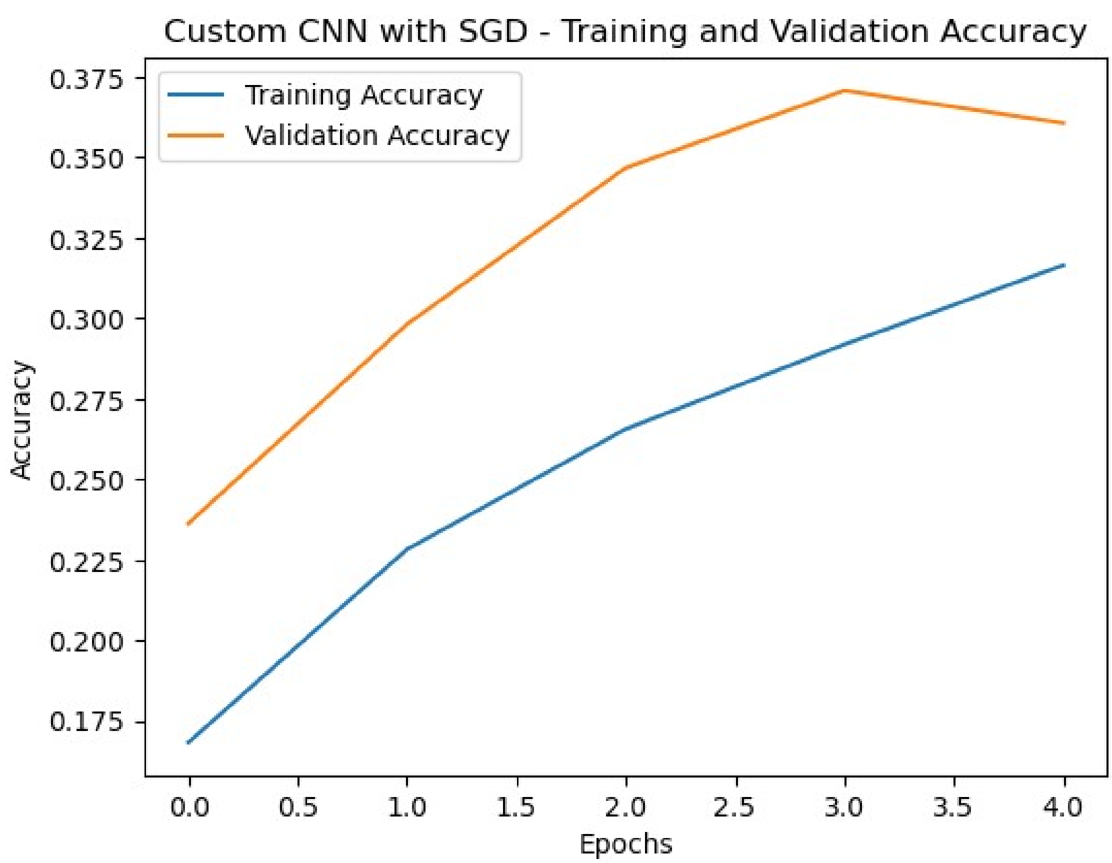
```python
# Data Augmentation
datagen = tf.keras.preprocessing.image.ImageDataGenerator(
    rotation_range=20,
    width_shift_range=0.2,
    height_shift_range=0.2,
    horizontal_flip=True
)
datagen.fit(x_train)

# Custom CNN Model
def create_custom_cnn_model():
    model = models.Sequential([
        layers.Conv2D(32, (3, 3), activation='relu', input_shape=(32,
32, 3)),
        layers.MaxPooling2D((2, 2)),
        layers.Conv2D(64, (3, 3), activation='relu'),
        layers.MaxPooling2D((2, 2)),
```

```
        layers.Conv2D(128, (3, 3), activation='relu'),
        layers.Flatten(),
        layers.Dense(128, activation='relu'),
        layers.Dropout(0.5),
        layers.Dense(10, activation='softmax')
    ])
    return model

# ResNet-18 Model from Scratch
def create_resnet18_model():
    from tensorflow.keras.applications import ResNet50
    base_model = ResNet50(weights=None, input_shape=(32, 32, 3),
classes=10)
    return base_model

def create_alexnet_model():
    model = models.Sequential([
        layers.Conv2D(96, (3, 3), activation='relu', input_shape=(32,
32, 3), padding='same'),
        layers.MaxPooling2D(pool_size=(2, 2)),
        layers.Conv2D(256, (3, 3), activation='relu', padding='same'),
        layers.MaxPooling2D(pool_size=(2, 2)),
        layers.Conv2D(384, (3, 3), activation='relu', padding='same'),
        layers.Conv2D(384, (3, 3), activation='relu', padding='same'),
        layers.Conv2D(256, (3, 3), activation='relu', padding='same'),
        layers.MaxPooling2D(pool_size=(2, 2)),
        layers.Flatten(),
        layers.Dense(4096, activation='relu'),
        layers.Dropout(0.5),
        layers.Dense(4096, activation='relu'),
        layers.Dropout(0.5),
        layers.Dense(10, activation='softmax')
    ])
    return model

# training, and evaluating the model
def train_and_evaluate(model, optimizer_name, model_name):
    if optimizer_name == "SGD":
        optimizer = tf.keras.optimizers.SGD()
    elif optimizer_name == "Adam":
        optimizer = tf.keras.optimizers.Adam()
    elif optimizer_name == "RMSprop":
        optimizer = tf.keras.optimizers.RMSprop()
    else:
        raise ValueError("Unknown optimizer")


    model.compile(optimizer=optimizer,
loss='categorical_crossentropy', metrics=['accuracy'])
```

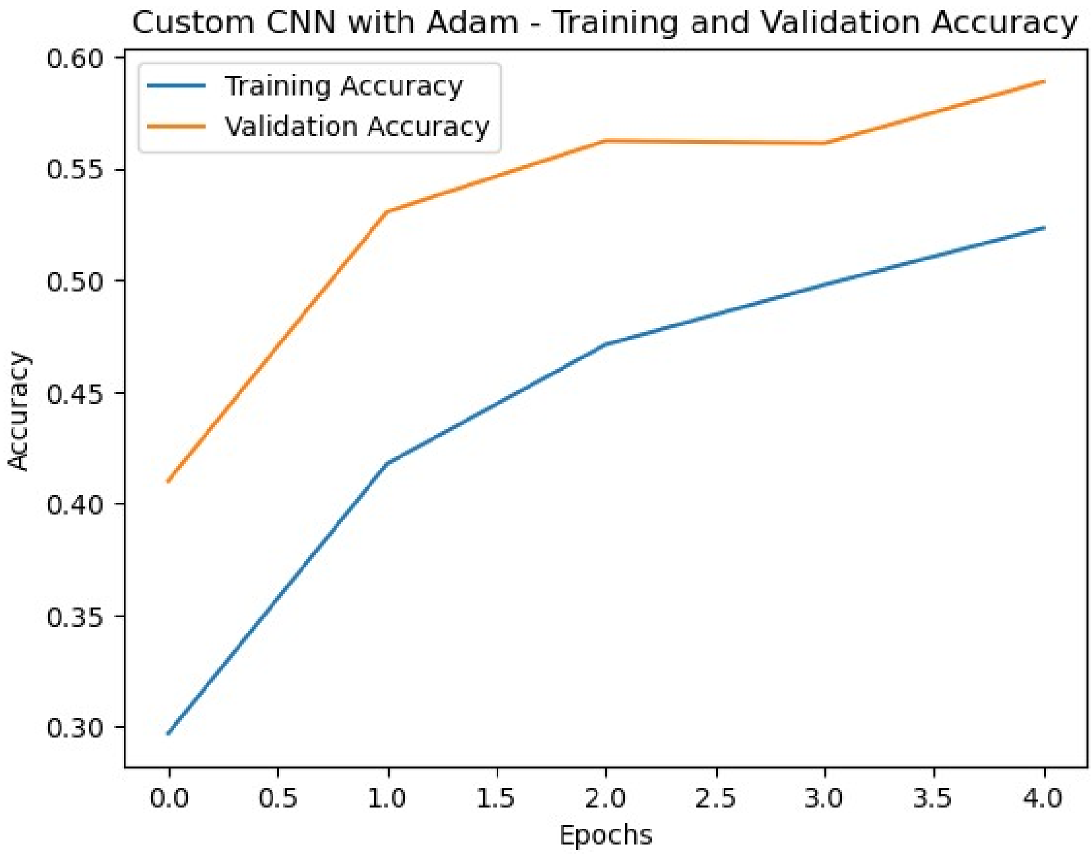
```
    # Training the model for 5 epochs
    history = model.fit(datagen.flow(x_train, y_train, batch_size=64),
                        epochs=5,
                        validation_data=(x_test, y_test),
                        verbose=1)

    # Evaluating the model
    loss, accuracy = model.evaluate(x_test, y_test, verbose=0)

    # Plot training and validation accuracy
    plt.plot(history.history['accuracy'], label='Training Accuracy')
    plt.plot(history.history['val_accuracy'], label='Validation
Accuracy')
    plt.title(f'{model_name} with {optimizer_name} - Training and
Validation Accuracy')
