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# -- coding: utf-8 --
"""
Train a custom ResNet model on CIFAR-10 (cat and dog only), then attack it using Differential Evolution
with 1 to 5 pixel perturbations.
"""

import numpy as np
import matplotlib.pyplot as plt
from tensorflow.keras.datasets import cifar10
from tensorflow.keras.models import Model, load_model
from tensorflow.keras.layers import (
    Input, Conv2D, BatchNormalization, ReLU, Add, GlobalAveragePooling2D, Dense
)
from tensorflow.keras.utils import to_categorical
from tensorflow.keras.optimizers import Adam
from tensorflow.keras.callbacks import ModelCheckpoint

# ---- 1) Define custom ResNet-20 ----
def resnet_block(x, filters, downsample=False):
    stride = 2 if downsample else 1
    shortcut = x
    if downsample or x.shape[-1] != filters:
        shortcut = Conv2D(filters, kernel_size=1, strides=stride, padding='same')(shortcut)
        shortcut = BatchNormalization()(shortcut)
    x = Conv2D(filters, kernel_size=3, strides=stride, padding='same')(x)
    x = BatchNormalization()(x)
    x = ReLU()(x)
    x = Conv2D(filters, kernel_size=3, strides=1, padding='same')(x)
    x = BatchNormalization()(x)
    x = Add()([shortcut, x])
    x = ReLU()(x)
    return x

def build_resnet(input_shape=(32, 32, 3), num_classes=2):
    inputs = Input(shape=input_shape)
    x = Conv2D(16, 3, padding='same')(inputs)
    x = BatchNormalization()(x)
    x = ReLU()(x)
    for filters, downsample in zip([16]*3 + [32]*3 + [64]*3,
                                    [False, False, False, True, False, False, True, False, False]):
        x = resnet_block(x, filters, downsample)
    x = GlobalAveragePooling2D()(x)
    outputs = Dense(num_classes, activation='softmax')(x)
    return Model(inputs, outputs)

# ---- 2) Filter CIFAR-10 for cat/dog and preprocess ----
(x_train, y_train), (x_test, y_test) = cifar10.load_data()
y_train = y_train.flatten()
y_test = y_test.flatten()
cat_label, dog_label = 3, 5
train_mask = np.isin(y_train, [cat_label, dog_label])
test_mask = np.isin(y_test, [cat_label, dog_label])
x_train, y_train = x_train[train_mask], y_train[train_mask]
x_test, y_test = x_test[test_mask], y_test[test_mask]
y_train = np.where(y_train == cat_label, 0, 1)
y_test = np.where(y_test == cat_label, 0, 1)
x_train = x_train.astype("float32") / 255.0
x_test = x_test.astype("float32") / 255.0
y_train_cat = to_categorical(y_train, 2)
y_test_cat = to_categorical(y_test, 2)

# ---- 3) Train ResNet-20 ----
model = build_resnet()
model.compile(optimizer=Adam(1e-3), loss='categorical_crossentropy', metrics=['accuracy'])
checkpoint = ModelCheckpoint("resnet_cat_dog.h5", save_best_only=True, monitor='val_accuracy', mode='max')
model.fit(x_train, y_train_cat, epochs=20, batch_size=64, validation_split=0.1, callbacks=[checkpoint])

# ---- 4) Load best model ----
model = load_model('resnet_cat_dog.h5')
class_names = ['cat', 'dog']

# ---- 5) Select image for attack ----
img_index = 0
original_img = x_test[img_index]
true_label = y_test[img_index]
orig_pred = model.predict(original_img[None])[0]

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orig_class = np.argmax(orig_pred)

print(f"Original prediction: {class_names[orig_class]} ({orig_pred[orig_class]:.4f})")
print(f"True label: {class_names[true_label]}")

# ---- 6) Perturbation function ----
def perturb_image(vectors, img):
    vs = np.atleast_2d(vectors).astype(int)
    out = np.tile(img, [len(vs), 1, 1, 1])
    for i, v in enumerate(vs):
        pixels = np.split(v, len(v) // 5)
        for (x, y, r, g, b) in pixels:
            out[i, x, y] = [r / 255.0, g / 255.0, b / 255.0]
    return out

# ---- 7) Fitness function for DE ----
def fitness(vec):
    pert = perturb_image(vec, original_img)[0]
    p = model.predict(pert[None])[0]
    return p[true_label]

