Base Code

Part 1: Import Necessary Modules

In [3]:

```
import tensorflow as tf
from tensorflow.keras import layers, models
import numpy as np
import matplotlib.pyplot as plt
import shap
import os
from ipywidgets import interact, IntSlider

print("TensorFlow version:", tf.__version__)
print("GPU is", "available" if tf.config.list_physical_devices('GPU') else "NOT AVAILABL
```

```
TensorFlow version: 2.13.0
GPU is NOT AVAILABLE
```

Part 2: Data Preparation

In [4]:

```
(train_images, train_labels), (test_images, test_labels) = tf.keras.datasets.cifar10.loa
train_images, test_images = train_images / 255.0, test_images / 255.0
class_names = ['airplane', 'automobile', 'bird', 'cat', 'deer', 'dog', 'frog', 'horse',
```

```
Downloading data from https://www.cs.toronto.edu/~kriz/cifar-10-python.tar.gz
170498071/170498071 [==============================] - 5s 0us/step
```

Part 3: Model Definition

In [5]:

```
def create_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(64, (3, 3), activation='relu'),
        layers.Flatten(),
        layers.Dense(64, activation='relu'),
        layers.Dense(10, activation='softmax')
    ])
    model.compile(optimizer='adam', loss='sparse_categorical_crossentropy', metrics=['ac
    return model
```

Part 4: Model Loading or Training

In [6]:

```
model_path = 'cifar10_cnn.keras'
if os.path.exists(model_path):
    print("Loading pre-trained model...")
    model = tf.keras.models.load_model(model_path)
else:
    print("No pre-trained model found. Training a new model...")
    model = create_model()
    history = model.fit(train_images, train_labels, epochs=10, validation_data=(test_ima
    model.save(model_path)
    print(f"Model saved to {model_path}")
```

```
No pre-trained model found. Training a new model...
Epoch 1/10
```

```
1563/1563 [==============================] - 18s 11ms/step - loss: 1.5174 - accuracy: 0.
4437 - val_loss: 1.3275 - val_accuracy: 0.5291
Epoch 2/10
1563/1563 [==============================] - 17s 11ms/step - loss: 1.1595 - accuracy: 0.
5871 - val_loss: 1.1212 - val_accuracy: 0.5991
Epoch 3/10
1563/1563 [==============================] - 17s 11ms/step - loss: 1.0043 - accuracy: 0.
6476 - val_loss: 0.9968 - val_accuracy: 0.6491
Epoch 4/10
1563/1563 [==============================] - 17s 11ms/step - loss: 0.9087 - accuracy: 0.
6795 - val_loss: 0.9443 - val_accuracy: 0.6694
Epoch 5/10
1563/1563 [==============================] - 17s 11ms/step - loss: 0.8333 - accuracy: 0.
7079 - val_loss: 0.9446 - val_accuracy: 0.6760
Epoch 6/10
1563/1563 [==============================] - 17s 11ms/step - loss: 0.7732 - accuracy: 0.
7285 - val_loss: 0.9059 - val_accuracy: 0.6929
Epoch 7/10
1563/1563 [==============================] - 17s 11ms/step - loss: 0.7246 - accuracy: 0.
7467 - val_loss: 0.9244 - val_accuracy: 0.6773
Epoch 8/10
1563/1563 [==============================] - 17s 11ms/step - loss: 0.6830 - accuracy: 0.
7602 - val_loss: 0.8865 - val_accuracy: 0.7002
Epoch 9/10
1563/1563 [==============================] - 17s 11ms/step - loss: 0.6442 - accuracy: 0.
7736 - val_loss: 0.9400 - val_accuracy: 0.6877
Epoch 10/10
1563/1563 [==============================] - 17s 11ms/step - loss: 0.6051 - accuracy: 0.
7880 - val_loss: 0.9346 - val_accuracy: 0.6901
Model saved to cifar10_cnn.keras
```

Part 5: Model Evaluation

In [7]:

```python
test_loss, test_acc = model.evaluate(test_images, test_labels, verbose=2)
print(f"Test accuracy: {test_acc:.2f}")
```

```
313/313 - 1s - loss: 0.9346 - accuracy: 0.6901 - 1s/epoch - 4ms/step
Test accuracy: 0.69
```