    plt.xlabel('Epochs')
    plt.ylabel('Accuracy')
    plt.legend()
    plt.show()

    #  model saving
    model.save(f"{model_name}_{optimizer_name}_model.h5")
    print(f"Model saved as {model_name}_{optimizer_name}_model.h5")


    return accuracy

# List of models and optimizers
models_list = [
    ("Custom CNN", create_custom_cnn_model),
    ("ResNet-18", create_resnet18_model),
    ("AlexNet", create_alexnet_model)
]

optimizers_list = ["SGD", "Adam", "RMSprop"]

# storing the results
results = {}

# Training each model with each optimizer and storing the results
for model_name, model_function in models_list:
    for optimizer_name in optimizers_list:
        print(f"\nTraining {model_name} with {optimizer_name}
optimizer...")
        model = model_function()
        accuracy = train_and_evaluate(model, optimizer_name,
model_name)
        results[f"{model_name} with {optimizer_name}"] = accuracy

# Predicting the best model
```

```
best_model = max(results, key=results.get)
best_accuracy = results[best_model]
print(f"\nBest Model: {best_model} with Accuracy: {best_accuracy *
100:.2f}%")
```

```
Training Custom CNN with SGD optimizer...
Epoch 1/5
782/782 ━━━━━━━━━━━━━━━━━━━━ 51s 64ms/step - accuracy: 0.1425 - loss:
2.2630 - val_accuracy: 0.2363 - val_loss: 2.0566
Epoch 2/5
782/782 ━━━━━━━━━━━━━━━━━━━━ 46s 59ms/step - accuracy: 0.2148 - loss:
2.0948 - val_accuracy: 0.2982 - val_loss: 1.9390
Epoch 3/5
782/782 ━━━━━━━━━━━━━━━━━━━━ 50s 64ms/step - accuracy: 0.2554 - loss:
2.0106 - val_accuracy: 0.3468 - val_loss: 1.8253
Epoch 4/5
782/782 ━━━━━━━━━━━━━━━━━━━━ 45s 57ms/step - accuracy: 0.2894 - loss:
1.9270 - val_accuracy: 0.3708 - val_loss: 1.7256
Epoch 5/5
782/782 ━━━━━━━━━━━━━━━━━━━━ 46s 58ms/step - accuracy: 0.3134 - loss:
1.8608 - val_accuracy: 0.3607 - val_loss: 1.7536
```



```
WARNING:absl:You are saving your model as an HDF5 file via
`model.save()` or `keras.saving.save_model(model)`. This file format
is considered legacy. We recommend using instead the native Keras
format, e.g. `model.save('my_model.keras')` or
`keras.saving.save_model(model, 'my_model.keras')`.

Model saved as Custom CNN_SGD_model.h5

Training Custom CNN with Adam optimizer...
Epoch 1/5
782/782 ━━━━━━━━━━━━━━━━━━━━ 48s 59ms/step - accuracy: 0.2321 - loss:
2.0277 - val_accuracy: 0.4101 - val_loss: 1.6282
Epoch 2/5
782/782 ━━━━━━━━━━━━━━━━━━━━ 49s 62ms/step - accuracy: 0.3981 - loss:
1.6354 - val_accuracy: 0.5306 - val_loss: 1.2958
Epoch 3/5
782/782 ━━━━━━━━━━━━━━━━━━━━ 48s 61ms/step - accuracy: 0.4641 - loss:
1.4923 - val_accuracy: 0.5624 - val_loss: 1.2237
Epoch 4/5
782/782 ━━━━━━━━━━━━━━━━━━━━ 45s 57ms/step - accuracy: 0.4915 - loss:
1.4183 - val_accuracy: 0.5613 - val_loss: 1.2291
Epoch 5/5
782/782 ━━━━━━━━━━━━━━━━━━━━ 47s 59ms/step - accuracy: 0.5145 - loss:
1.3636 - val_accuracy: 0.5889 - val_loss: 1.1459
```




```
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`keras.saving.save_model(model, 'my_model.keras')`.

