SETUP AND INSTALLATION

```
!pip install roboflow kagglehub --quiet

import os
import pandas as pd
import numpy as np
import tensorflow as tf
from roboflow import Roboflow
from sklearn.model_selection import train_test_split
from sklearn.utils import resample
from tensorflow.keras.preprocessing.image import ImageDataGenerator
import matplotlib.pyplot as plt
import cv2
from google.colab import files
from google.colab.patches import cv2_imshow

print("done..")
```

```
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   ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 4.2/4.2 MB 82.8 MB/s eta 0:00:00
done..
```

download datasets

```
# Dictionary to hold the paths to our downloaded data
paths = {}

try:
    # --- Roboflow Downloads ---
    from roboflow import Roboflow
    rf = Roboflow(api_key="Z2BdotJhyaVVEojm45J8") # Using the key from the original notebook

    print("--- Downloading Original Datasets ---")
    print("  -> Downloading Graffiti dataset...")
    project = rf.workspace("hruts-workspace").project("graffiti-l6az9")
    dataset = project.version(1).download("yolov8")
    paths['graffiti'] = dataset.location

    print("  -> Downloading Damaged Construction (Concrete) dataset...")
    project = rf.workspace("road-ywxxe").project("concrete-pugqq")
    dataset = project.version(3).download("yolov8")
    paths['concrete'] = dataset.location

    print("  -> Downloading Damaged Signs (HIND) dataset...")
    project = rf.workspace("road-inspection").project("damaged-signs-hind")
    dataset = project.version(2).download("yolov8")
    paths['signs_hind'] = dataset.location

    print("\n--- Downloading and Aggregating Datasets for Minority Classes ---")

    # PARKING DATASETS
    print("  -> Downloading Parking (Original)...")
    project = rf.workspace("parking-amu50").project("illegal-parking")
    dataset = project.version(5).download("yolov8")
    paths['parking_original'] = dataset.location

    print("  -> Downloading Parking (New 1)...")
    project = rf.workspace("hao-61fh1").project("illegal-parking-xtkyr")
    dataset = project.version(1).download("yolov8")
    paths['parking_new_1'] = dataset.location

    # POTHOLE DATASETS
    print("  -> Downloading Potholes (Original)...")
    project = rf.workspace("road-holes").project("road-holes-iow4h")
    dataset = project.version(1).download("yolov8")
    paths['potholes_original'] = dataset.location
```

```
        print("  -> Downloading Potholes (New 1)...")
        project = rf.workspace("evansworkspace").project("pothole-ek")
        dataset = project.version(1).download("yolov8")
        paths['potholes_new_1'] = dataset.location

        # TRASH DATASETS
        print("  -> Downloading Trash (Original)...")
        project = rf.workspace("trash-drone").project("domestic-trash-ryw1h")
        dataset = project.version(2).download("yolov8")
        paths['trash_original'] = dataset.location

        print("  -> Downloading Trash (New 1)...")
        project = rf.workspace("datacluster-labs-agryi").project("domestic-trash")
        dataset = project.version(1).download("yolov8")
        paths['trash_new_1'] = dataset.location


        print("\nAll datasets downloaded successfully!")
        for name, path in paths.items():
            print(f"  - {name}: {path}")

    except Exception as e:
        print(f"\n An error occurred during download: {e}")
```

```
Downloading Dataset Version Zip in concrete-3 to yolov8:: 100%|██████████| 98686/98686 [00:03<00:00, 28697.89it/s]

Extracting Dataset Version Zip to concrete-3 in yolov8:: 100%|██████████| 1992/1992 [00:01<00:00, 1790.78it/s]  -> Downloading Damaged
loading Roboflow workspace...

loading Roboflow project...
Downloading Dataset Version Zip in damaged-signs-Hind-2 to yolov8:: 100%|██████████| 86874/86874 [00:02<00:00, 37475.81it/s]

Extracting Dataset Version Zip to damaged-signs-Hind-2 in yolov8:: 100%|██████████| 4830/4830 [00:00<00:00, 5025.08it/s]
--- Downloading and Aggregating Datasets for Minority Classes ---
  -> Downloading Parking (Original)...
loading Roboflow workspace...

loading Roboflow project...
Downloading Dataset Version Zip in Illegal-Parking-5 to yolov8:: 100%|██████████| 6248/6248 [00:00<00:00, 24068.73it/s]

Extracting Dataset Version Zip to Illegal-Parking-5 in yolov8:: 100%|██████████| 220/220 [00:00<00:00, 5684.46it/s]  -> Downloading Pa
loading Roboflow workspace...

loading Roboflow project...
Downloading Dataset Version Zip in illegal-parking-1 to yolov8:: 100%|██████████| 78407/78407 [00:01<00:00, 55070.46it/s]

Extracting Dataset Version Zip to illegal-parking-1 in yolov8:: 100%|██████████| 4238/4238 [00:00<00:00, 5152.69it/s]  -> Downloading
loading Roboflow workspace...

loading Roboflow project...
Downloading Dataset Version Zip in Road-holes-1 to yolov8:: 100%|██████████| 11134/11134 [00:00<00:00, 24829.50it/s]

Extracting Dataset Version Zip to Road-holes-1 in yolov8:: 100%|██████████| 378/378 [00:00<00:00, 3208.50it/s]  -> Downloading Pothole
loading Roboflow workspace...

loading Roboflow project...
Downloading Dataset Version Zip in pothole-ek-1 to yolov8:: 100%|██████████| 28816/28816 [00:00<00:00, 47220.77it/s]

Extracting Dataset Version Zip to pothole-ek-1 in yolov8:: 100%|██████████| 1058/1058 [00:00<00:00, 5749.01it/s]
  -> Downloading Trash (Original)...
loading Roboflow workspace...
loading Roboflow project...
Downloading Dataset Version Zip in Domestic-trash-2 to yolov8:: 100%|██████████| 20020/20020 [00:00<00:00, 38659.07it/s]

Extracting Dataset Version Zip to Domestic-trash-2 in yolov8:: 100%|██████████| 508/508 [00:00<00:00, 4415.60it/s]  -> Downloading Tra
loading Roboflow workspace...

loading Roboflow project...
Downloading Dataset Version Zip in Domestic-Trash--1 to yolov8:: 100%|██████████| 399716/399716 [00:07<00:00, 51102.31it/s]

Extracting Dataset Version Zip to Domestic-Trash--1 in yolov8:: 100%|██████████| 508/508 [00:01<00:00, 367.97it/s]
```

Process dataset

```
all_data = []

def process_yolo_folder(path, label, data_list):
    """Processes folders with train/valid/test subdirectories."""
    if path is None: return # Skip if a dataset failed to download
    for split in ["train", "valid", "test"]:
        image_path = os.path.join(path, f"{split}/images")
        print(f"  -> Processing: {image_path} for label: {label}")
        try:
            if not os.path.exists(image_path):
                print(f"    --> WARNING: Path does not exist. Skipping.")
                continue
            for img_file in os.listdir(image_path):
                if img_file.lower().endswith(('.png', '.jpg', '.jpeg')):
                    data_list.append({'filepath': os.path.join(image_path, img_file), 'label': label})
        except Exception as e:
            print(f"    --> ERROR processing {path}: {e}")

# Process majority class datasets
process_yolo_folder(paths.get('graffiti'), "Vandalism_Graffiti", all_data)
process_yolo_folder(paths.get('signs_hind'), "Road_Issues_Damaged_Sign", all_data)
process_yolo_folder(paths.get('concrete'), "Infrastructure_Damage_Concrete", all_data)

# Aggregate original and new datasets for the augmented classes
process_yolo_folder(paths.get('parking_original'), "Parking_Issues_Illegal_Parking", all_data)
process_yolo_folder(paths.get('parking_new_1'), "Parking_Issues_Illegal_Parking", all_data)

process_yolo_folder(paths.get('potholes_original'), "Road_Issues_Pothole", all_data)
process_yolo_folder(paths.get('potholes_new_1'), "Road_Issues_Pothole", all_data)

# Correctly combining all three sources for Domestic Trash
process_yolo_folder(paths.get('trash_original'), "Domestic_trash", all_data)
process_yolo_folder(paths.get('trash_new_1'), "Domestic_trash", all_data)

# Create the initial raw DataFrame
df_raw = pd.DataFrame(all_data)

if not df_raw.empty:
    print("\nInitial DataFrame created successfully.")
    print(f"Total raw images found: {len(df_raw)}")
    print("\n New (Imbalanced) Label Distribution:")
    print(df_raw['label'].value_counts())
else:
    print("\nError: No data was loaded. Please check the download paths.")
```

```
  -> Processing: /content/Graffiti-1/train/images for label: Vandalism_Graffiti
  -> Processing: /content/Graffiti-1/valid/images for label: Vandalism_Graffiti
  -> Processing: /content/Graffiti-1/test/images for label: Vandalism_Graffiti
  -> Processing: /content/damaged-signs-Hind-2/train/images for label: Road_Issues_Damaged_Sign
  -> Processing: /content/damaged-signs-Hind-2/valid/images for label: Road_Issues_Damaged_Sign
  -> Processing: /content/damaged-signs-Hind-2/test/images for label: Road_Issues_Damaged_Sign
  -> Processing: /content/concrete-3/train/images for label: Infrastructure_Damage_Concrete
  -> Processing: /content/concrete-3/valid/images for label: Infrastructure_Damage_Concrete
  -> Processing: /content/concrete-3/test/images for label: Infrastructure_Damage_Concrete
  -> Processing: /content/Illegal-Parking-5/train/images for label: Parking_Issues_Illegal_Parking
  -> Processing: /content/Illegal-Parking-5/valid/images for label: Parking_Issues_Illegal_Parking
  -> Processing: /content/Illegal-Parking-5/test/images for label: Parking_Issues_Illegal_Parking
  -> Processing: /content/illegal-parking-1/train/images for label: Parking_Issues_Illegal_Parking
  -> Processing: /content/illegal-parking-1/valid/images for label: Parking_Issues_Illegal_Parking
  -> Processing: /content/illegal-parking-1/test/images for label: Parking_Issues_Illegal_Parking
  -> Processing: /content/Road-holes-1/train/images for label: Road_Issues_Pothole
  -> Processing: /content/Road-holes-1/valid/images for label: Road_Issues_Pothole
  -> Processing: /content/Road-holes-1/test/images for label: Road_Issues_Pothole
  -> Processing: /content/pothole-ek-1/train/images for label: Road_Issues_Pothole
  -> Processing: /content/pothole-ek-1/valid/images for label: Road_Issues_Pothole
  -> Processing: /content/pothole-ek-1/test/images for label: Road_Issues_Pothole
  -> Processing: /content/Domestic-trash-2/train/images for label: Domestic_trash
  -> Processing: /content/Domestic-trash-2/valid/images for label: Domestic_trash
  -> Processing: /content/Domestic-trash-2/test/images for label: Domestic_trash
  -> Processing: /content/Domestic-Trash--1/train/images for label: Domestic_trash
  -> Processing: /content/Domestic-Trash--1/valid/images for label: Domestic_trash
  -> Processing: /content/Domestic-Trash--1/test/images for label: Domestic_trash

Initial DataFrame created successfully.
```

```
Total raw images found: 8946

 New (Imbalanced) Label Distribution:
label
Road_Issues_Damaged_Sign          2409
Parking_Issues_Illegal_Parking    2217
Vandalism_Graffiti                2128
Infrastructure_Damage_Concrete     990
Road_Issues_Pothole                706
Domestic_trash                     496
Name: count, dtype: int64
```