Part 6: Model Testing

In [8]:

```python
def test_model(model, test_images, test_labels, num_samples=5):
    indices = np.random.choice(test_images.shape[0], num_samples, replace=False)
    sample_images = test_images[indices]
    sample_labels = test_labels[indices]

    predictions = model.predict(sample_images)

    fig, axes = plt.subplots(1, num_samples, figsize=(15, 3))
    for i, ax in enumerate(axes):
        ax.imshow(sample_images[i])
        predicted_class = class_names[np.argmax(predictions[i])]
        true_class = class_names[sample_labels[i][0]]
        ax.set_title(f"Pred: {predicted_class}\nTrue: {true_class}")
        ax.axis('off')
    plt.tight_layout()
    plt.show()
```

SHAP Preparation

In [11]:

```python
# Initialize SHAP explainer for the Keras model
explainer = shap.DeepExplainer(model, train_images[:100])  # Use a small subset for the
```

```
def shap_visualization(image_index):
    image = test_images[image_index:image_index+1]
    true_label = test_labels[image_index][0]

    # Generate and process SHAP values
    shap_values = explainer.shap_values(image)
    prediction = model.predict(image)
    predicted_class = np.argmax(prediction)
    shap_values_for_class = shap_values[0, ..., predicted_class]
    shap_sum = np.sum(shap_values_for_class, axis=-1)

    # Normalize SHAP values for scatter plot
    shap_normalized = (shap_sum - shap_sum.min()) / (shap_sum.max() - shap_sum.min())

    # Create figure with subplots
    fig, axs = plt.subplots(1, 2, figsize=(12, 6))

    # Original Image
    axs[0].imshow(image[0])
    axs[0].set_title("Original Image\nTrue: " + class_names[true_label])
    axs[0].axis('off')

    # Scatter Plot with Stars on Image
    y, x = np.indices(shap_sum.shape)
    colors = shap_sum.flatten()  # Color by SHAP values
    sizes = 100 * shap_normalized.flatten() + 10  # Size of stars
    axs[1].imshow(image[0], aspect='auto')  # Display the original image as background
    scatter = axs[1].scatter(x.flatten(), y.flatten(), c=colors, s=sizes, cmap='coolwarm
    axs[1].set_title("SHAP Scatter on Image\nPredicted: " + class_names[predicted_class]
    axs[1].axis('off')
    fig.colorbar(scatter, ax=axs[1], orientation='vertical', fraction=0.046, pad=0.04)

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