Model saved as Custom CNN_Adam_model.h5

Training Custom CNN with RMSprop optimizer...
Epoch 1/5
782/782 ━━━━━━━━━━━━━━━━━━━━ 52s 65ms/step - accuracy: 0.2269 - loss:
2.0621 - val_accuracy: 0.4706 - val_loss: 1.4545
Epoch 2/5
782/782 ━━━━━━━━━━━━━━━━━━━━ 47s 59ms/step - accuracy: 0.4037 - loss:
1.6535 - val_accuracy: 0.4710 - val_loss: 1.4542
Epoch 3/5
782/782 ━━━━━━━━━━━━━━━━━━━━ 47s 60ms/step - accuracy: 0.4635 - loss:
1.4910 - val_accuracy: 0.5498 - val_loss: 1.2298
Epoch 4/5
782/782 ━━━━━━━━━━━━━━━━━━━━ 43s 55ms/step - accuracy: 0.5038 - loss:
1.3955 - val_accuracy: 0.6010 - val_loss: 1.1344
Epoch 5/5
```
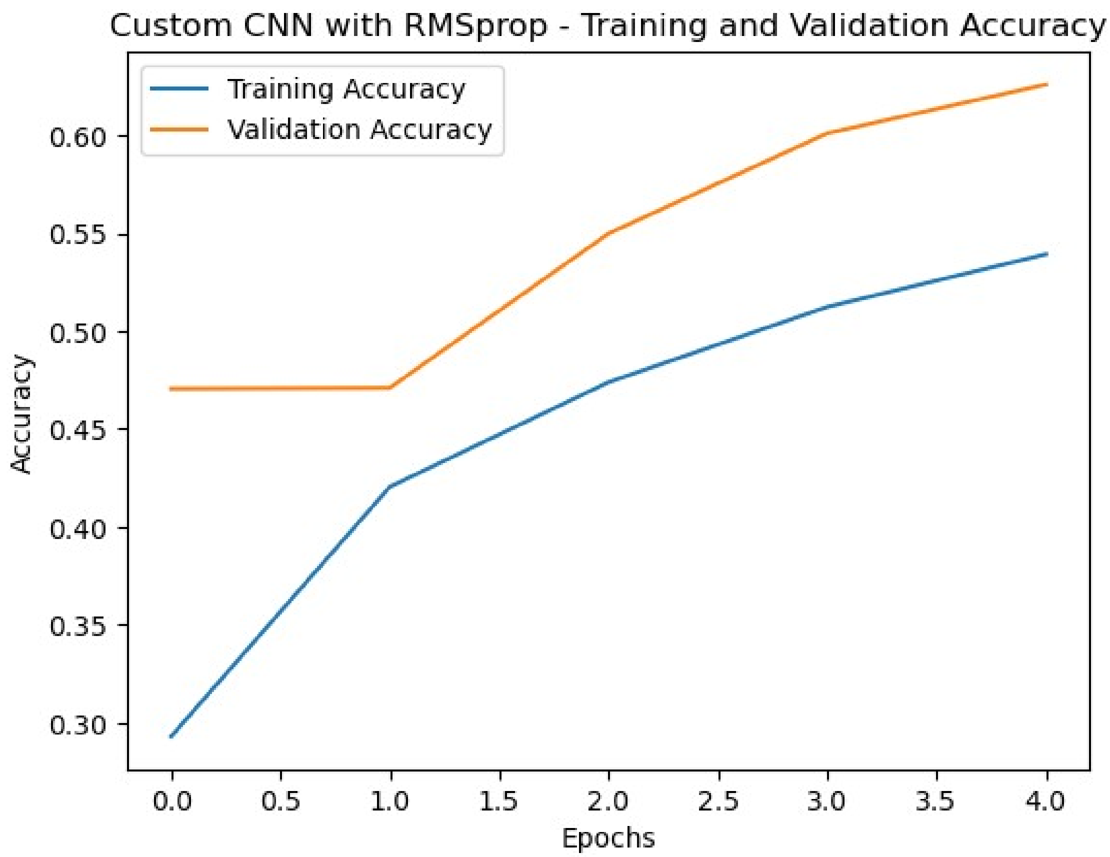
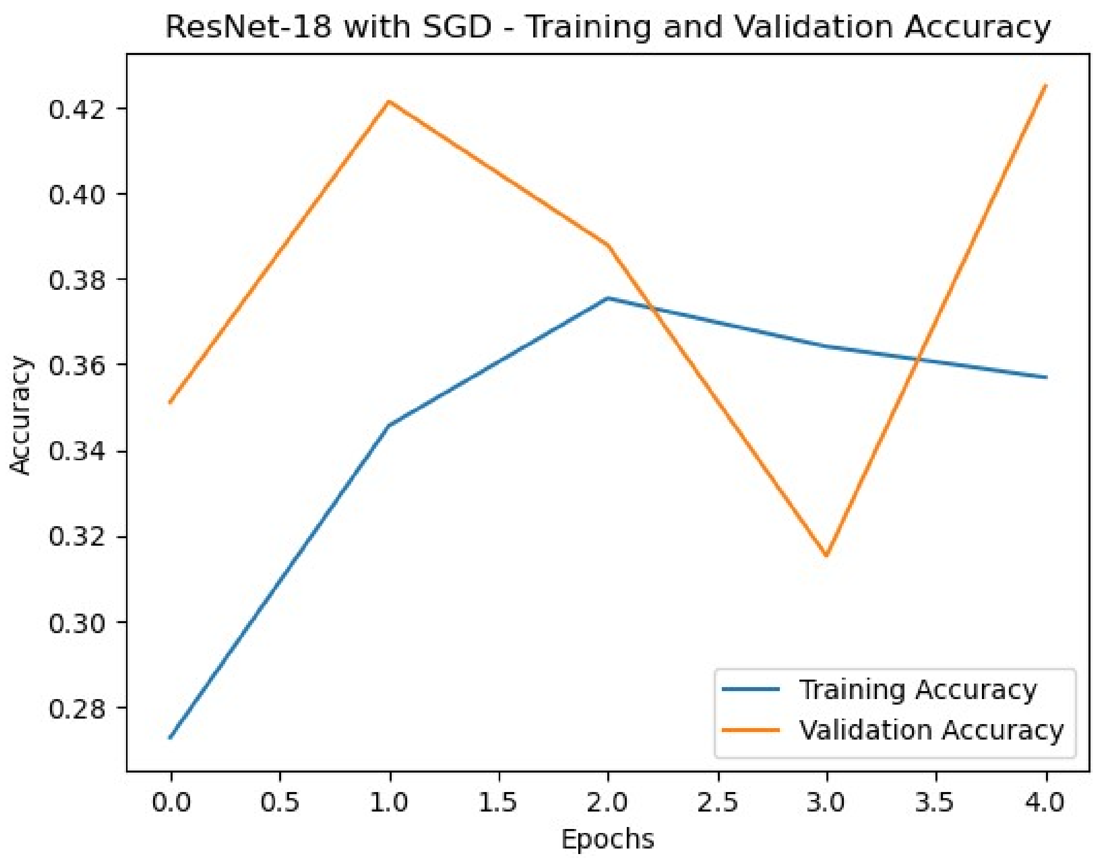

```
782/782 ━━━━━━━━━━━━━━━━━━━━ 49s 63ms/step - accuracy: 0.5322 - loss: 1.3258 - val_accuracy: 0.6259 - val_loss: 1.0481
```




```
WARNING:absl:You are saving your model as an HDF5 file via `model.save()` or `keras.saving.save_model(model)`. This file format is considered legacy. We recommend using instead the native Keras format, e.g. `model.save('my_model.keras')` or `keras.saving.save_model(model, 'my_model.keras')`.