Balanced using oversampling

```
if not df_raw.empty:
    # Find the size of the largest class from our newly aggregated data
    max_size = df_raw['label'].value_counts().max()
    print(f" Target size for each class (based on the largest) will be: {max_size}")

    # Use scikit-learn's resample() to perform oversampling
    df_balanced_list = []
    for class_label in df_raw['label'].unique():
        df_class = df_raw[df_raw['label'] == class_label]

        # If the class is already the largest, no need to resample, just add it
        if len(df_class) == max_size:
            df_balanced_list.append(df_class)
            continue

        df_class_oversampled = resample(df_class,
                                        replace=True,     # Create copies of images
                                        n_samples=max_size,
                                        random_state=42)  # for reproducibility
        df_balanced_list.append(df_class_oversampled)

    # Combine the oversampled classes into a single, balanced DataFrame
    df_balanced = pd.concat(df_balanced_list)

    print("\n New balanced label distribution:")
    print(df_balanced['label'].value_counts())
    print(f"\nTotal images for training after balancing: {len(df_balanced)}")
else:
    print("\nSkipping balancing because the initial dataframe is empty.")
```

```
 Target size for each class (based on the largest) will be: 2409

 New balanced label distribution:
label
Vandalism_Graffiti                2409
Road_Issues_Damaged_Sign          2409
Infrastructure_Damage_Concrete    2409
Parking_Issues_Illegal_Parking    2409
Road_Issues_Pothole               2409
Domestic_trash                    2409
Name: count, dtype: int64

Total images for training after balancing: 14454
```

ANONYMIZE DATA

```
import cv2
import numpy as np
import os

# --- Face Detector Setup ---
face_cascade_file = 'haarcascade_frontalface_default.xml'
if not os.path.exists(face_cascade_file):
    print("Downloading face detector model...")
    !wget -q https://raw.githubusercontent.com/opencv/opencv/master/data/haarcascades/haarcascade_frontalface_default.xml

# --- License Plate Detector Setup ---
plate_cascade_file = 'haarcascade_russian_plate_number.xml'
if not os.path.exists(plate_cascade_file):
    print("Downloading license plate detector model...")
    !wget -q https://raw.githubusercontent.com/opencv/opencv/master/data/haarcascades/haarcascade_russian_plate_number.xml

# Load both cascade classifiers
face_cascade = cv2.CascadeClassifier(face_cascade_file)
plate_cascade = cv2.CascadeClassifier(plate_cascade_file)
print("Face and license plate detectors loaded.")

def anonymize_image(img_array):
    """
    Takes a NumPy array of an image, finds faces AND license plates, blurs them,
    and returns the anonymized image array.
    """
    # Convert image to BGR for OpenCV processing
    img_bgr = cv2.cvtColor(img_array.astype(np.uint8), cv2.COLOR_RGB2BGR)
    gray = cv2.cvtColor(img_bgr, cv2.COLOR_BGR2GRAY)

    # --- 1. Detect and blur faces ---
    faces = face_cascade.detectMultiScale(gray, 1.1, 4)
    for (x, y, w, h) in faces:
        face_roi = img_bgr[y:y+h, x:x+w]
        blurred_face = cv2.GaussianBlur(face_roi, (99, 99), 30)
        img_bgr[y:y+h, x:x+w] = blurred_face

    # --- 2. Detect and blur license plates ---
    plates = plate_cascade.detectMultiScale(gray, 1.1, 4)
    for (x, y, w, h) in plates:
        plate_roi = img_bgr[y:y+h, x:x+w]
        blurred_plate = cv2.GaussianBlur(plate_roi, (99, 99), 30)
        img_bgr[y:y+h, x:x+w] = blurred_plate

    # Convert back to RGB and cast to float32 for the ImageDataGenerator
    # THIS IS THE CORRECTED LINE
    return cv2.cvtColor(img_bgr, cv2.COLOR_BGR2RGB).astype(np.float32)
```

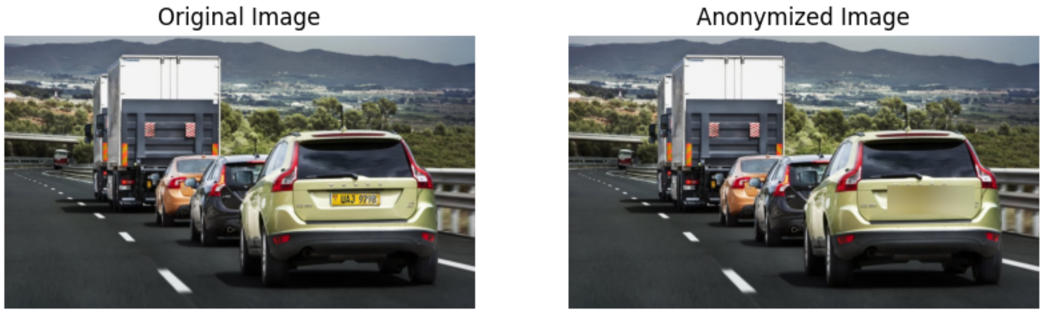
```
Downloading face detector model...
Downloading license plate detector model...
Face and license plate detectors loaded.
```

```
from google.colab import files
import matplotlib.pyplot as plt
import cv2
import numpy as np

# A check to ensure the anonymize_image function is available
if 'anonymize_image' not in locals():
    print(" Error: The 'anonymize_image' function cell was not run. Please run it first.")
else:
    print("Please upload up to 3 images with faces or license plates to test anonymization.")
    # Upload files from your local drive
    uploaded = files.upload()

    # Process and display each uploaded image
    for filename in uploaded.keys():
        print(f"\n--- Processing '{filename}' ---")
        try:
            # Read the uploaded image using OpenCV
            img_data = uploaded[filename]
            img_array = np.frombuffer(img_data, np.uint8)
            img_bgr = cv2.imdecode(img_array, cv2.IMREAD_COLOR)

            # Convert from BGR (OpenCV default) to RGB for our function and Matplotlib
            img_rgb = cv2.cvtColor(img_bgr, cv2.COLOR_BGR2RGB)

            # Run the anonymization function
            anonymized_rgb = anonymize_image(img_rgb)

            # Display side-by-side for comparison
            plt.figure(figsize=(10, 5))

            # Original Image
            plt.subplot(1, 2, 1)
            plt.imshow(img_rgb)
            plt.title("Original Image")
            plt.axis('off')

            # Anonymized Image
            plt.subplot(1, 2, 2)
            # Convert the float array back to uint8 for correct display
            plt.imshow(anonymized_rgb.astype(np.uint8))
            plt.title("Anonymized Image")
            plt.axis('off')

            plt.show()

        except Exception as e:
            print(f"Could not process image {filename}. Error: {e}")
```

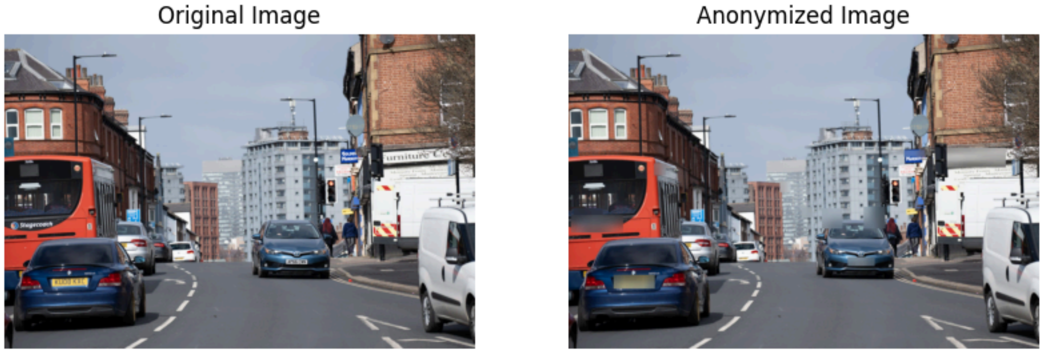
```
Please upload up to 3 images with faces or license plates to test anonymization.
```

Choose Files No file chosen Upload widget is only available when the cell has been executed in the current browser session. Please rerun this cell to enable.