# ---- 8) Differential Evolution Class ----
class DifferentialEvolution:
    def __init__(self, func, bounds, popsize=10, maxiter=100, F=0.5, CR=0.7, seed=None):
        self.func = func
        self.bounds = np.array(bounds)
        self.n_dim = len(bounds)
        self.popsize = popsize
        self.maxiter = maxiter
        self.F = F
        self.CR = CR
        self.rng = np.random.RandomState(seed)
        low, high = self.bounds[:, 0], self.bounds[:, 1]
        self.pop = low + self.rng.rand(popsize, self.n_dim) * (high - low)
        self.pop_f = np.array([self.func(ind) for ind in self.pop])

    def solve(self):
        low, high = self.bounds[:, 0], self.bounds[:, 1]
        for gen in range(self.maxiter):
            best_idx = np.argmin(self.pop_f)
            best = self.pop[best_idx]
            for i in range(self.popsize):
                idxs = [idx for idx in range(self.popsize) if idx != i and idx != best_idx]
                r0, r1 = self.rng.choice(idxs, 2, replace=False)
                mutant = best + self.F * (self.pop[r0] - self.pop[r1])
                trial = self.pop[i].copy()
                jrand = self.rng.randint(self.n_dim)
                for j in range(self.n_dim):
                    if self.rng.rand() < self.CR or j == jrand:
                        trial[j] = mutant[j]
                trial = np.clip(trial, low, high)
                f_trial = self.func(trial)
                if f_trial < self.pop_f[i]:
                    self.pop[i] = trial
                    self.pop_f[i] = f_trial
            if np.std(self.pop_f) / (np.abs(np.mean(self.pop_f)) + 1e-12) < 1e-6:
                break
        best_idx = np.argmin(self.pop_f)
        return self.pop[best_idx], self.pop_f[best_idx]

# ---- 9) Run DE for 1 to 5 pixels ----
pixel_range = [1, 2, 3, 4, 5]
results = []

for num_pixels in pixel_range:
    print(f"\n==== {num_pixels}-Pixel Attack ===")
    bounds = [(0, 31), (0, 31), (0, 255), (0, 255), (0, 255)] * num_pixels

    de = DifferentialEvolution(
        func=fitness,
        bounds=bounds,
        popsize=20,
        maxiter=200,
        F=0.5,
        CR=0.7,
        seed=42
    )

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best_vec, best_score = de.solve()
perturbed = perturb_image(best_vec, original_img)[0]
pert_pred = model.predict(perturbed[None])[0]
pert_class = np.argmax(pert_pred)

print(f"Confidence in true class: {best_score:.4f}")
print(f"Predicted class after attack: {class_names[pert_class]} ({pert_pred[pert_class]:.4f})")

results.append({
    'num_pixels': num_pixels,
    'true_class_conf': best_score,
    'predicted_class': class_names[pert_class],
    'predicted_conf': pert_pred[pert_class],
    'image': perturbed
})

# Show images
plt.figure(figsize=(6, 3))
plt.subplot(1, 2, 1)
plt.imshow(original_img)
plt.title(f"Original: {class_names[orig_class]} ({orig_pred[orig_class]:.2f})")
plt.axis('off')

plt.subplot(1, 2, 2)
plt.imshow(perturbed)
plt.title(f"{num_pixels}-Pixel: {class_names[pert_class]} ({pert_pred[pert_class]:.2f})")
plt.axis('off')