Model saved as Custom CNN_RMSprop_model.h5

Training ResNet-18 with SGD optimizer...
Epoch 1/5
782/782 ━━━━━━━━━━━━━━━━━━━━ 418s 513ms/step - accuracy: 0.2224 - loss: 2.9194 - val_accuracy: 0.3512 - val_loss: 3.1761
Epoch 2/5
782/782 ━━━━━━━━━━━━━━━━━━━━ 377s 482ms/step - accuracy: 0.3366 - loss: 2.1665 - val_accuracy: 0.4215 - val_loss: 2.9457
Epoch 3/5
782/782 ━━━━━━━━━━━━━━━━━━━━ 369s 472ms/step - accuracy: 0.3744 - loss: 2.0131 - val_accuracy: 0.3879 - val_loss: 2.0184
Epoch 4/5
782/782 ━━━━━━━━━━━━━━━━━━━━ 379s 484ms/step - accuracy: 0.3785 -
```

```
loss: 1.9743 - val_accuracy: 0.3152 - val_loss: 8.8636
Epoch 5/5
782/782 ━━━━━━━━━━━━━━━━━━━━ 369s 471ms/step - accuracy: 0.3425 -
loss: 2.0657 - val_accuracy: 0.4251 - val_loss: 3.7996
```




```
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format, e.g. `model.save('my_model.keras')` or
`keras.saving.save_model(model, 'my_model.keras')`.

Model saved as ResNet-18_SGD_model.h5

Training ResNet-18 with Adam optimizer...
Epoch 1/5
782/782 ━━━━━━━━━━━━━━━━━━━━ 510s 617ms/step - accuracy: 0.2629 -
loss: 2.4147 - val_accuracy: 0.1261 - val_loss: 12.2278
Epoch 2/5
782/782 ━━━━━━━━━━━━━━━━━━━━ 472s 604ms/step - accuracy: 0.2931 -
loss: 2.1253 - val_accuracy: 0.1042 - val_loss: 6404.8013
Epoch 3/5
782/782 ━━━━━━━━━━━━━━━━━━━━ 476s 609ms/step - accuracy: 0.3057 -
loss: 2.1543 - val_accuracy: 0.1694 - val_loss: 2.7235
```
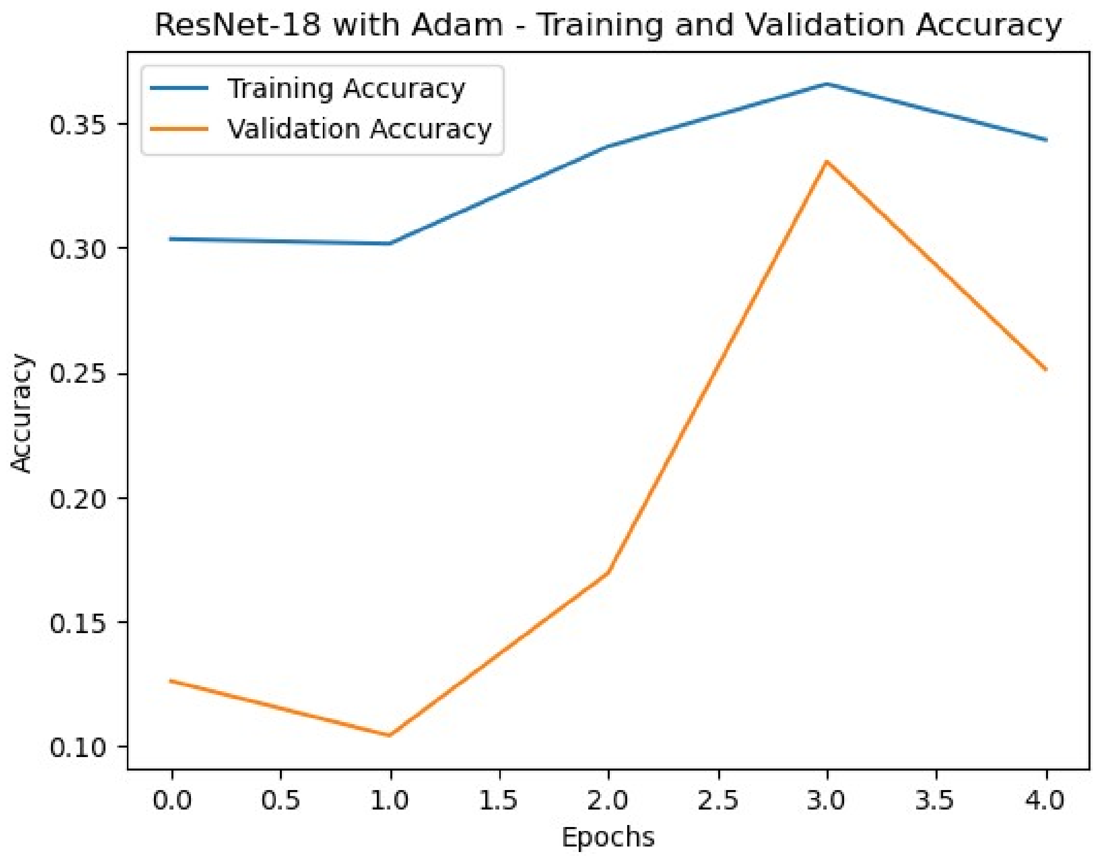

```
Epoch 4/5
782/782 ━━━━━━━━━━━━━━━━━━━━ 481s 615ms/step - accuracy: 0.3685 -
loss: 1.9414 - val_accuracy: 0.3346 - val_loss: 1.8869
Epoch 5/5
782/782 ━━━━━━━━━━━━━━━━━━━━ 478s 611ms/step - accuracy: 0.3384 -
loss: 1.9913 - val_accuracy: 0.2513 - val_loss: 2.2245
```




```
WARNING:absl:You are saving your model as an HDF5 file via
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`keras.saving.save_model(model, 'my_model.keras')`.