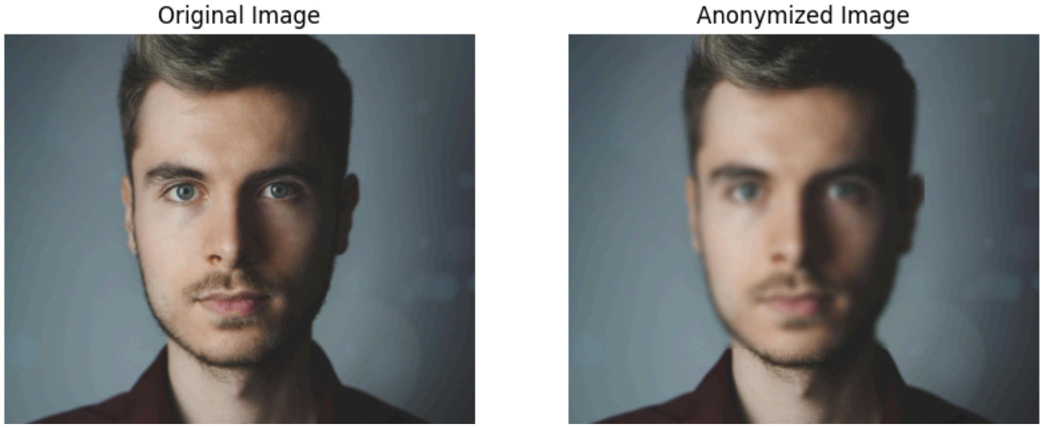
```
Saving driving-highway.jpg to driving-highway.jpg
Saving NumberPlates-scaled.jpeg to NumberPlates-scaled (3).jpeg
Saving pexels-simon-robben-55958-614810.jpg to pexels-simon-robben-55958-614810 (2).jpg

--- Processing 'driving-highway.jpg' ---
```



```
--- Processing 'NumberPlates-scaled (3).jpeg' ---
```



```
--- Processing 'pexels-simon-robben-55958-614810 (2).jpg' ---
```



PREPARE DATA FOR TRAINING

```
print("\nSplitting data into Train, Validation, and Test sets...")

# First, split the balanced data into a 90% block (for training+validation) and a 10% block (for testing)
train_val_df, test_df = train_test_split(
    df_balanced,
    test_size=0.10, # 10% for the final test set
    random_state=42,
    stratify=df_balanced['label']
)

# Next, split the 90% block into training and validation sets.
train_df, val_df = train_test_split(
    train_val_df,
    test_size=0.111, # This makes the validation set ~10% of the original total data
    random_state=42,
    stratify=train_val_df['label']
)

print(f"\nTotal balanced samples: {len(df_balanced)}")
print(f" -> Training samples:   {len(train_df)}")
print(f" -> Validation samples: {len(val_df)}")
print(f" -> Test samples:       {len(test_df)}")

# Create Data Generators with Augmentation and our Anonymization function
train_datagen = ImageDataGenerator(
    rescale=1./255,
    rotation_range=20,
    width_shift_range=0.2,
    height_shift_range=0.2,
    shear_range=0.2,
    zoom_range=0.2,
    horizontal_flip=True,
    fill_mode='nearest',
    preprocessing_function=anonymize_image
)

val_test_datagen = ImageDataGenerator(
    rescale=1./255,
    preprocessing_function=anonymize_image
)

IMG_SIZE = (128, 128)
BATCH_SIZE = 64

# Create all three generators
train_generator = train_datagen.flow_from_dataframe(
    dataframe=train_df,
    x_col='filepath',
    y_col='label',
    target_size=IMG_SIZE,
    batch_size=BATCH_SIZE,
    class_mode='categorical',
    shuffle=True
)

validation_generator = val_test_datagen.flow_from_dataframe(
    dataframe=val_df,
    x_col='filepath',
    y_col='label',
    target_size=IMG_SIZE,
    batch_size=BATCH_SIZE,
    class_mode='categorical',
    shuffle=False
)

test_generator = val_test_datagen.flow_from_dataframe(
    dataframe=test_df,
    x_col='filepath',
    y_col='label',
    target_size=IMG_SIZE,
    batch_size=BATCH_SIZE,
    class_mode='categorical',
    shuffle=False
)
print("\nTrain, Validation, and Test generators created successfully with anonymization.")


# --- EXPORT THE DATAFRAME SPLITS TO CSV FILES ---
# This part goes at the end of this cell because it needs train_df, val_df, and test_df.
print("\nExporting DataFrame splits to CSV files...")
try:
```

```
    train_df.to_csv('train.csv', index=False)
    val_df.to_csv('validate.csv', index=False)
    test_df.to_csv('test.csv', index=False)
    print("train.csv, validate.csv, and test.csv have been created successfully.")
except Exception as e:
    print(f"Error exporting to CSV: {e}")
```

```
Splitting data into Train, Validation, and Test sets...

Total balanced samples: 14454
 -> Training samples:   11564
 -> Validation samples: 1444
 -> Test samples:       1446
Found 11564 validated image filenames belonging to 6 classes.
Found 1444 validated image filenames belonging to 6 classes.
Found 1446 validated image filenames belonging to 6 classes.

Train, Validation, and Test generators created successfully with anonymization.

Exporting DataFrame splits to CSV files...
train.csv, validate.csv, and test.csv have been created successfully.
```

BUILD AND COMPILE THE MODEL

```
if 'train_generator' in locals():
    print("\n  Building the CNN Model...")

    num_classes = len(df_balanced['label'].unique())
    print(f"Number of classes for output layer: {num_classes}")

    model = tf.keras.models.Sequential([
        # First Convolutional Block
        tf.keras.layers.Conv2D(32, (3, 3), activation='relu', input_shape=(128, 128, 3)),
        tf.keras.layers.MaxPooling2D(2, 2),

        # Second Convolutional Block
        tf.keras.layers.Conv2D(64, (3, 3), activation='relu'),
        tf.keras.layers.MaxPooling2D(2, 2),

        # Third Convolutional Block
        tf.keras.layers.Conv2D(128, (3, 3), activation='relu'),
        tf.keras.layers.MaxPooling2D(2, 2),

        # Dense Layers
        tf.keras.layers.Flatten(),
        tf.keras.layers.Dense(512, activation='relu'),
        tf.keras.layers.Dropout(0.5), # Dropout for regularization
        tf.keras.layers.Dense(num_classes, activation='softmax') # Softmax for multi-class
    ])

    model.compile(
        optimizer=tf.keras.optimizers.Adam(learning_rate=0.001),
        loss='categorical_crossentropy',
        metrics=['accuracy']
    )

    model.summary()
else:
    print("\nSkipping model building because data generators are not ready.")
```

```
 Building the CNN Model...
Number of classes for output layer: 6
Do not pass an `input_shape`/`input_dim` argument to a layer. When using Sequential models, prefer using an `Input(shape)` object as the
Model: "sequential_2"
┏━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━┳━━━━━━━━━━━━━━━━━━━━━━━━┳━━━━━━━━━━━━━━━┓
┃ Layer (type)                    ┃ Output Shape           ┃       Param # ┃
┡━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━╇━━━━━━━━━━━━━━━━━━━━━━━━╇━━━━━━━━━━━━━━━┩
│ conv2d_6 (Conv2D)               │ (None, 126, 126, 32)   │           896 │
├─────────────────────────────────┼────────────────────────┼───────────────┤
│ max_pooling2d_6 (MaxPooling2D)  │ (None, 63, 63, 32)     │             0 │
├─────────────────────────────────┼────────────────────────┼───────────────┤
│ conv2d_7 (Conv2D)               │ (None, 61, 61, 64)     │        18,496 │
├─────────────────────────────────┼────────────────────────┼───────────────┤
│ max_pooling2d_7 (MaxPooling2D)  │ (None, 30, 30, 64)     │             0 │
├─────────────────────────────────┼────────────────────────┼───────────────┤
│ conv2d_8 (Conv2D)               │ (None, 28, 28, 128)    │        73,856 │
├─────────────────────────────────┼────────────────────────┼───────────────┤
│ max_pooling2d_8 (MaxPooling2D)  │ (None, 14, 14, 128)    │             0 │
├─────────────────────────────────┼────────────────────────┼───────────────┤
│ flatten_2 (Flatten)             │ (None, 25088)          │             0 │
├─────────────────────────────────┼────────────────────────┼───────────────┤
│ dense_4 (Dense)                 │ (None, 512)            │    12,845,568 │
├─────────────────────────────────┼────────────────────────┼───────────────┤
│ dropout_2 (Dropout)             │ (None, 512)            │             0 │
├─────────────────────────────────┼────────────────────────┼───────────────┤
│ dense_5 (Dense)                 │ (None, 6)              │         3,078 │
└─────────────────────────────────┴────────────────────────┴───────────────┘
 Total params: 12,941,894 (49.37 MB)
 Trainable params: 12,941,894 (49.37 MB)
```

train model

```
if 'model' in locals():
    print("\nStarting Model Training...")

    # Callbacks for smarter training
    callbacks = [
        tf.keras.callbacks.EarlyStopping(monitor='val_loss', patience=5, restore_best_weights=True),
        tf.keras.callbacks.ModelCheckpoint('MlArtist_model.h5', monitor='val_accuracy', save_best_only=True, mode='max'),
        tf.keras.callbacks.ReduceLROnPlateau(monitor='val_loss', factor=0.2, patience=3, min_lr=1e-6)
    ]

    EPOCHS = 30 # Train epochs

    history = model.fit(
        train_generator,
        epochs=EPOCHS,
        validation_data=validation_generator,
        callbacks=callbacks
    )

else:
    print("\nSkipping training because the model was not built.")
```