plt.suptitle(f"Confidence {orig_pred[true_label]:.2f} → {pert_pred[true_label]:.2f}")
plt.tight_layout()
plt.show()
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↳ Downloading data from https://www.cs.toronto.edu/~kriz/cifar-10-python.tar.gz
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Epoch 1/20
141/141 0s 63ms/step - accuracy: 0.5885 - loss: 0.6757WARNING:absl:You are saving your model as an HDF5 file via `m
141/141 35s 90ms/step - accuracy: 0.5887 - loss: 0.6756 - val_accuracy: 0.5370 - val_loss: 0.6946
Epoch 2/20
139/141 0s 15ms/step - accuracy: 0.6944 - loss: 0.5769WARNING:absl:You are saving your model as an HDF5 file via `m
141/141 22s 18ms/step - accuracy: 0.6945 - loss: 0.5768 - val_accuracy: 0.6460 - val_loss: 0.6245
Epoch 3/20
138/141 0s 15ms/step - accuracy: 0.7541 - loss: 0.4993WARNING:absl:You are saving your model as an HDF5 file via `m
141/141 3s 18ms/step - accuracy: 0.7540 - loss: 0.4992 - val_accuracy: 0.6640 - val_loss: 0.7721
Epoch 4/20
140/141 0s 15ms/step - accuracy: 0.7968 - loss: 0.4403WARNING:absl:You are saving your model as an HDF5 file via `m
141/141 5s 17ms/step - accuracy: 0.7967 - loss: 0.4403 - val_accuracy: 0.6870 - val_loss: 0.6719
Epoch 5/20
139/141 0s 14ms/step - accuracy: 0.8224 - loss: 0.3833WARNING:absl:You are saving your model as an HDF5 file via `m
141/141 3s 17ms/step - accuracy: 0.8223 - loss: 0.3835 - val_accuracy: 0.7110 - val_loss: 0.6629
Epoch 6/20
141/141 2s 15ms/step - accuracy: 0.8695 - loss: 0.3139 - val_accuracy: 0.6860 - val_loss: 0.7959
Epoch 7/20
141/141 2s 17ms/step - accuracy: 0.8853 - loss: 0.2656 - val_accuracy: 0.6510 - val_loss: 0.9102
Epoch 8/20
141/141 0s 14ms/step - accuracy: 0.9117 - loss: 0.2194WARNING:absl:You are saving your model as an HDF5 file via `m
141/141 2s 16ms/step - accuracy: 0.9116 - loss: 0.2196 - val_accuracy: 0.7250 - val_loss: 0.9996
Epoch 9/20
141/141 2s 15ms/step - accuracy: 0.9333 - loss: 0.1686 - val_accuracy: 0.7200 - val_loss: 0.8083
Epoch 10/20
141/141 0s 14ms/step - accuracy: 0.9454 - loss: 0.1400WARNING:absl:You are saving your model as an HDF5 file via `m
141/141 3s 16ms/step - accuracy: 0.9454 - loss: 0.1400 - val_accuracy: 0.7520 - val_loss: 0.6941
Epoch 11/20
141/141 2s 15ms/step - accuracy: 0.9623 - loss: 0.1044 - val_accuracy: 0.7080 - val_loss: 1.0808
Epoch 12/20
141/141 3s 16ms/step - accuracy: 0.9677 - loss: 0.0858 - val_accuracy: 0.7370 - val_loss: 0.9307
Epoch 13/20
141/141 0s 14ms/step - accuracy: 0.9757 - loss: 0.0712WARNING:absl:You are saving your model as an HDF5 file via `m
141/141 2s 17ms/step - accuracy: 0.9756 - loss: 0.0713 - val_accuracy: 0.7530 - val_loss: 0.8678
Epoch 14/20
141/141 2s 15ms/step - accuracy: 0.9725 - loss: 0.0760 - val_accuracy: 0.7370 - val_loss: 1.0845
Epoch 15/20
141/141 3s 15ms/step - accuracy: 0.9780 - loss: 0.0615 - val_accuracy: 0.6980 - val_loss: 1.6908
Epoch 16/20
138/141 0s 15ms/step - accuracy: 0.9807 - loss: 0.0545WARNING:absl:You are saving your model as an HDF5 file via `m
141/141 3s 18ms/step - accuracy: 0.9807 - loss: 0.0545 - val_accuracy: 0.7580 - val_loss: 1.0369
Epoch 17/20
141/141 5s 16ms/step - accuracy: 0.9898 - loss: 0.0347 - val_accuracy: 0.7380 - val_loss: 1.0138
Epoch 18/20
141/141 2s 16ms/step - accuracy: 0.9787 - loss: 0.0517 - val_accuracy: 0.6800 - val_loss: 2.6137
Epoch 19/20
141/141 2s 15ms/step - accuracy: 0.9780 - loss: 0.0578 - val_accuracy: 0.7560 - val_loss: 1.0270
Epoch 20/20
141/141 2s 16ms/step - accuracy: 0.9830 - loss: 0.0452 - val_accuracy: 0.7300 - val_loss: 1.1696
WARNING:absl:Compiled the loaded model, but the compiled metrics have yet to be built. `model.compile_metrics` will be empty until you t
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Original prediction: cat (0.8166)
True label: cat
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1/1 ━━━━━━ 0s 35ms/step
1/1 ━━━━━━ 0s 36ms/step
1/1 ━━━━━━ 0s 61ms/step
1/1 ━━━━━━ 0s 62ms/step
1/1 ━━━━━━ 0s 49ms/step
1/1 ━━━━━━ 0s 47ms/step
1/1 ━━━━━━ 0s 65ms/step
1/1 ━━━━━━ 0s 49ms/step
1/1 ━━━━━━ 0s 48ms/step
1/1 ━━━━━━ 0s 55ms/step
1/1 ━━━━━━ 0s 51ms/step
1/1 ━━━━━━ 0s 54ms/step
1/1 ━━━━━━ 0s 51ms/step
1/1 ━━━━━━ 0s 61ms/step
1/1 ━━━━━━ 0s 47ms/step
1/1 ━━━━━━ 0s 56ms/step
1/1 ━━━━━━ 0s 50ms/step
1/1 ━━━━━━ 0s 47ms/step
1/1 ━━━━━━ 0s 44ms/step
1/1 ━━━━━━ 0s 48ms/step
1/1 ━━━━━━ 0s 30ms/step
1/1 ━━━━━━ 0s 35ms/step
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1/1 ━━━━━━ 0s 36ms/step
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1/1 ━━━━━━ 0s 51ms/step
1/1 ━━━━━━ 0s 32ms/step
1/1 ━━━━━━ 0s 35ms/step
1/1 ━━━━━━ 0s 30ms/step
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1/1 ━━━━━━ 0s 31ms/step
1/1 ━━━━━━ 0s 30ms/step
1/1 ━━━━━━ 0s 30ms/step
1/1 ━━━━━━ 0s 32ms/step
1/1 ━━━━━━ 0s 35ms/step
1/1 ━━━━━━ 0s 31ms/step
1/1 ━━━━━━ 0s 37ms/step
1/1 ━━━━━━ 0s 45ms/step
1/1 ━━━━━━ 0s 34ms/step
1/1 ━━━━━━ 0s 31ms/step
1/1 ━━━━━━ 0s 30ms/step
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1/1 ━━━━━━ 0s 34ms/step
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1/1 ━━━━━━ 0s 35ms/step
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1/1 ━━━━━━ 0s 36ms/step
1/1 ━━━━━━ 0s 32ms/step
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1/1 ━━━━━━ 0s 34ms/step
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1/1 ━━━━━━ 0s 31ms/step
1/1 ━━━━━━ 0s 38ms/step
1/1 ━━━━━━ 0s 35ms/step
1/1 ━━━━━━ 0s 33ms/step
1/1 ━━━━━━ 0s 33ms/step
1/1 ━━━━━━ 0s 36ms/step
1/1 ━━━━━━ 0s 35ms/step
1/1 ━━━━━━ 0s 32ms/step
1/1 ━━━━━━ 0s 33ms/step
1/1 ━━━━━━ 0s 39ms/step
1/1 ━━━━━━ 0s 32ms/step
1/1 ━━━━━━ 0s 37ms/step