Model saved as ResNet-18_Adam_model.h5

Training ResNet-18 with RMSprop optimizer...
Epoch 1/5
782/782 ━━━━━━━━━━━━━━━━━━━━ 468s 572ms/step - accuracy: 0.2219 -
loss: 2.8002 - val_accuracy: 0.2180 - val_loss: 2.1203
Epoch 2/5
782/782 ━━━━━━━━━━━━━━━━━━━━ 434s 554ms/step - accuracy: 0.2768 -
loss: 2.2972 - val_accuracy: 0.2286 - val_loss: 2.3177
Epoch 3/5
```
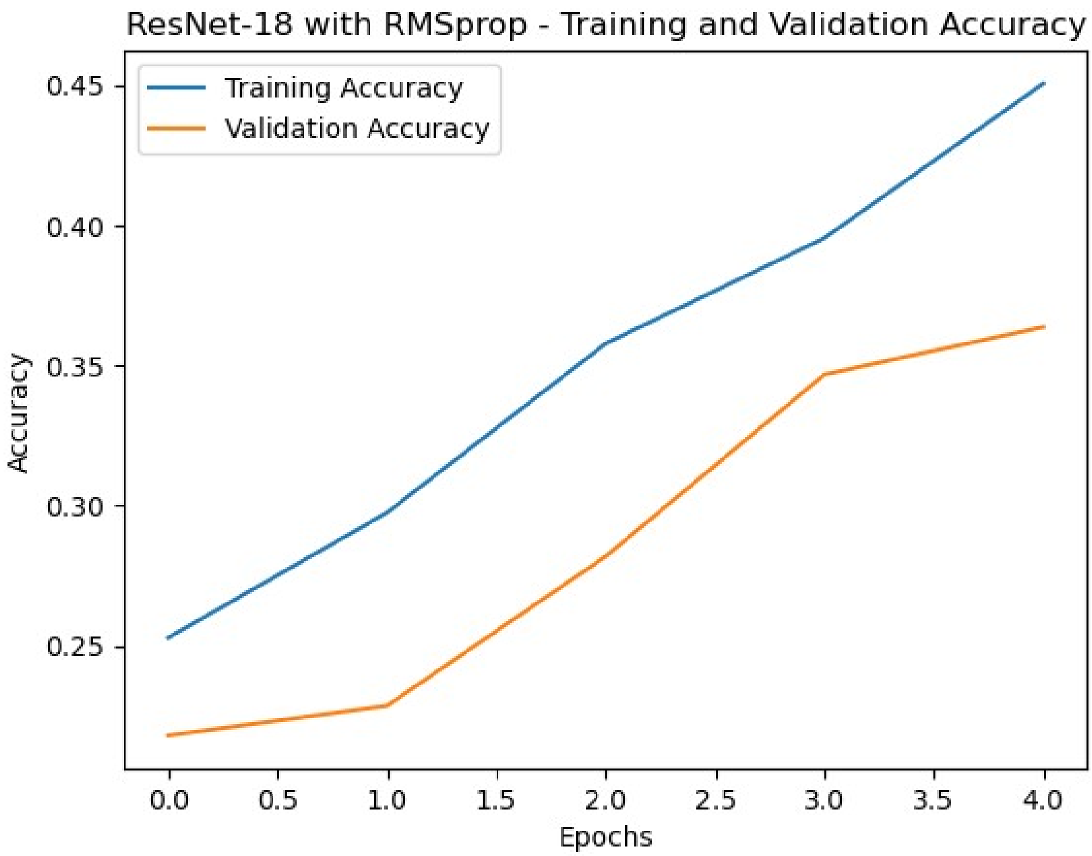

```
782/782 ━━━━━━━━━━━━━━━━━━━━ 445s 569ms/step - accuracy: 0.3483 -
loss: 2.0476 - val_accuracy: 0.2819 - val_loss: 144.1120
Epoch 4/5
782/782 ━━━━━━━━━━━━━━━━━━━━ 459s 587ms/step - accuracy: 0.3851 -
loss: 1.9709 - val_accuracy: 0.3468 - val_loss: 1.8172
Epoch 5/5
782/782 ━━━━━━━━━━━━━━━━━━━━ 477s 609ms/step - accuracy: 0.4420 -
loss: 1.7564 - val_accuracy: 0.3637 - val_loss: 61.9801
```




```
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is considered legacy. We recommend using instead the native Keras
format, e.g. `model.save('my_model.keras')` or
`keras.saving.save_model(model, 'my_model.keras')`.

Model saved as ResNet-18_RMSprop_model.h5

Training AlexNet with SGD optimizer...