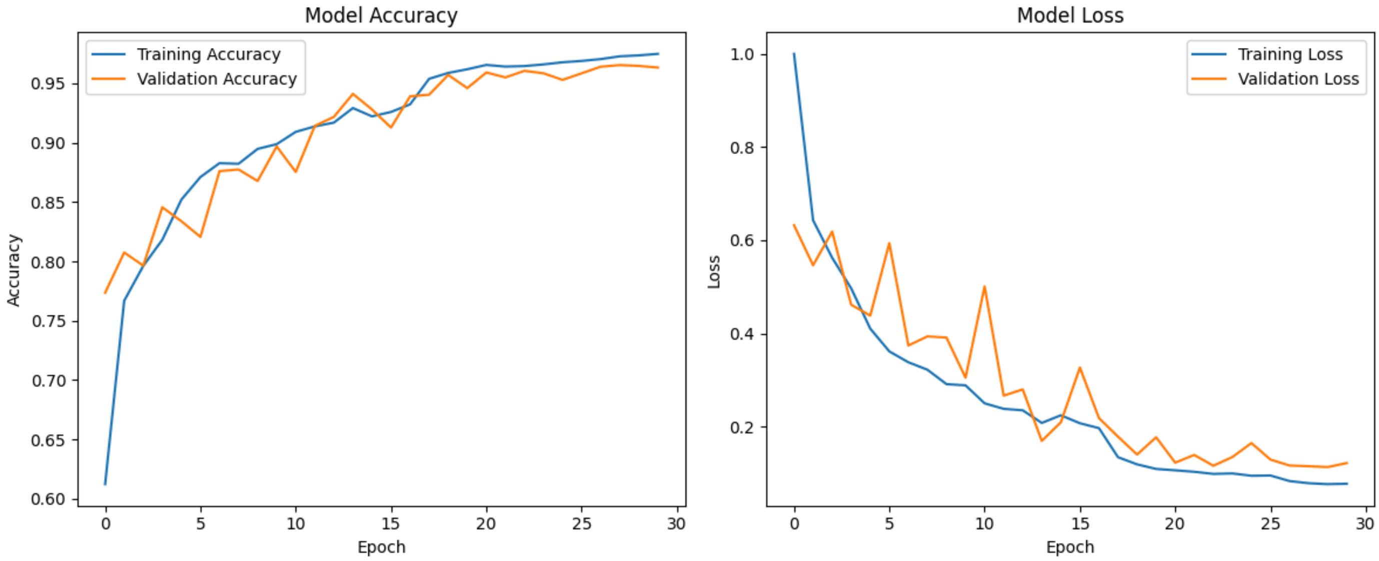
```
Starting Model Training...
Your `PyDataset` class should call `super().__init__(**kwargs)` in its constructor. `**kwargs` can include `workers`, `use_multiproces
Epoch 1/30
181/181 ━━━━━━━━━━━━━━━━━━━━ 0s 1s/step - accuracy: 0.4797 - loss: 1.3166WARNING:absl:You are saving your model as an HDF5 file via `m
181/181 ━━━━━━━━━━━━━━━━━━━━ 302s 2s/step - accuracy: 0.4804 - loss: 1.3149 - val_accuracy: 0.7735 - val_loss: 0.6322 - learning_rate:
Epoch 2/30
181/181 ━━━━━━━━━━━━━━━━━━━━ 0s 1s/step - accuracy: 0.7471 - loss: 0.6798WARNING:absl:You are saving your model as an HDF5 file via `m
181/181 ━━━━━━━━━━━━━━━━━━━━ 288s 2s/step - accuracy: 0.7472 - loss: 0.6796 - val_accuracy: 0.8075 - val_loss: 0.5463 - learning_rate:
Epoch 3/30
181/181 ━━━━━━━━━━━━━━━━━━━━ 299s 2s/step - accuracy: 0.7989 - loss: 0.5535 - val_accuracy: 0.7964 - val_loss: 0.6185 - learning_rate:
Epoch 4/30
181/181 ━━━━━━━━━━━━━━━━━━━━ 0s 1s/step - accuracy: 0.8157 - loss: 0.5096WARNING:absl:You are saving your model as an HDF5 file via `m
181/181 ━━━━━━━━━━━━━━━━━━━━ 283s 2s/step - accuracy: 0.8157 - loss: 0.5096 - val_accuracy: 0.8456 - val_loss: 0.4615 - learning_rate:
Epoch 5/30
181/181 ━━━━━━━━━━━━━━━━━━━━ 283s 2s/step - accuracy: 0.8572 - loss: 0.4026 - val_accuracy: 0.8338 - val_loss: 0.4382 - learning_rate:
Epoch 6/30
181/181 ━━━━━━━━━━━━━━━━━━━━ 274s 2s/step - accuracy: 0.8645 - loss: 0.3741 - val_accuracy: 0.8206 - val_loss: 0.5939 - learning_rate:
Epoch 7/30
181/181 ━━━━━━━━━━━━━━━━━━━━ 0s 1s/step - accuracy: 0.8782 - loss: 0.3482WARNING:absl:You are saving your model as an HDF5 file via `m
181/181 ━━━━━━━━━━━━━━━━━━━━ 281s 2s/step - accuracy: 0.8782 - loss: 0.3481 - val_accuracy: 0.8760 - val_loss: 0.3741 - learning_rate:
Epoch 8/30
181/181 ━━━━━━━━━━━━━━━━━━━━ 0s 1s/step - accuracy: 0.8785 - loss: 0.3322WARNING:absl:You are saving your model as an HDF5 file via `m
181/181 ━━━━━━━━━━━━━━━━━━━━ 287s 2s/step - accuracy: 0.8785 - loss: 0.3322 - val_accuracy: 0.8774 - val_loss: 0.3936 - learning_rate:
Epoch 9/30
```

```
181/181 ━━━━━━━━━━━━━━━━━━━━ 308s 2s/step - accuracy: 0.8976 - loss: 0.2871 - val_accuracy: 0.8677 - val_loss: 0.3910 - learning_rate:
Epoch 10/30
181/181 ━━━━━━━━━━━━━━━━━━━━ 0s 1s/step - accuracy: 0.9026 - loss: 0.2844WARNING:absl:You are saving your model as an HDF5 file via `m
181/181 ━━━━━━━━━━━━━━━━━━━━ 292s 2s/step - accuracy: 0.9026 - loss: 0.2845 - val_accuracy: 0.8968 - val_loss: 0.3049 - learning_rate:
Epoch 11/30
181/181 ━━━━━━━━━━━━━━━━━━━━ 284s 2s/step - accuracy: 0.9012 - loss: 0.2610 - val_accuracy: 0.8753 - val_loss: 0.5010 - learning_rate:
Epoch 12/30
181/181 ━━━━━━━━━━━━━━━━━━━━ 0s 1s/step - accuracy: 0.9125 - loss: 0.2431WARNING:absl:You are saving your model as an HDF5 file via `m
181/181 ━━━━━━━━━━━━━━━━━━━━ 295s 2s/step - accuracy: 0.9125 - loss: 0.2431 - val_accuracy: 0.9141 - val_loss: 0.2665 - learning_rate:
Epoch 13/30
181/181 ━━━━━━━━━━━━━━━━━━━━ 0s 1s/step - accuracy: 0.9166 - loss: 0.2359WARNING:absl:You are saving your model as an HDF5 file via `m
181/181 ━━━━━━━━━━━━━━━━━━━━ 296s 2s/step - accuracy: 0.9166 - loss: 0.2359 - val_accuracy: 0.9217 - val_loss: 0.2798 - learning_rate:
Epoch 14/30
181/181 ━━━━━━━━━━━━━━━━━━━━ 0s 1s/step - accuracy: 0.9301 - loss: 0.2135WARNING:absl:You are saving your model as an HDF5 file via `m
181/181 ━━━━━━━━━━━━━━━━━━━━ 275s 2s/step - accuracy: 0.9301 - loss: 0.2134 - val_accuracy: 0.9411 - val_loss: 0.1693 - learning_rate:
Epoch 15/30
181/181 ━━━━━━━━━━━━━━━━━━━━ 325s 2s/step - accuracy: 0.9255 - loss: 0.2104 - val_accuracy: 0.9280 - val_loss: 0.2092 - learning_rate:
Epoch 16/30
181/181 ━━━━━━━━━━━━━━━━━━━━ 297s 2s/step - accuracy: 0.9280 - loss: 0.2017 - val_accuracy: 0.9127 - val_loss: 0.3267 - learning_rate:
Epoch 17/30
181/181 ━━━━━━━━━━━━━━━━━━━━ 285s 2s/step - accuracy: 0.9239 - loss: 0.2189 - val_accuracy: 0.9391 - val_loss: 0.2183 - learning_rate:
Epoch 18/30
181/181 ━━━━━━━━━━━━━━━━━━━━ 277s 2s/step - accuracy: 0.9507 - loss: 0.1400 - val_accuracy: 0.9404 - val_loss: 0.1784 - learning_rate:
Epoch 19/30
181/181 ━━━━━━━━━━━━━━━━━━━━ 0s 1s/step - accuracy: 0.9597 - loss: 0.1192WARNING:absl:You are saving your model as an HDF5 file via `m
181/181 ━━━━━━━━━━━━━━━━━━━━ 298s 2s/step - accuracy: 0.9597 - loss: 0.1192 - val_accuracy: 0.9571 - val_loss: 0.1400 - learning_rate:
Epoch 20/30
181/181 ━━━━━━━━━━━━━━━━━━━━ 295s 2s/step - accuracy: 0.9588 - loss: 0.1168 - val_accuracy: 0.9460 - val_loss: 0.1771 - learning_rate:
Epoch 21/30
181/181 ━━━━━━━━━━━━━━━━━━━━ 0s 1s/step - accuracy: 0.9657 - loss: 0.1086WARNING:absl:You are saving your model as an HDF5 file via `m
181/181 ━━━━━━━━━━━━━━━━━━━━ 276s 2s/step - accuracy: 0.9657 - loss: 0.1086 - val_accuracy: 0.9591 - val_loss: 0.1226 - learning_rate:
Epoch 22/30
181/181 ━━━━━━━━━━━━━━━━━━━━ 276s 2s/step - accuracy: 0.9645 - loss: 0.1041 - val_accuracy: 0.9550 - val_loss: 0.1392 - learning_rate:
```