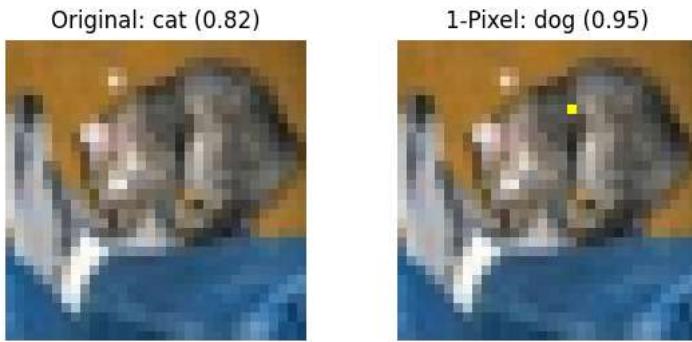
1/1 ━━━━━━ 0s 32ms/step
1/1 ━━━━━━ 0s 32ms/step
1/1 ━━━━━━ 0s 36ms/step
1/1 ━━━━━━ 0s 35ms/step
1/1 ━━━━━━ 0s 45ms/step
1/1 ━━━━━━ 0s 36ms/step
1/1 ━━━━━━ 0s 38ms/step
1/1 ━━━━━━ 0s 34ms/step
1/1 ━━━━━━ 0s 32ms/step
1/1 ━━━━━━ 0s 33ms/step
1/1 ━━━━━━ 0s 38ms/step
1/1 ━━━━━━ 0s 33ms/step
1/1 ━━━━━━ 0s 32ms/step
1/1 ━━━━━━ 0s 35ms/step
1/1 ━━━━━━ 0s 34ms/step
1/1 ━━━━━━ 0s 45ms/step
1/1 ━━━━━━ 0s 34ms/step
1/1 ━━━━━━ 0s 34ms/step
1/1 ━━━━━━ 0s 36ms/step
1/1 ━━━━━━ 0s 32ms/step
1/1 ━━━━━━ 0s 33ms/step
1/1 ━━━━━━ 0s 37ms/step
1/1 ━━━━━━ 0s 37ms/step
1/1 ━━━━━━ 0s 32ms/step
1/1 ━━━━━━ 0s 32ms/step
1/1 ━━━━━━ 0s 35ms/step
1/1 ━━━━━━ 0s 34ms/step
1/1 ━━━━━━ 0s 36ms/step
1/1 ━━━━━━ 0s 38ms/step
1/1 ━━━━━━ 0s 39ms/step
1/1 ━━━━━━ 0s 40ms/step
1/1 ━━━━━━ 0s 45ms/step
1/1 ━━━━━━ 0s 32ms/step
1/1 ━━━━━━ 0s 37ms/step
1/1 ━━━━━━ 0s 39ms/step
1/1 ━━━━━━ 0s 35ms/step
1/1 ━━━━━━ 0s 36ms/step
1/1 ━━━━━━ 0s 38ms/step
1/1 ━━━━━━ 0s 35ms/step
1/1 ━━━━━━ 0s 37ms/step
1/1 ━━━━━━ 0s 34ms/step
1/1 ━━━━━━ 0s 39ms/step
1/1 ━━━━━━ 0s 36ms/step
1/1 ━━━━━━ 0s 35ms/step
1/1 ━━━━━━ 0s 37ms/step
1/1 ━━━━━━ 0s 33ms/step
1/1 ━━━━━━ 0s 34ms/step
1/1 ━━━━━━ 0s 38ms/step
1/1 ━━━━━━ 0s 39ms/step
1/1 ━━━━━━ 0s 36ms/step
1/1 ━━━━━━ 0s 33ms/step
1/1 ━━━━━━ 0s 37ms/step
1/1 ━━━━━━ 0s 37ms/step
1/1 ━━━━━━ 0s 32ms/step
1/1 ━━━━━━ 0s 34ms/step
1/1 ━━━━━━ 0s 43ms/step
1/1 ━━━━━━ 0s 62ms/step
1/1 ━━━━━━ 0s 83ms/step
1/1 ━━━━━━ 0s 77ms/step
1/1 ━━━━━━ 0s 77ms/step
1/1 ━━━━━━ 0s 54ms/step
1/1 ━━━━━━ 0s 54ms/step
1/1 ━━━━━━ 0s 47ms/step
1/1 ━━━━━━ 0s 53ms/step
1/1 ━━━━━━ 0s 62ms/step
1/1 ━━━━━━ 0s 50ms/step
1/1 ━━━━━━ 0s 63ms/step
1/1 ━━━━━━ 0s 52ms/step
1/1 ━━━━━━ 0s 50ms/step
1/1 ━━━━━━ 0s 50ms/step
1/1 ━━━━━━ 0s 63ms/step
1/1 ━━━━━━ 0s 56ms/step
1/1 ━━━━━━ 0s 55ms/step
1/1 ━━━━━━ 0s 44ms/step
1/1 ━━━━━━ 0s 51ms/step
1/1 ━━━━━━ 0s 55ms/step
1/1 ━━━━━━ 0s 50ms/step
1/1 ━━━━━━ 0s 37ms/step
1/1 ━━━━━━ 0s 37ms/step
1/1 ━━━━━━ 0s 40ms/step
1/1 ━━━━━━ 0s 35ms/step
1/1 ━━━━━━ 0s 34ms/step
1/1 ━━━━━━ 0s 33ms/step
1/1 ━━━━━━ 0s 45ms/step
1/1 ━━━━━━ 0s 33ms/step

```
-- -- -- -- --  
1/1 0s 41ms/step  
1/1 0s 39ms/step  
1/1 0s 46ms/step  
1/1 0s 42ms/step  
1/1 0s 37ms/step  
1/1 0s 44ms/step  
1/1 0s 39ms/step  
1/1 0s 36ms/step  
1/1 0s 44ms/step  
1/1 0s 35ms/step  
1/1 0s 35ms/step  
1/1 0s 34ms/step  
1/1 0s 34ms/step  
1/1 0s 34ms/step  
1/1 0s 38ms/step  
1/1 0s 35ms/step  
1/1 0s 37ms/step  
1/1 0s 35ms/step  
1/1 0s 45ms/step  
1/1 0s 37ms/step  
1/1 0s 36ms/step  
1/1 0s 32ms/step  
1/1 0s 32ms/step  
1/1 0s 33ms/step  
1/1 0s 33ms/step  
1/1 0s 42ms/step  
1/1 0s 37ms/step  
1/1 0s 32ms/step  
1/1 0s 35ms/step  
1/1 0s 37ms/step  
1/1 0s 36ms/step  
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1/1 0s 32ms/step  
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1/1 0s 36ms/step  
1/1 0s 36ms/step  
1/1 0s 35ms/step  
1/1 0s 55ms/step  
1/1 0s 37ms/step  
1/1 0s 38ms/step  
1/1 0s 31ms/step  
1/1 0s 39ms/step  
1/1 0s 42ms/step  
1/1 0s 34ms/step  
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1/1 0s 47ms/step  
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1/1 0s 51ms/step  
1/1 0s 37ms/step  
1/1 0s 36ms/step  
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1/1 0s 34ms/step  
1/1 0s 37ms/step  
1/1 0s 36ms/step  
1/1 0s 36ms/step  
1/1 0s 35ms/step  
1/1 0s 45ms/step  
1/1 0s 37ms/step  
1/1 0s 32ms/step
```

```
1/1 0s 20ms/step
1/1 0s 36ms/step
1/1 0s 38ms/step
1/1 0s 36ms/step
1/1 0s 40ms/step
1/1 0s 36ms/step
1/1 0s 40ms/step
1/1 0s 38ms/step
1/1 0s 37ms/step
1/1 0s 36ms/step
1/1 0s 44ms/step
1/1 0s 53ms/step
1/1 0s 57ms/step
1/1 0s 48ms/step
1/1 0s 53ms/step
1/1 0s 46ms/step
1/1 0s 47ms/step
1/1 0s 45ms/step
1/1 0s 45ms/step
1/1 0s 49ms/step
1/1 0s 51ms/step
```