Epoch 1/5
782/782 ━━━━━━━━━━━━━━━━━━━━ 468s 597ms/step - accuracy: 0.1197 -
loss: 2.2875 - val_accuracy: 0.2274 - val_loss: 2.0547
Epoch 2/5
782/782 ━━━━━━━━━━━━━━━━━━━━ 449s 573ms/step - accuracy: 0.2282 -
```
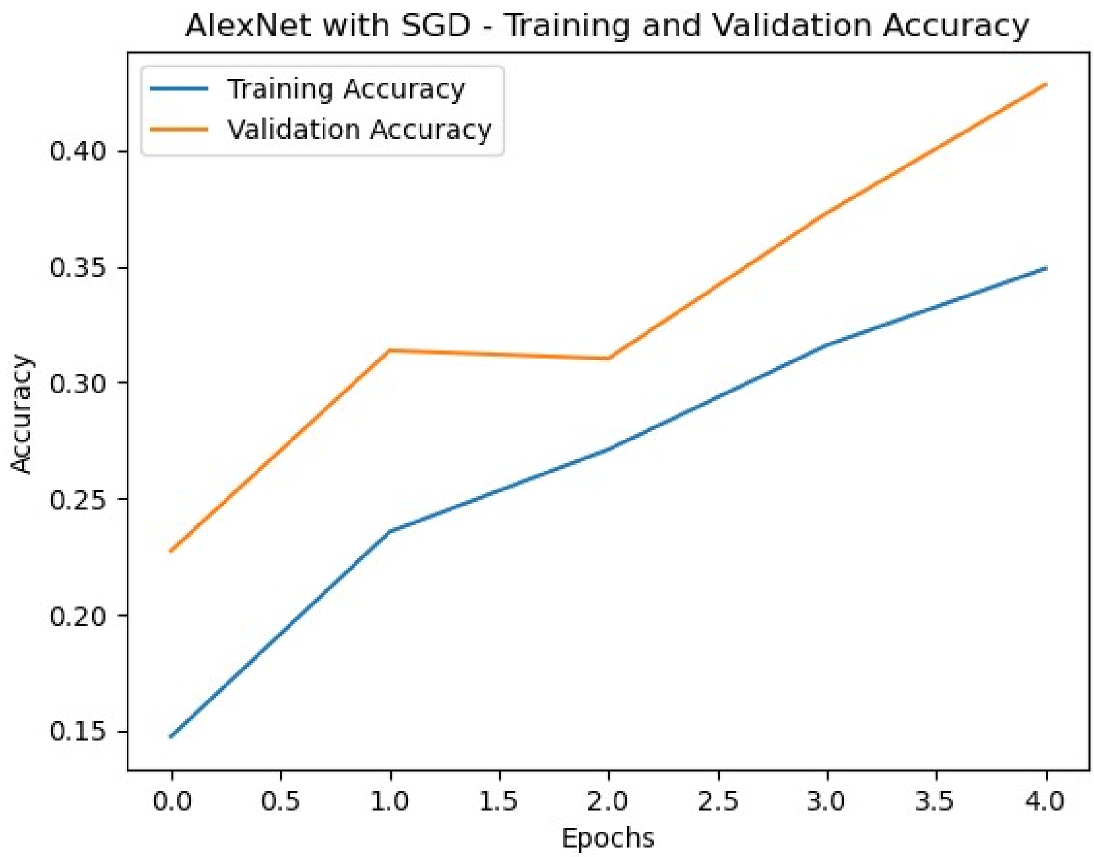

```
loss: 2.0683 - val_accuracy: 0.3137 - val_loss: 1.9204
Epoch 3/5
782/782 ━━━━━━━━━━━━━━━━━━━━ 448s 573ms/step - accuracy: 0.2612 -
loss: 1.9914 - val_accuracy: 0.3102 - val_loss: 1.9069
Epoch 4/5
782/782 ━━━━━━━━━━━━━━━━━━━━ 477s 609ms/step - accuracy: 0.3125 -
loss: 1.8809 - val_accuracy: 0.3730 - val_loss: 1.7464
Epoch 5/5
782/782 ━━━━━━━━━━━━━━━━━━━━ 464s 593ms/step - accuracy: 0.3413 -
loss: 1.7978 - val_accuracy: 0.4283 - val_loss: 1.5747
```




```
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format, e.g. `model.save('my_model.keras')` or
`keras.saving.save_model(model, 'my_model.keras')`.

Model saved as AlexNet_SGD_model.h5

Training AlexNet with Adam optimizer...
Epoch 1/5
782/782 ━━━━━━━━━━━━━━━━━━━━ 610s 775ms/step - accuracy: 0.2041 -
loss: 2.1058 - val_accuracy: 0.3666 - val_loss: 1.7424
```
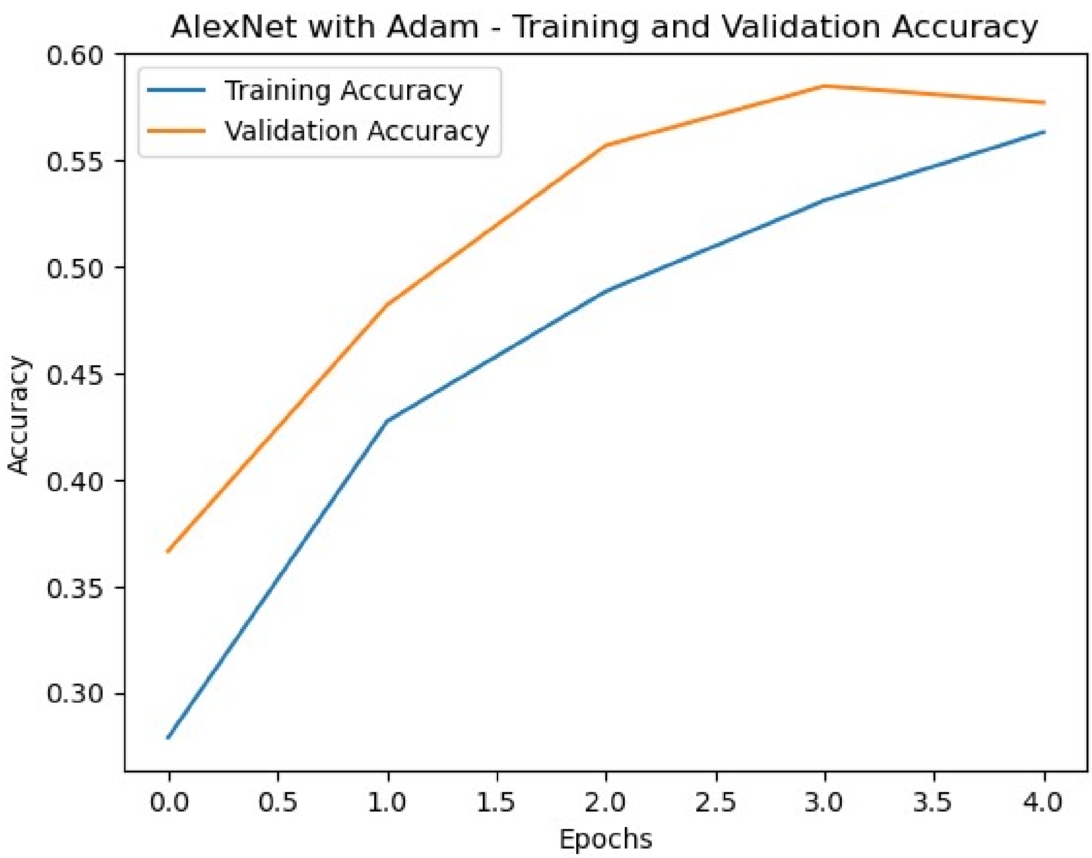

```
Epoch 2/5
782/782 ━━━━━━━━━━━━━━━━━━━━ 601s 768ms/step - accuracy: 0.4031 -
loss: 1.6083 - val_accuracy: 0.4821 - val_loss: 1.4000
Epoch 3/5
782/782 ━━━━━━━━━━━━━━━━━━━━ 573s 732ms/step - accuracy: 0.4754 -
loss: 1.4282 - val_accuracy: 0.5571 - val_loss: 1.2308
Epoch 4/5
782/782 ━━━━━━━━━━━━━━━━━━━━ 563s 719ms/step - accuracy: 0.5238 -