EVALUATE AND VISUALIZE

```
from sklearn.metrics import classification_report

if 'history' in locals():
    print("\nPlotting training history...")

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

    # Plot Accuracy
    plt.subplot(1, 2, 1)
    plt.plot(history.history['accuracy'], label='Training Accuracy')
    plt.plot(history.history['val_accuracy'], label='Validation Accuracy')
    plt.title('Model Accuracy')
    plt.xlabel('Epoch')
    plt.ylabel('Accuracy')
    plt.legend()

    # Plot Loss
    plt.subplot(1, 2, 2)
    plt.plot(history.history['loss'], label='Training Loss')
    plt.plot(history.history['val_loss'], label='Validation Loss')
    plt.title('Model Loss')
    plt.xlabel('Epoch')
    plt.ylabel('Loss')
    plt.legend()

    plt.tight_layout()
    plt.show()

    # --- Final evaluation on the UNSEEN TEST DATA ---
    print("\nFinal evaluation on the unseen Test data:")
    # Load the best performing model saved by ModelCheckpoint
    best_model = tf.keras.models.load_model('MlArtist_model.h5')

    # Evaluate using the test_generator
    test_loss, test_accuracy = best_model.evaluate(test_generator, verbose=0)
    print(f"  -> Test Accuracy: {test_accuracy*100:.2f}%")
    print(f"  -> Test Loss: {test_loss:.4f}")

    # --- Classification Report on the UNSEEN TEST DATA ---
    print("\nClassification Report on Test Data:")
    # Get predictions from the test generator
    y_pred = best_model.predict(test_generator)
    y_pred_classes = np.argmax(y_pred, axis=1)

    # Get true labels from the test generator
    y_true = test_generator.classes

    # Get class labels
    class_labels = list(test_generator.class_indices.keys())

    print(classification_report(y_true, y_pred_classes, target_names=class_labels))

else:
    print("\nSkipping evaluation because training was not completed.")
```

```
Plotting training history...
```



```
WARNING:absl:Compiled the loaded model, but the compiled metrics have yet to be built. `model.compile_metrics` will be empty until you t

Final evaluation on the unseen Test data:
Your `PyDataset` class should call `super().__init__(**kwargs)` in its constructor. `**kwargs` can include `workers`, `use_multiprocessi
  -> Test Accuracy: 97.72%
  -> Test Loss: 0.0730

Classification Report on Test Data:
23/23 ━━━━━━━━━━━━━━━━━━━━ 30s 1s/step
                                precision    recall  f1-score   support

                Domestic_trash       0.99      1.00      1.00       241
Infrastructure_Damage_Concrete       0.97      1.00      0.99       241
Parking_Issues_Illegal_Parking       0.99      0.98      0.99       241
      Road_Issues_Damaged_Sign       1.00      0.97      0.98       241
          Road_Issues_Pothole       0.96      0.98      0.97       241
            Vandalism_Graffiti       0.95      0.94      0.95       241

                      accuracy                           0.98      1446
                     macro avg       0.98      0.98      0.98      1446
                  weighted avg       0.98      0.98      0.98      1446
```

save model as pickle

```
import pickle


pickle_filename = 'MlArtist_FinalModel.pkl'

print(f"Saving model to {pickle_filename}...")

with open(pickle_filename, 'wb') as file:
    pickle.dump(best_model, file)

print(" Model successfully saved as a pickle file.")
```

```
Saving model to MlArtist_FinalModel.pkl...
 Model successfully saved as a pickle file.
```