Confidence in true class: 0.0507
 Predicted class after attack: dog (0.9493)

Confidence 0.82 → 0.05



```
== 2-Pixel Attack ==
1/1 0s 47ms/step
1/1 0s 50ms/step
1/1 0s 52ms/step
1/1 0s 49ms/step
1/1 0s 47ms/step
1/1 0s 53ms/step
1/1 0s 57ms/step
1/1 0s 50ms/step
1/1 0s 35ms/step
1/1 0s 36ms/step
1/1 0s 34ms/step
1/1 0s 35ms/step
1/1 0s 31ms/step
1/1 0s 32ms/step
1/1 0s 30ms/step
1/1 0s 29ms/step
1/1 0s 31ms/step
1/1 0s 30ms/step
1/1 0s 43ms/step
1/1 0s 36ms/step
1/1 0s 32ms/step
1/1 0s 31ms/step
1/1 0s 35ms/step
1/1 0s 33ms/step
1/1 0s 31ms/step
1/1 0s 31ms/step
1/1 0s 31ms/step
1/1 0s 29ms/step
1/1 0s 29ms/step
1/1 0s 31ms/step
1/1 0s 33ms/step
1/1 0s 32ms/step
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1/1 0s 36ms/step
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1/1 0s 32ms/step
1/1 0s 31ms/step
1/1 0s 30ms/step
1/1 0s 33ms/step
1/1 0s 31ms/step
1/1 0s 33ms/step
1/1 0s 31ms/step
1/1 0s 32ms/step
1/1 0s 37ms/step
```