loss: 1.3211 - val_accuracy: 0.5850 - val_loss: 1.1762
Epoch 5/5
782/782 ━━━━━━━━━━━━━━━━━━━━ 547s 699ms/step - accuracy: 0.5569 -
loss: 1.2347 - val_accuracy: 0.5772 - val_loss: 1.2378
```




```
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format, e.g. `model.save('my_model.keras')` or
`keras.saving.save_model(model, 'my_model.keras')`.

Model saved as AlexNet_Adam_model.h5

Training AlexNet with RMSprop optimizer...
Epoch 1/5
```
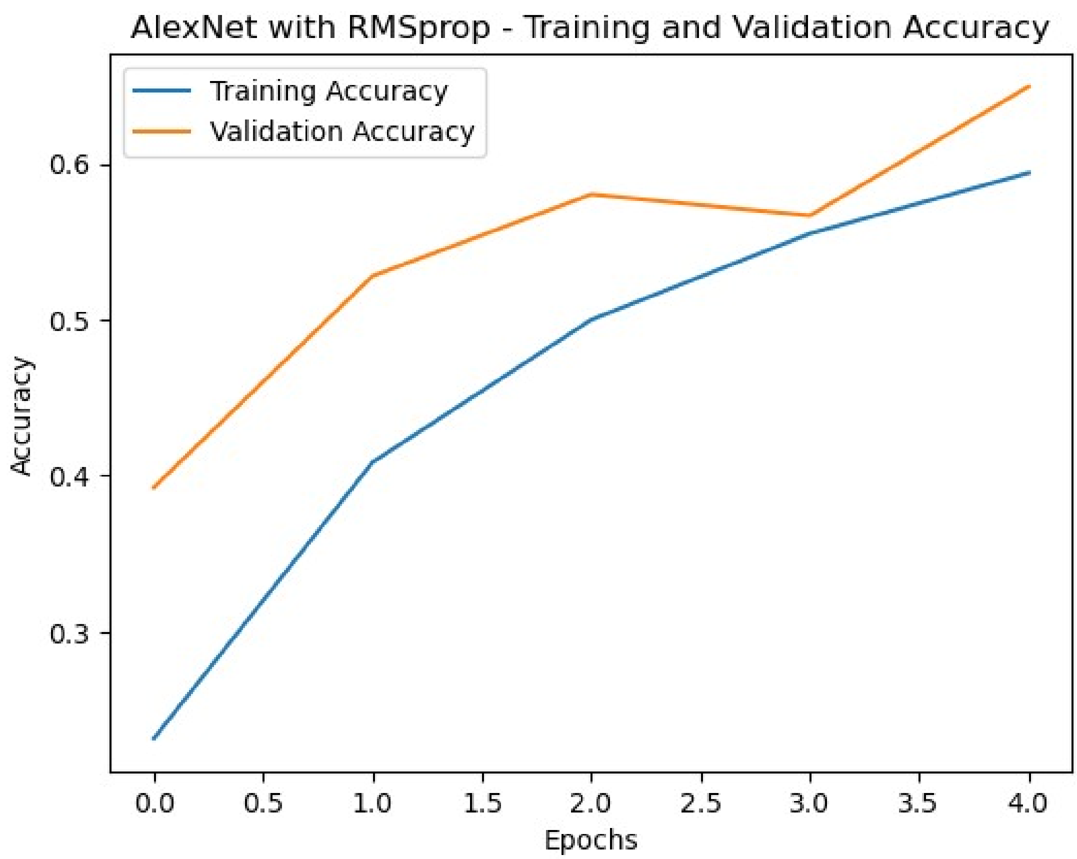

```
782/782 ━━━━━━━━━━━━━━━━━━━━ 504s 641ms/step - accuracy: 0.1605 -
loss: 2.1947 - val_accuracy: 0.3925 - val_loss: 1.6118
Epoch 2/5
782/782 ━━━━━━━━━━━━━━━━━━━━ 504s 644ms/step - accuracy: 0.3814 -
loss: 1.6787 - val_accuracy: 0.5279 - val_loss: 1.2782
Epoch 3/5
782/782 ━━━━━━━━━━━━━━━━━━━━ 507s 649ms/step - accuracy: 0.4839 -
loss: 1.4379 - val_accuracy: 0.5802 - val_loss: 1.1778
Epoch 4/5
782/782 ━━━━━━━━━━━━━━━━━━━━ 504s 645ms/step - accuracy: 0.5450 -
loss: 1.3035 - val_accuracy: 0.5666 - val_loss: 1.2680
Epoch 5/5
782/782 ━━━━━━━━━━━━━━━━━━━━ 503s 643ms/step - accuracy: 0.5865 -
loss: 1.1955 - val_accuracy: 0.6493 - val_loss: 1.0522
```




```
WARNING:absl:You are saving your model as an HDF5 file via
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is considered legacy. We recommend using instead the native Keras
format, e.g. `model.save('my_model.keras')` or
`keras.saving.save_model(model, 'my_model.keras')`.