```
c:\Users\Jun\AppData\Local\Programs\Python\Python310\lib\site-packages\shap\explainers\_
deep\deep_tf.py:99: UserWarning: Your TensorFlow version is newer than 2.4.0 and so grap
h support has been removed in eager mode and some static graphs may not be supported. Se
e PR #1483 for discussion.
  warnings.warn("Your TensorFlow version is newer than 2.4.0 and so graph support has be
en removed in eager mode and some static graphs may not be supported. See PR #1483 for d
iscussion.")
```

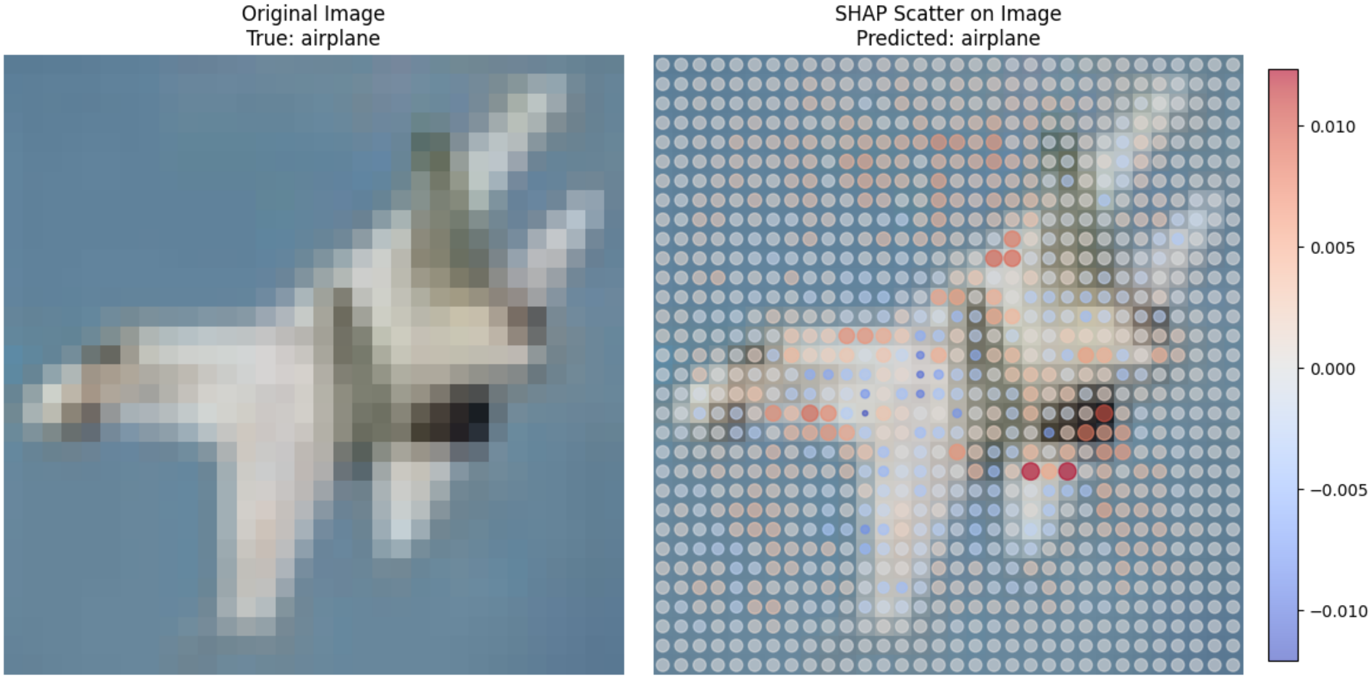
Test the Function

In [12]:

```
# Test the function
shap_visualization(10)  # Visualize SHAP values for the 11th image
```

```
c:\Users\Jun\AppData\Local\Programs\Python\Python310\lib\site-packages\keras\src\backen
d.py:452: UserWarning: `tf.keras.backend.set_learning_phase` is deprecated and will be r
emoved after 2020-10-11. To update it, simply pass a True/False value to the `training`
argument of the `__call__` method of your layer or model.
  warnings.warn(
WARNING:tensorflow:5 out of the last 5 calls to <function TFDeep.phi_symbolic.<locals>.g
rad_graph at 0x0000020ECEE0B250> triggered tf.function retracing. Tracing is expensive a
nd the excessive number of tracings could be due to (1) creating @tf.function repeatedly
in a loop, (2) passing tensors with different shapes, (3) passing Python objects instead
of tensors. For (1), please define your @tf.function outside of the loop. For (2), @tf.f
unction has reduce_retracing=True option that can avoid unnecessary retracing. For (3),
please refer to https://www.tensorflow.org/guide/function#controlling_retracing and http
s://www.tensorflow.org/api_docs/python/tf/function for  more details.
WARNING:tensorflow:6 out of the last 6 calls to <function TFDeep.phi_symbolic.<locals>.g
rad_graph at 0x0000020ED9F609D0> triggered tf.function retracing. Tracing is expensive a
```

```
nd the excessive number of tracings could be due to (1) creating @tf.function repeatedly
in a loop, (2) passing tensors with different shapes, (3) passing Python objects instead
of tensors. For (1), please define your @tf.function outside of the loop. For (2), @tf.f
unction has reduce_retracing=True option that can avoid unnecessary retracing. For (3),
please refer to https://www.tensorflow.org/guide/function#controlling_retracing and http
s://www.tensorflow.org/api_docs/python/tf/function for  more details.
1/1 [==============================] - 0s 61ms/step
```


Original Image
True: airplane
SHAP Scatter on Image
Predicted: airplane