1/1 0s 35ms/step
1/1 0s 33ms/step
1/1 0s 32ms/step
1/1 0s 32ms/step
1/1 0s 35ms/step
1/1 0s 36ms/step
1/1 0s 30ms/step
1/1 0s 32ms/step
1/1 0s 33ms/step
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1/1 0s 36ms/step
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1/1 0s 31ms/step
1/1 0s 32ms/step
1/1 0s 38ms/step
1/1 0s 31ms/step
1/1 0s 33ms/step
1/1 0s 31ms/step
1/1 0s 32ms/step
1/1 0s 31ms/step
1/1 0s 31ms/step
1/1 0s 36ms/step
1/1 0s 32ms/step
1/1 0s 44ms/step
1/1 0s 33ms/step
1/1 0s 33ms/step
1/1 0s 31ms/step
1/1 0s 31ms/step
1/1 0s 30ms/step
1/1 0s 31ms/step
1/1 0s 33ms/step
1/1 0s 31ms/step
1/1 0s 32ms/step
1/1 0s 31ms/step
1/1 0s 30ms/step
1/1 0s 43ms/step
1/1 0s 32ms/step
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1/1 0s 32ms/step
1/1 0s 36ms/step
1/1 0s 32ms/step
1/1 0s 33ms/step
1/1 0s 33ms/step
1/1 0s 35ms/step
1/1 0s 39ms/step
1/1 0s 39ms/step
1/1 0s 66ms/step

```
1/1 -- - - - - -  
1/1 0s 42ms/step  
1/1 0s 50ms/step  
1/1 0s 59ms/step  
1/1 0s 52ms/step  
1/1 0s 47ms/step  
1/1 0s 59ms/step  
1/1 0s 48ms/step  
1/1 0s 49ms/step  
1/1 0s 60ms/step  
1/1 0s 50ms/step  
1/1 0s 53ms/step  
1/1 0s 51ms/step  
1/1 0s 54ms/step  
1/1 0s 56ms/step  
1/1 0s 50ms/step  
1/1 0s 55ms/step  
1/1 0s 52ms/step  
1/1 0s 65ms/step  
1/1 0s 35ms/step  
1/1 0s 37ms/step  
1/1 0s 33ms/step  
1/1 0s 37ms/step  
1/1 0s 35ms/step  
1/1 0s 38ms/step  
1/1 0s 33ms/step  
1/1 0s 34ms/step  
1/1 0s 33ms/step  
1/1 0s 35ms/step  
1/1 0s 31ms/step  
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1/1 0s 32ms/step  
1/1 0s 38ms/step  
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1/1 0s 35ms/step  
1/1 0s 40ms/step  
1/1 0s 36ms/step  
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1/1 0s 38ms/step  
1/1 0s 35ms/step  
1/1 0s 32ms/step  
1/1 0s 33ms/step  
1/1 0s 40ms/step  
1/1 0s 31ms/step  
1/1 0s 34ms/step  
1/1 0s 37ms/step  
1/1 0s 42ms/step  
1/1 0s 38ms/step  
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1/1 0s 33ms/step  
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1/1 0s 34ms/step  
1/1 0s 34ms/step  
1/1 0s 31ms/step  
1/1 0s 37ms/step  
1/1 0s 32ms/step  
1/1 0s 36ms/step  
1/1 0s 36ms/step  
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1/1 0s 38ms/step  
1/1 0s 52ms/step  
1/1 0s 37ms/step  
1/1 0s 33ms/step  
1/1 0s 35ms/step  
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1/1 0s 32ms/step  
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1/1 0s 32ms/step  
1/1 0s 32ms/step  
1/1 0s 32ms/step  
1/1 0s 34ms/step  
1/1 0s 45ms/step  
1/1 0s 27ms/step
```

```
1/1    0s 27ms/step  
1/1    0s 38ms/step  
1/1    0s 37ms/step  
1/1    0s 34ms/step  
1/1    0s 35ms/step  
1/1    0s 37ms/step  
1/1    0s 35ms/step  
1/1    0s 34ms/step  
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1/1    0s 37ms/step  
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1/1    0s 36ms/step  
1/1    0s 37ms/step  
1/1    0s 35ms/step  
1/1    0s 35ms/step  
1/1    0s 32ms/step  
1/1    0s 35ms/step  
1/1    0s 40ms/step  
1/1    0s 41ms/step  
1/1    0s 39ms/step  
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1/1    0s 39ms/step  
1/1    0s 41ms/step  
1/1    0s 36ms/step  
1/1    0s 36ms/step  
1/1    0s 52ms/step  
1/1    0s 60ms/step  
1/1    0s 54ms/step  
1/1    0s 50ms/step  
1/1    0s 54ms/step  
1/1    0s 52ms/step  
1/1    0s 49ms/step  
1/1    0s 55ms/step  
1/1    0s 62ms/step  
1/1    0s 67ms/step  
1/1    0s 59ms/step  
1/1    0s 55ms/step  
1/1    0s 54ms/step  
1/1    0s 58ms/step  
1/1    0s 58ms/step  
1/1    0s 58ms/step  
1/1    0s 50ms/step  
1/1    0s 33ms/step  
1/1    0s 33ms/step  
1/1    0s 38ms/step  
1/1    0s 41ms/step  
1/1    0s 37ms/step  
1/1    0s 42ms/step  
1/1    0s 35ms/step  
1/1    0s 37ms/step  
1/1    0s 40ms/step  
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1/1 0s 55ms/step
1/1 0s 79ms/step
1/1 0s 56ms/step
1/1 0s 64ms/step

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1/1 ━━━━━━ 0s 45ms/sten

Original: cat (0.82)



2-Pixel: dog (0.98)



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== 3-Pixel Attack ==  
1/1 0s 35ms/step  
1/1 0s 34ms/step  
1/1 0s 37ms/step  
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1/1 0s 32ms/step
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1/1 0s 38ms/step
1/1 0s 37ms/step
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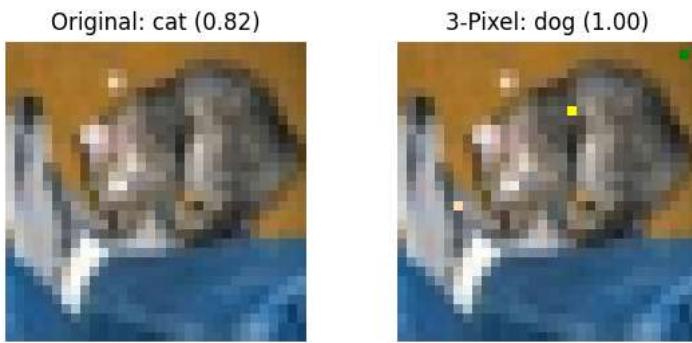
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1/1 ━━━━━━ 0s 59ms/step
```