prediction

```
import pickle

# --- Load Model from Pickle File ---
try:
    # Define the pickle filename
    pickle_filename = 'MlArtist_FinalModel.pkl'
    print(f"Loading model from {pickle_filename}...")

    # Open the file in read-binary mode and load the model
    with open(pickle_filename, 'rb') as file:
        best_model = pickle.load(file)

    print(" Best trained model loaded successfully from pickle file.")
except Exception as e:
    print(f" Error loading model from pickle file: {e}")
    best_model = None


# --- Prediction Function ---
# This function uses the global 'anonymize_image' function defined in a previous cell.
def predict_on_upload(model_to_use, train_gen):
    if model_to_use is None:
        print("Model is not loaded. Cannot predict.")
        return

    # Create the label map from the training generator
    class_indices = train_gen.class_indices
    labels_map = {v: k for k, v in class_indices.items()}

    # Upload files
    uploaded = files.upload()
    for filename in uploaded.keys():
        print(f"\n--- Analyzing '{filename}' ---")
        try:
            # Load the image for processing
            img = tf.keras.preprocessing.image.load_img(filename, target_size=(128, 128))
            img_array_rgb = tf.keras.preprocessing.image.img_to_array(img)

            # Anonymize the image using our function (which returns a float32 array)
            anonymized_array_float = anonymize_image(img_array_rgb)

            # Prepare the image for the model (rescale and add batch dimension)
            img_batch = np.expand_dims(anonymized_array_float, axis=0)
            img_preprocessed = img_batch / 255.0  # Rescale float[0,255] to float[0,1]

            # Make the prediction
            prediction = model_to_use.predict(img_preprocessed)

            predicted_index = np.argmax(prediction[0])
            predicted_label = labels_map[predicted_index]
            confidence = np.max(prediction[0]) * 100

            main_category, sub_category = predicted_label.split('_', 1)

            # --- Display the results ---
            print("\n Anonymized Input Image:")

            # For display, convert the float array back to a uint8 BGR image for cv2_imshow
            display_img_uint8 = anonymized_array_float.astype(np.uint8)
            display_img_bgr = cv2.cvtColor(display_img_uint8, cv2.COLOR_RGB2BGR)
            cv2_imshow(display_img_bgr)

            print(f"\n Prediction Result:")
            print(f"  - Main Category: {main_category}")
            print(f"  - Sub Category:  {sub_category.replace('_', ' ')}")
            print(f"  - Confidence:    {confidence:.2f}%")

        except Exception as e:
            print(f"Error processing {filename}: {e}")


# --- Run Prediction ---
# This check ensures that the model has been loaded and the generators exist
if 'best_model' in locals() and best_model is not None and 'train_generator' in locals():
    print("\nReady to predict! Use the button below to upload an image.")
    predict_on_upload(best_model, train_generator)
else:
    print("\nCannot run prediction. Ensure the model was trained and data generators were created.")


# --- Load Model from Pickle File ---
try:
    # Define the pickle filename
    pickle_filename = 'MlArtist_FinalModel.pkl'
    print(f"Loading model from {pickle_filename}...")

    # Open the file in read-binary mode and load the model
    with open(pickle_filename, 'rb') as file:
        best_model = pickle.load(file)

    print(" Best trained model loaded successfully from pickle file.")
except Exception as e:
    print(f" Error loading model from pickle file: {e}")
    best_model = None


# --- Prediction Function ---
# This function uses the global 'anonymize_image' function defined in a previous cell.
def predict_on_upload(model_to_use, train_gen):
    if model_to_use is None:
        print("Model is not loaded. Cannot predict.")
        return

    # Create the label map from the training generator
    class_indices = train_gen.class_indices
    labels_map = {v: k for k, v in class_indices.items()}

    # Upload files
    uploaded = files.upload()
    for filename in uploaded.keys():
        print(f"\n--- Analyzing '{filename}' ---")
        try:
            # Load the image for processing
            img = tf.keras.preprocessing.image.load_img(filename, target_size=(128, 128))
            img_array_rgb = tf.keras.preprocessing.image.img_to_array(img)

            # Anonymize the image using our function (which returns a float32 array)
            anonymized_array_float = anonymize_image(img_array_rgb)

            # Prepare the image for the model (rescale and add batch dimension)
            img_batch = np.expand_dims(anonymized_array_float, axis=0)
            img_preprocessed = img_batch / 255.0  # Rescale float[0,255] to float[0,1]

            # Make the prediction
            prediction = model_to_use.predict(img_preprocessed)

            predicted_index = np.argmax(prediction[0])
            predicted_label = labels_map[predicted_index]
            confidence = np.max(prediction[0]) * 100

            main_category, sub_category = predicted_label.split('_', 1)

            # --- Display the results ---
            print("\n Anonymized Input Image:")

            # For display, convert the float array back to a uint8 BGR image for cv2_imshow
            display_img_uint8 = anonymized_array_float.astype(np.uint8)
            display_img_bgr = cv2.cvtColor(display_img_uint8, cv2.COLOR_RGB2BGR)
            cv2_imshow(display_img_bgr)

            print(f"\n Prediction Result:")
            print(f"  - Main Category: {main_category}")
            print(f"  - Sub Category:  {sub_category.replace('_', ' ')}")
            print(f"  - Confidence:    {confidence:.2f}%")

        except Exception as e:
            print(f"Error processing {filename}: {e}")


# --- Run Prediction ---
# This check ensures that the model has been loaded and the generators exist
if 'best_model' in locals() and best_model is not None and 'train_generator' in locals():
    print("\nReady to predict! Use the button below to upload an image.")
    predict_on_upload(best_model, train_generator)
else:
    print("\nCannot run prediction. Ensure the model was trained and data generators were created.")


# --- Load Model from Pickle File ---
try:
    # Define the pickle filename
    pickle_filename = 'MlArtist_FinalModel.pkl'
    print(f"Loading model from {pickle_filename}...")

    # Open the file in read-binary mode and load the model
    with open(pickle_filename, 'rb') as file:
        best_model = pickle.load(file)

    print(" Best trained model loaded successfully from pickle file.")
except Exception as e:
    print(f" Error loading model from pickle file: {e}")
    best_model = None


# --- Prediction Function ---
# This function uses the global 'anonymize_image' function defined in a previous cell.
def predict_on_upload(model_to_use, train_gen):
    if model_to_use is None:
        print("Model is not loaded. Cannot predict.")
        return

    # Create the label map from the training generator
    class_indices = train_gen.class_indices
    labels_map = {v: k for k, v in class_indices.items()}

    # Upload files
    uploaded = files.upload()
    for filename in uploaded.keys():
        print(f"\n--- Analyzing '{filename}' ---")
        try:
            # Load the image for processing
            img = tf.keras.preprocessing.image.load_img(filename, target_size=(128, 128))
            img_array_rgb = tf.keras.preprocessing.image.img_to_array(img)

            # Anonymize the image using our function (which returns a float32 array)
            anonymized_array_float = anonymize_image(img_array_rgb)

            # Prepare the image for the model (rescale and add batch dimension)
            img_batch = np.expand_dims(anonymized_array_float, axis=0)
            img_preprocessed = img_batch / 255.0  # Rescale float[0,255] to float[0,1]

            # Make the prediction
            prediction = model_to_use.predict(img_preprocessed)

            predicted_index = np.argmax(prediction[0])
            predicted_label = labels_map[predicted_index]
            confidence = np.max(prediction[0]) * 100

            main_category, sub_category = predicted_label.split('_', 1)

            # --- Display the results ---
            print("\n Anonymized Input Image:")

            # For display, convert the float array back to a uint8 BGR image for cv2_imshow
            display_img_uint8 = anonymized_array_float.astype(np.uint8)
            display_img_bgr = cv2.cvtColor(display_img_uint8, cv2.COLOR_RGB2BGR)
            cv2_imshow(display_img_bgr)

            print(f"\n Prediction Result:")
            print(f"  - Main Category: {main_category}")
            print(f"  - Sub Category:  {sub_category.replace('_', ' ')}")
            print(f"  - Confidence:    {confidence:.2f}%")

        except Exception as e:
            print(f"Error processing {filename}: {e}")


# --- Run Prediction ---
# This check ensures that the model has been loaded and the generators exist
if 'best_model' in locals() and best_model is not None and 'train_generator' in locals():
    print("\nReady to predict! Use the button below to upload an image.")
    predict_on_upload(best_model, train_generator)
else:
    print("\nCannot run prediction. Ensure the model was trained and data generators were created.")


# --- Load Model from Pickle File ---
try:
    # Define the pickle filename
    pickle_filename = 'MlArtist_FinalModel.pkl'
    print(f"Loading model from {pickle_filename}...")

    # Open the file in read-binary mode and load the model
    with open(pickle_filename, 'rb') as file:
        best_model = pickle.load(file)

    print(" Best trained model loaded successfully from pickle file.")
except Exception as e:
    print(f" Error loading model from pickle file: {e}")
    best_model = None


# --- Prediction Function ---
# This function uses the global 'anonymize_image' function defined in a previous cell.
def predict_on_upload(model_to_use, train_gen):
    if model_to_use is None:
        print("Model is not loaded. Cannot predict.")
        return

    # Create the label map from the training generator
    class_indices = train_gen.class_indices
    labels_map = {v: k for k, v in class_indices.items()}

    # Upload files
    uploaded = files.upload()
    for filename in uploaded.keys():
        print(f"\n--- Analyzing '{filename}' ---")
        try:
            # Load the image for processing
            img = tf.keras.preprocessing.image.load_img(filename, target_size=(128, 128))
            img_array_rgb = tf.keras.preprocessing.image.img_to_array(img)

            # Anonymize the image using our function (which returns a float32 array)
            anonymized_array_float = anonymize_image(img_array_rgb)

            # Prepare the image for the model (rescale and add batch dimension)
            img_batch = np.expand_dims(anonymized_array_float, axis=0)
            img_preprocessed = img_batch / 255.0  # Rescale float[0,255] to float[0,1]

            # Make the prediction
            prediction = model_to_use.predict(img_preprocessed)

            predicted_index = np.argmax(prediction[0])
            predicted_label = labels_map[predicted_index]
            confidence = np.max(prediction[0]) * 100

            main_category, sub_category = predicted_label.split('_', 1)

            # --- Display the results ---
            print("\n Anonymized Input Image:")

            # For display, convert the float array back to a uint8 BGR image for cv2_imshow
            display_img_uint8 = anonymized_array_float.astype(np.uint8)
            display_img_bgr = cv2.cvtColor(display_img_uint8, cv2.COLOR_RGB2BGR)
            cv2_imshow(display_img_bgr)

            print(f"\n Prediction Result:")
            print(f"  - Main Category: {main_category}")
            print(f"  - Sub Category:  {sub_category.replace('_', ' ')}")
            print(f"  - Confidence:    {confidence:.2f}%")

        except Exception as e:
            print(f"Error processing {filename}: {e}")


# --- Run Prediction ---
# This check ensures that the model has been loaded and the generators exist
if 'best_model' in locals() and best_model is not None and 'train_generator' in locals():
    print("\nReady to predict! Use the button below to upload an image.")
    predict_on_upload(best_model, train_generator)
else:
    print("\nCannot run prediction. Ensure the model was trained and data generators were created.")


# --- Load Model from Pickle File ---
try:
    # Define the pickle filename
    pickle_filename = 'MlArtist_FinalModel.pkl'
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    # Open the file in read-binary mode and load the model
    with open(pickle_filename, 'rb') as file:
        best_model = pickle.load(file)

    print(" Best trained model loaded successfully from pickle file.")
except Exception as e:
    print(f" Error loading model from pickle file: {e}")
    best_model = None



# --- Prediction Function ---
# This function uses the global 'anonymize_image' function defined in a previous cell.
def predict_on_upload(model_to_use, train_gen):
    if model_to_use is None:
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    class_indices = train_gen.class_indices
    labels_map = {v: k for k, v in class_indices.items()}

    # Upload files
    uploaded = files.upload()
    for filename in uploaded.keys():
        print(f"\n--- Analyzing '{filename}' ---")
        try:
            # Load the image for processing
            img = tf.keras.preprocessing.image.load_img(filename, target_size=(128, 128))
            img_array_rgb = tf.keras.preprocessing.image.img_to_array(img)

            # Anonymize the image using our function (which returns a float32 array)
            anonymized_array_float = anonymize_image(img_array_rgb)

            # Prepare the image for the model (rescale and add batch dimension)
            img_batch = np.expand_dims(anonymized_array_float, axis=0)
            img_preprocessed = img_batch / 255.0  # Rescale float[0,255] to float[0,1]

            # Make the prediction
            prediction = model_to_use.predict(img_preprocessed)

            predicted_index = np.argmax(prediction[0])
            predicted_label = labels_map[predicted_index]
            confidence = np.max(prediction[0]) * 100

            main_category, sub_category = predicted_label.split('_', 1)

            # --- Display the results ---
            print("\n Anonymized Input Image:")

            # For display, convert the float array back to a uint8 BGR image for cv2_imshow
            display_img_uint8 = anonymized_array_float.astype(np.uint8)
            display_img_bgr = cv2.cvtColor(display_img_uint8, cv2.COLOR_RGB2BGR)
            cv2_imshow(display_img_bgr)
            print(f"\n Prediction Result:")
            print(f"  - Main Category: {main_category}")
            print(f"  - Sub Category:  {sub_category.replace('_', ' ')}")
            print(f"  - Confidence:    {confidence:.2f}%")

        except Exception as e:
            print(f"Error processing {filename}: {e}")


# --- Run Prediction ---
# This check ensures that the model has been loaded and the generators exist
if 'best_model' in locals() and best_model is not None and 'train_generator' in locals():
    print("\nReady to predict! Use the button below to upload an image.")
    predict_on_upload(best_model, train_generator)
else:
    print("\nCannot run prediction. Ensure the model was trained and data generators were created.")


# --- Load Model from Pickle File ---
try:
    # Define the pickle filename
    pickle_filename = 'MlArtist_FinalModel.pkl'
    print(f"Loading model from {pickle_filename}...")

    # Open the file in read-binary mode and load the model
    with open(pickle_filename, 'rb') as file:
        best_model = pickle.load(file)

    print(" Best trained model loaded successfully from pickle file.")
except Exception as e:
    print(f" Error loading model from pickle file: {e}")
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# --- Prediction Function ---
# This function uses the global 'anonymize_image' function defined in a previous cell.
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    class_indices = train_gen.class_indices
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    uploaded = files.upload()
    for filename in uploaded.keys():
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        try:
            # Load the image for processing
            img = tf.keras.preprocessing.image.load_img(filename, target_size=(128, 128))
            img_array_rgb = tf.keras.preprocessing.image.img_to_array(img)

            # Anonymize the image using our function (which returns a float32 array)
            anonymized_array_float = anonymize_image(img_array_rgb)

            # Prepare the image for the model (rescale and add batch dimension)
            img_batch = np.expand_dims(anonymized_array_float, axis=0)
            img_preprocessed = img_batch / 255.0  # Rescale float[0,255] to float[0,1]

            # Make the prediction
            prediction = model_to_use.predict(img_preprocessed)

            predicted_index = np.argmax(prediction[0])
            predicted_label = labels_map[predicted_index]
            confidence = np.max(prediction[0]) * 100

            main_category, sub_category = predicted_label.split('_', 1)

            # --- Display the results ---
            print("\n Anonymized Input Image:")

            # For display, convert the float array back to a uint8 BGR image for cv2_imshow
            display_img_uint8 = anonymized_array_float.astype(np.uint8)
            display_img_bgr = cv2.cvtColor(display_img_uint8, cv2.COLOR_RGB2BGR)
            cv2_imshow(display_img_bgr)
            print(f"\n Prediction Result:")
            print(f"  - Main Category: {main_category}")
            print(f"  - Sub Category:  {sub_category.replace('_', ' ')}")
            print(f"  - Confidence:    {confidence:.2f}%")

        except Exception as e:
            print(f"Error processing {filename}: {e}")


# --- Run Prediction ---
# This check ensures that the model has been loaded and the generators exist
if 'best_model' in locals() and best_model is not None and 'train_generator' in locals():
    print("\nReady to predict! Use the button below to upload an image.")
    predict_on_upload(best_model, train_generator)
else:
    print("\nCannot run prediction. Ensure the model was trained and data generators were created.")
```