```
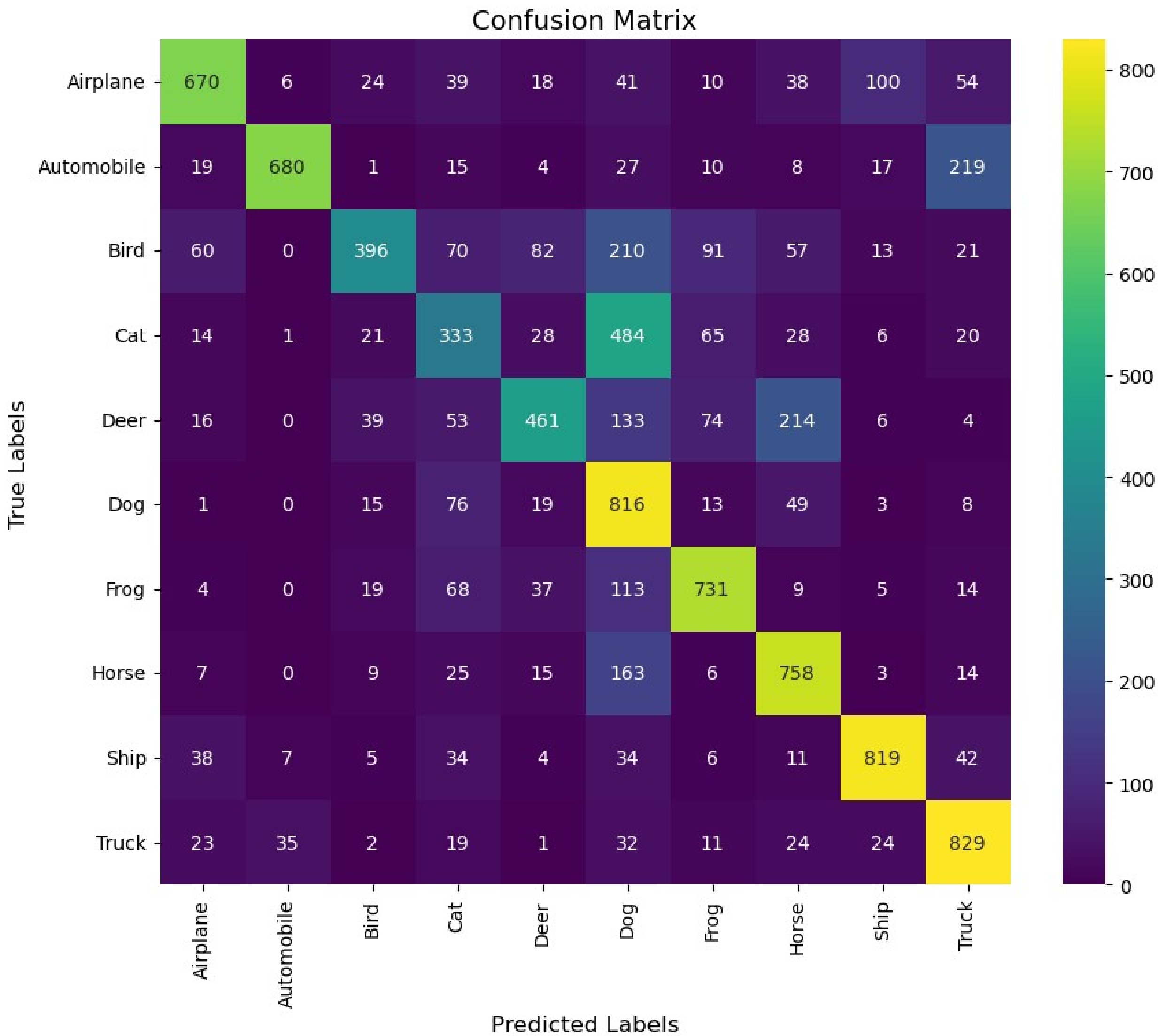

```
Model saved as AlexNet_RMSprop_model.h5

Best Model: AlexNet with RMSprop with Accuracy: 64.93%
```

```python
# Generating the predictions
y_pred_probs = model.predict(x_test)
y_pred = np.argmax(y_pred_probs, axis=1)
y_true = np.argmax(y_test, axis=1)

# the confusion matrix
conf_matrix = confusion_matrix(y_true, y_pred)

# Plotting the confusion matrix
def plot_confusion_matrix(cm, class_names):
    plt.figure(figsize=(10, 8))
    sns.heatmap(cm, annot=True, fmt='d', cmap='viridis',
xticklabels=class_names, yticklabels=class_names)
    plt.xlabel('Predicted Labels', fontsize=12)
    plt.ylabel('True Labels', fontsize=12)
    plt.title('Confusion Matrix', fontsize=14)
    plt.show()

# Class names for CIFAR-10 dataset
class_names = [
    'Airplane', 'Automobile', 'Bird', 'Cat', 'Deer',
    'Dog', 'Frog', 'Horse', 'Ship', 'Truck'
]


plot_confusion_matrix(conf_matrix, class_names)
```

```
313/313 ━━━━━━━━━━━━━━━━━━━━ 21s 67ms/step
```




```
report = classification_report(y_true, y_pred,
target_names=class_names, output_dict=True)
# Plotting the classification report
def plot_classification_report(report, class_names):
    plt.figure(figsize=(10, 6))
    precision = [report[label]['precision'] for label in class_names]
    recall = [report[label]['recall'] for label in class_names]
    f1_score = [report[label]['f1-score'] for label in class_names]

    # Set up the bar width
    bar_width = 0.25
    index = np.arange(len(class_names))

    # Plot the bars
    plt.bar(index, precision, bar_width, label='Precision')
    plt.bar(index + bar_width, recall, bar_width, label='Recall')
```

```
    plt.bar(index + 2 * bar_width, f1_score, bar_width, label='F1-
Score')

    # the plot
    plt.xlabel('Classes', fontsize=12)
    plt.ylabel('Scores', fontsize=12)
    plt.title('Classification Report', fontsize=14)
    plt.xticks(index + bar_width, class_names, rotation=45)
    plt.legend()
    plt.tight_layout()
    plt.show()

#
plot_classification_report(report, class_names)
```