Confidence in true class: 0.0030
Predicted class after attack: dog (0.9970)

Confidence 0.82 → 0.00



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== 4-Pixel Attack ==
1/1 ━━━━━━ 0s 38ms/step
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1/1 ━━━━━━ 0s 36ms/step
1/1 ━━━━━━ 0s 38ms/step
1/1 ━━━━━━ 0s 42ms/step
1/1 ━━━━━━ 0s 38ms/step
1/1 ━━━━━━ 0s 39ms/step
1/1 ━━━━━━ 0s 35ms/step
1/1 ━━━━━━ 0s 36ms/step
1/1 ━━━━━━ 0s 39ms/step
1/1 ━━━━━━ 0s 39ms/step
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1/1 ━━━━━━ 0s 36ms/step
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1/1 ━━━━━━ 0s 41ms/step
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1/1 ━━━━━━ 0s 41ms/step
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1/1 ━━━━━━ 0s 40ms/step
1/1 ━━━━━━ 0s 58ms/step
1/1 ━━━━━━ 0s 55ms/step
1/1 ━━━━━━ 0s 61ms/step
1/1 ━━━━━━ 0s 46ms/step
1/1 ━━━━━━ 0s 55ms/step
1/1 ━━━━━━ 0s 73ms/step
1/1 ━━━━━━ 0s 61ms/step
1/1 ━━━━━━ 0s 55ms/step
1/1 ━━━━━━ 0s 48ms/step
1/1 ━━━━━━ 0s 51ms/step
1/1 ━━━━━━ 0s 56ms/step
1/1 ━━━━━━ 0s 61ms/step
1/1 ━━━━━━ 0s 63ms/step
1/1 ━━━━━━ 0s 51ms/step
1/1 ━━━━━━ 0s 59ms/step
1/1 ━━━━━━ 0s 59ms/step
1/1 ━━━━━━ 0s 63ms/step