Default title text

```
# @title Default title text
# --- Load Model from Pickle File ---
try:
    # Define the pickle filename
    pickle_filename = 'MlArtist_FinalModel.pkl'
    print(f"Loading model from {pickle_filename}...")

    # Open the file in read-binary mode and load the model
    with open(pickle_filename, 'rb') as file:
        best_model = pickle.load(file)

    print(" Best trained model loaded successfully from pickle file.")
except Exception as e:
    print(f" Error loading model from pickle file: {e}")
    best_model = None


# --- Prediction Function ---
# This function uses the global 'anonymize_image' function defined in a previous cell.
def predict_on_upload(model_to_use, train_gen):
    if model_to_use is None:
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            # Prepare the image for the model (rescale and add batch dimension)
            img_batch = np.expand_dims(anonymized_array_float, axis=0)
            img_preprocessed = img_batch / 255.0  # Rescale float[0,255] to float[0,1]

            # Make the prediction
            prediction = model_to_use.predict(img_preprocessed)

            predicted_index = np.argmax(prediction[0])
            predicted_label = labels_map[predicted_index]
            confidence = np.max(prediction[0]) * 100

            main_category, sub_category = predicted_label.split('_', 1)

            # --- Display the results ---
            print("\n Anonymized Input Image:")
            # For display, convert the float array back to a uint8 BGR image for cv2_imshow
            display_img_uint8 = anonymized_array_float.astype(np.uint8)
            display_img_bgr = cv2.cvtColor(display_img_uint8, cv2.COLOR_RGB2BGR)
            cv2_imshow(display_img_bgr)

            print(f"\n Prediction Result:")
            print(f"  - Main Category: {main_category}")
            print(f"  - Sub Category:  {sub_category.replace('_', ' ')}")
            print(f"  - Confidence:    {confidence:.2f}%")

        except Exception as e:
            print(f"Error processing {filename}: {e}")


# --- Run Prediction ---
# This check ensures that the model has been loaded and the generators exist
if 'best_model' in locals() and best_model is not None and 'train_generator' in locals():
    print("\nReady to predict! Use the button below to upload an image.")
    predict_on_upload(best_model, train_generator)
else:
    print("\nCannot run prediction. Ensure the model was trained and data generators were created.")


# --- Load Model from Pickle File ---
try:
    # Define the pickle filename
    pickle_filename = 'MlArtist_FinalModel.pkl'
    print(f"Loading model from {pickle_filename}...")

    # Open the file in read-binary mode and load the model
    with open(pickle_filename, 'rb') as file:
        best_model = pickle.load(file)

    print(" Best trained model loaded successfully from pickle file.")
except Exception as e:
    print(f" Error loading model from pickle file: {e}")
    best_model = None


# --- Prediction Function ---
# This function uses the global 'anonymize_image' function defined in a previous cell.
def predict_on_upload(model_to_use, train_gen):
    if model_to_use is None:
        print("Model is not loaded. Cannot predict.")
        return

    # Create the label map from the training generator
    class_indices = train_gen.class_indices
    labels_map = {v: k for k, v in class_indices.items()}

    # Upload files
    uploaded = files.upload()
    for filename in uploaded.keys():
        print(f"\n--- Analyzing '{filename}' ---")
        try:
            # Load the image for processing
            img = tf.keras.preprocessing.image.load_img(filename, target_size=(128, 128))
            img_array_rgb = tf.keras.preprocessing.image.img_to_array(img)

            # Anonymize the image using our function (which returns a float32 array)
            anonymized_array_float = anonymize_image(img_array_rgb)

            # Prepare the image for the model (rescale and add batch dimension)
            img_batch = np.expand_dims(anonymized_array_float, axis=0)
            img_preprocessed = img_batch / 255.0  # Rescale float[0,255] to float[0,1]

            # Make the prediction
            prediction = model_to_use.predict(img_preprocessed)

            predicted_index = np.argmax(prediction[0])
            predicted_label = labels_map[predicted_index]
            confidence = np.max(prediction[0]) * 100

            main_category, sub_category = predicted_label.split('_', 1)

            # --- Display the results ---
            print("\n Anonymized Input Image:")
            # For display, convert the float array back to a uint8 BGR image for cv2_imshow
            display_img_uint8 = anonymized_array_float.astype(np.uint8)
            display_img_bgr = cv2.cvtColor(display_img_uint8, cv2.COLOR_RGB2BGR)
            cv2_imshow(display_img_bgr)

            print(f"\n Prediction Result:")
            print(f"  - Main Category: {main_category}")
            print(f"  - Sub Category:  {sub_category.replace('_', ' ')}")
            print(f"  - Confidence:    {confidence:.2f}%")

        except Exception as e:
            print(f"Error processing {filename}: {e}")


# --- Run Prediction ---
# This check ensures that the model has been loaded and the generators exist
if 'best_model' in locals() and best_model is not None and 'train_generator' in locals():
    print("\nReady to predict! Use the button below to upload an image.")
    predict_on_upload(best_model, train_generator)
else:
    print("\nCannot run prediction. Ensure the model was trained and data generators were created.")
```

```
Ready to predict! Use the button below to upload an image.
```