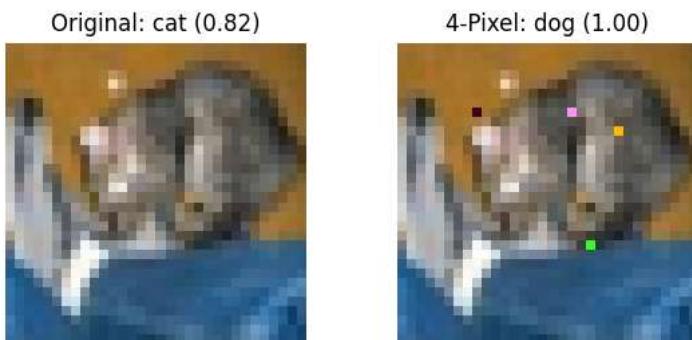
1/1 0s 75ms/step
1/1 0s 54ms/step
1/1 0s 38ms/step
1/1 0s 36ms/step
1/1 0s 37ms/step
1/1 0s 35ms/step
1/1 0s 37ms/step
1/1 0s 37ms/step
1/1 0s 40ms/step
1/1 0s 40ms/step
1/1 0s 46ms/step
1/1 0s 39ms/step
1/1 0s 39ms/step
1/1 0s 38ms/step
1/1 0s 37ms/step
1/1 0s 34ms/step
1/1 0s 49ms/step
1/1 0s 37ms/step
1/1 0s 38ms/step
1/1 0s 37ms/step
1/1 0s 36ms/step
1/1 0s 43ms/step
1/1 0s 38ms/step
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1/1 0s 40ms/step
1/1 0s 36ms/step
1/1 0s 39ms/step
1/1 0s 42ms/step
1/1 0s 40ms/step
1/1 0s 47ms/step
1/1 0s 41ms/step
1/1 0s 36ms/step
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1/1 0s 38ms/step
1/1 0s 36ms/step
1/1 0s 35ms/step
1/1 0s 37ms/step
1/1 0s 52ms/step
1/1 0s 40ms/step
1/1 0s 38ms/step
1/1 0s 38ms/step
1/1 0s 42ms/step

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1/1    0s 37ms/step  
1/1    0s 36ms/step  
1/1    0s 36ms/step  
1/1    0s 40ms/step  
1/1    0s 34ms/step  
1/1    0s 38ms/step  
1/1    0s 53ms/step  
1/1    0s 42ms/step  
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1/1    0s 38ms/step  
1/1    0s 42ms/step  
1/1    0s 39ms/step  
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1/1    0s 38ms/step  
1/1    0s 42ms/step  
1/1    0s 57ms/step  
1/1    0s 53ms/step  
1/1    0s 62ms/step  
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1/1    0s 61ms/step  
1/1    0s 60ms/step  
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1/1    0s 48ms/step  
1/1    0s 52ms/step  
1/1    0s 56ms/step  
1/1    0s 94ms/step  
1/1    0s 66ms/step  
1/1    0s 61ms/step  
1/1    0s 60ms/step  
1/1    0s 51ms/step  
1/1    0s 35ms/step  
1/1    0s 37ms/step  
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1/1    0s 38ms/step  
1/1    0s 41ms/step  
1/1    0s 41ms/step  
1/1    0s 39ms/step  
1/1    0s 38ms/step  
1/1    0s 46ms/step
```

```
1/1 ━━━━━━ 0s 84ms/step
1/1 ━━━━━━ 0s 56ms/step
1/1 ━━━━━━ 0s 59ms/step
1/1 ━━━━━━ 0s 50ms/step
1/1 ━━━━━━ 0s 81ms/step
1/1 ━━━━━━ 0s 51ms/step
1/1 ━━━━━━ 0s 49ms/step
1/1 ━━━━━━ 0s 58ms/step
1/1 ━━━━━━ 0s 59ms/step
1/1 ━━━━━━ 0s 54ms/step
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1/1 ━━━━━━ 0s 44ms/step
1/1 ━━━━━━ 0s 45ms/step
1/1 ━━━━━━ 0s 51ms/step
1/1 ━━━━━━ 0s 43ms/step
1/1 ━━━━━━ 0s 42ms/step
```

Confidence in true class: 0.0002
Predicted class after attack: dog (0.9998)

Confidence 0.82 → 0.00



```
== 5-Pixel Attack ==
1/1 ━━━━━━ 0s 47ms/step
1/1 ━━━━━━ 0s 42ms/step
1/1 ━━━━━━ 0s 39ms/step
1/1 ━━━━━━ 0s 47ms/step
1/1 ━━━━━━ 0s 48ms/step
1/1 ━━━━━━ 0s 41ms/step
1/1 ━━━━━━ 0s 42ms/step
1/1 ━━━━━━ 0s 43ms/step
```

```
1/1 ━━━━━━ 0s 41ms/step  
1/1 ━━━━━━ 0s 38ms/step  
1/1 ━━━━━━ 0s 43ms/step  
1/1 ━━━━━━ 0s 41ms/step  
1/1 ━━━━━━ 0s 38ms/step  
1/1 ━━━━━━ 0s 42ms/step  
1/1 ━━━━━━ 0s 38ms/step  
1/1 ━━━━━━ 0s 37ms/step  
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1/1 ━━━━━━ 0s 38ms/step  
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1/1 ━━━━━━ 0s 73ms/step  
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1/1 ━━━━━━ 0s 50ms/step
```

1/1 ━━━━━━ 0s 39ms/step
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1/1 ━━━━━━ 0s 80ms/step
1/1 ━━━━━━ 0s 79ms/step
1/1 ━━━━━━ 0s 58ms/step
1/1 ━━━━━━ 0s 54ms/step
1/1 ━━━━━━ 0s 68ms/step

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