Choose Files No file chosen Upload widget is only available when the cell has been executed in the current browser session. Please rerun this cell to enable.

```
Saving images (4).jpg to images (4).jpg

--- Analyzing 'images (4).jpg' ---
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 30ms/step

 Anonymized Input Image:
```

```
 Prediction Result:
  - Main Category: Vandalism
  - Sub Category:  Graffiti
  - Confidence:    99.57%
```

```
# --- Load Model from Pickle File ---
try:
    # Define the pickle filename
    pickle_filename = 'MlArtist_FinalModel.pkl'
    print(f"Loading model from {pickle_filename}...")

    # Open the file in read-binary mode and load the model
    with open(pickle_filename, 'rb') as file:
        best_model = pickle.load(file)

    print(" Best trained model loaded successfully from pickle file.")
except Exception as e:
    print(f" Error loading model from pickle file: {e}")
    best_model = None


# --- Prediction Function ---
# This function uses the global 'anonymize_image' function defined in a previous cell.
def predict_on_upload(model_to_use, train_gen):
    if model_to_use is None:
        print("Model is not loaded. Cannot predict.")
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    # Create the label map from the training generator
    class_indices = train_gen.class_indices
    labels_map = {v: k for k, v in class_indices.items()}

    # Upload files
    uploaded = files.upload()
    for filename in uploaded.keys():
        print(f"\n--- Analyzing '{filename}' ---")
        try:
            # Load the image for processing
            img = tf.keras.preprocessing.image.load_img(filename, target_size=(128, 128))
            img_array_rgb = tf.keras.preprocessing.image.img_to_array(img)

            # Anonymize the image using our function (which returns a float32 array)
            anonymized_array_float = anonymize_image(img_array_rgb)

            # Prepare the image for the model (rescale and add batch dimension)
            img_batch = np.expand_dims(anonymized_array_float, axis=0)
            img_preprocessed = img_batch / 255.0  # Rescale float[0,255] to float[0,1]

            # Make the prediction
            prediction = model_to_use.predict(img_preprocessed)

            predicted_index = np.argmax(prediction[0])
            predicted_label = labels_map[predicted_index]
            confidence = np.max(prediction[0]) * 100

            main_category, sub_category = predicted_label.split('_', 1)

            # --- Display the results ---
            print("\n Anonymized Input Image:")

            # For display, convert the float array back to a uint8 BGR image for cv2_imshow
            display_img_uint8 = anonymized_array_float.astype(np.uint8)
            display_img_bgr = cv2.cvtColor(display_img_uint8, cv2.COLOR_RGB2BGR)
            cv2_imshow(display_img_bgr)

            print(f"\n Prediction Result:")
            print(f"  - Main Category: {main_category}")
            print(f"  - Sub Category:  {sub_category.replace('_', ' ')}")
            print(f"  - Confidence:    {confidence:.2f}%")

        except Exception as e:
            print(f"Error processing {filename}: {e}")


# --- Run Prediction ---
# This check ensures that the model has been loaded and the generators exist
if 'best_model' in locals() and best_model is not None and 'train_generator' in locals():
    print("\nReady to predict! Use the button below to upload an image.")
    predict_on_upload(best_model, train_generator)
else:
    print("\nCannot run prediction. Ensure the model was trained and data generators were created.")
```

```
Ready to predict! Use the button below to upload an image.
```

Choose Files No file chosen Upload widget is only available when the cell has been executed in the current browser session. Please rerun this cell to enable.

```
Saving IMG_5515-1-1920x1440.webp to IMG_5515-1-1920x1440.webp

--- Analyzing 'IMG_5515-1-1920x1440.webp' ---
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 30ms/step

 Anonymized Input Image:
```

```
 Prediction Result:
  - Main Category: Domestic
  - Sub Category:  trash
  - Confidence:    95.33%
```

```
# --- Load Model from Pickle File ---
try:
    # Define the pickle filename
    pickle_filename = 'MlArtist_FinalModel.pkl'
    print(f"Loading model from {pickle_filename}...")

    # Open the file in read-binary mode and load the model
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        print(f"\n--- Analyzing '{filename}' ---")
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            # Load the image for processing
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            main_category, sub_category = predicted_label.split('_', 1)

            # --- Display the results ---
            print("\n Anonymized Input Image:")

            # For display, convert the float array back to a uint8 BGR image for cv2_imshow
            display_img_uint8 = anonymized_array_float.astype(np.uint8)
            display_img_bgr = cv2.cvtColor(display_img_uint8, cv2.COLOR_RGB2BGR)
            cv2_imshow(display_img_bgr)

            print(f"\n Prediction Result:")
            print(f"  - Main Category: {main_category}")
            print(f"  - Sub Category:  {sub_category.replace('_', ' ')}")
            print(f"  - Confidence:    {confidence:.2f}%")

        except Exception as e:
            print(f"Error processing {filename}: {e}")


# --- Run Prediction ---
# This check ensures that the model has been loaded and the generators exist
if 'best_model' in locals() and best_model is not None and 'train_generator' in locals():
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else:
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```

```
Ready to predict! Use the button below to upload an image.
```

Choose Files No file chosen Upload widget is only available when the cell has been executed in the current browser session. Please rerun this cell to enable.

```
Saving images (5).jpg to images (5).jpg

--- Analyzing 'images (5).jpg' ---
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 30ms/step

 Anonymized Input Image:
```

```
 Prediction Result:
  - Main Category: Vandalism
  - Sub Category:  Graffiti
```

```
# --- Load Model from Pickle File ---
try:
    # Define the pickle filename
    pickle_filename = 'MlArtist_FinalModel.pkl'
    print(f"Loading model from {pickle_filename}...")

    # Open the file in read-binary mode and load the model
    with open(pickle_filename, 'rb') as file:
        best_model = pickle.load(file)

    print(" Best trained model loaded successfully from pickle file.")
except Exception as e:
    print(f" Error loading model from pickle file: {e}")
    best_model = None


# --- Prediction Function ---
# This function uses the global 'anonymize_image' function defined in a previous cell.
def predict_on_upload(model_to_use, train_gen):
    if model_to_use is None:
        print("Model is not loaded. Cannot predict.")
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    # Create the label map from the training generator
    class_indices = train_gen.class_indices
    labels_map = {v: k for k, v in class_indices.items()}

    # Upload files
    uploaded = files.upload()
    for filename in uploaded.keys():
        print(f"\n--- Analyzing '{filename}' ---")
        try:
            # Load the image for processing
            img = tf.keras.preprocessing.image.load_img(filename, target_size=(128, 128))
            img_array_rgb = tf.keras.preprocessing.image.img_to_array(img)

            # Anonymize the image using our function (which returns a float32 array)
            anonymized_array_float = anonymize_image(img_array_rgb)

            # Prepare the image for the model (rescale and add batch dimension)
            img_batch = np.expand_dims(anonymized_array_float, axis=0)
            img_preprocessed = img_batch / 255.0  # Rescale float[0,255] to float[0,1]

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            predicted_label = labels_map[predicted_index]
            confidence = np.max(prediction[0]) * 100

            main_category, sub_category = predicted_label.split('_', 1)

            # --- Display the results ---
            print("\n Anonymized Input Image:")
            # For display, convert the float array back to a uint8 BGR image for cv2_imshow
            display_img_uint8 = anonymized_array_float.astype(np.uint8)
            display_img_bgr = cv2.cvtColor(display_img_uint8, cv2.COLOR_RGB2BGR)
            cv2_imshow(display_img_bgr)

            print(f"\n Prediction Result:")
            print(f"  - Main Category: {main_category}")
            print(f"  - Sub Category:  {sub_category.replace('_', ' ')}")
            print(f"  - Confidence:    {confidence:.2f}%")

        except Exception as e:
            print(f"Error processing {filename}: {e}")


# --- Run Prediction ---
# This check ensures that the model has been loaded and the generators exist
if 'best_model' in locals() and best_model is not None and 'train_generator' in locals():
    print("\nReady to predict! Use the button below to upload an image.")
    predict_on_upload(best_model, train_generator)
else:
    print("\nCannot run prediction. Ensure the model was trained and data generators were created.")
```

```
Ready to predict! Use the button below to upload an image.
```

Choose Files No file chosen Upload widget is only available when the cell has been executed in the current browser session. Please rerun this cell to enable.

```
Saving 87f4e7e6-512325_550x300_crop.jpg to 87f4e7e6-512325_550x300_crop.jpg

--- Analyzing '87f4e7e6-512325_550x300_crop.jpg' ---
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 31ms/step

 Anonymized Input Image:
```

```
 Prediction Result:
  - Main Category: Vandalism
  - Sub Category:  Graffiti
```

```
# --- Load Model from Pickle File ---
try:
    # Define the pickle filename
    pickle_filename = 'MlArtist_FinalModel.pkl'
    print(f"Loading model from {pickle_filename}...")

    # Open the file in read-binary mode and load the model
    with open(pickle_filename, 'rb') as file:
        best_model = pickle.load(file)

    print(" Best trained model loaded successfully from pickle file.")
except Exception as e:
    print(f" Error loading model from pickle file: {e}")
    best_model = None


# --- Prediction Function ---
# This function uses the global 'anonymize_image' function defined in a previous cell.
def predict_on_upload(model_to_use, train_gen):
    if model_to_use is None:
        print("Model is not loaded. Cannot predict.")
        return

    # Create the label map from the training generator
    class_indices = train_gen.class_indices
    labels_map = {v: k for k, v in class_indices.items()}

    # Upload files
    uploaded = files.upload()
    for filename in uploaded.keys():
        print(f"\n--- Analyzing '{filename}' ---")
        try:
            # Load the image for processing
            img = tf.keras.preprocessing.image.load_img(filename, target_size=(128, 128))
            img_array_rgb = tf.keras.preprocessing.image.img_to_array(img)

            # Anonymize the image using our function (which returns a float32 array)
            anonymized_array_float = anonymize_image(img_array_rgb)

            # Prepare the image for the model (rescale and add batch dimension)
            img_batch = np.expand_dims(anonymized_array_float, axis=0)
            img_preprocessed = img_batch / 255.0  # Rescale float[0,255] to float[0,1]

            # Make the prediction
            prediction = model_to_use.predict(img_preprocessed)

            predicted_index = np.argmax(prediction[0])
            predicted_label = labels_map[predicted_index]
            confidence = np.max(prediction[0]) * 100

            main_category, sub_category = predicted_label.split('_', 1)

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            print(f"  - Sub Category:  {sub_category.replace('_', ' ')}")
```