Cat vs Dog Image Classification

Abstract

This project presents an innovative approach to image classification, specifically targeting the distinction between cats and dogs. By leveraging transfer learning techniques, we combine the power of a pre-trained VGG16 convolutional neural network for feature extraction with a Support Vector Machine (SVM) classifier for final prediction. This hybrid model aims to achieve high accuracy in categorizing images while minimizing computational resources. The workflow encompasses data preparation, feature extraction using VGG16, SVM model training, performance evaluation, and a user-friendly interface for classifying new images. This research contributes to the field of computer vision by demonstrating an effective method for binary image classification that can be extended to various other image recognition tasks.

Workflow

1. **Setup and Data Preparation**:

    - Import necessary libraries
    - Set image size for processing
    - Load pre-trained VGG16 model (excluding top layers)

2. **Feature Extraction**:
   - Load and preprocess images from the dataset
   - Use VGG16 to extract features from each image
   - Store features and corresponding labels
3. **Model Training**:
   - Split data into training and testing sets
   - Train an SVM classifier on the extracted features
4. **Model Evaluation**:
   - Predict labels for the test set
   - Calculate and display accuracy and R2 score
5. **Image Classification**:
   - Implement a function to classify new images
   - Allow user to select images via file dialog
   - Preprocess selected images and extract features
   - Use trained SVM to predict and display results

In [ ]:
```
# Set the image size
image_size = (224, 224)

from keras.applications.vgg16 import VGG16
# Load the VGG16 model
vgg_model = VGG16(weights='imagenet', include_top=False, input_shape=(image_size[0]
```

Explanation

1. We're setting up a standardized image size (224x224) that matches VGG16's expected input.
2. We're importing the pre-trained VGG16 model from Keras for transfer learning.
3. By using `weights='imagenet'`, we leverage features learned from millions of images.
4. `include_top=False` removes the final classification layers, allowing us to use VGG16 for feature extraction only.
5. We specify the `input_shape` to match our desired image dimensions and color channels.

In [ ]:
```
import os
from tensorflow.keras.utils import load_img
from tensorflow.keras.utils import img_to_array
import numpy as np
from keras.applications.vgg16 import preprocess_input

# Extract features from images
X = []
y = []
dataset_dir = 'C:/Users/Hamad/Desktop/DataScience and AI 6 Months Mentorship/PRODIG
```

```
dog_count = 0
cat_count = 0
max_per_class = 150
total_count = 0

for file in os.listdir(dataset_dir):
    if file.endswith('.jpg'):
        label = file.split('.')[0]
        if (label == 'dog' and dog_count < max_per_class) or (label == 'cat' and ca
            if label == 'dog':
                y.append(1)
                dog_count += 1
            else:
                y.append(0)
                cat_count += 1

            image = load_img(os.path.join(dataset_dir, file), target_size=image_siz
            image = img_to_array(image)
            image = np.expand_dims(image, axis=0)
            image = preprocess_input(image)
            features = vgg_model.predict(image)
            features = features.flatten()
            X.append(features)

            total_count += 1
            if total_count % 10 == 0:
                print(f"{total_count} images processed")

        if dog_count >= max_per_class and cat_count >= max_per_class:
            break

X = np.array(X)
y = np.array(y)

# Ensure X and y have data
if len(X) == 0 or len(y) == 0:
    raise ValueError("No data found in X or y. Please check your dataset directory

print(f"Number of samples in X: {len(X)}")
print(f"Number of labels in y: {len(y)}")
print(f"Shape of X: {X.shape}")
print(f"Shape of y: {y.shape}")
print(f"Number of dog images: {dog_count}")
print(f"Number of cat images: {cat_count}")
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1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
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1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
140 images processed
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
150 images processed
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
```

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1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
160 images processed
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
170 images processed
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
180 images processed
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 2s 2s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 2s 2s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 2s 2s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 2s 2s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 2s 2s/step
190 images processed
1/1 ━━━━━━━━━━━━━━━━━━━━ 2s 2s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
200 images processed
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
```

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1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
210 images processed
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 2s 2s/step
220 images processed
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
230 images processed
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
240 images processed
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
250 images processed
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 2s 2s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
```

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1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
260 images processed
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
270 images processed
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 2s 2s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
280 images processed
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 2s 2s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
290 images processed
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 1s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 2s 2s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 2s 2s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 2s 2s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 2s 2s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 2s 2s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 2s 2s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 2s 2s/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 2s 2s/step
300 images processed
Number of samples in X: 300
Number of labels in y: 300
Shape of X: (300, 25088)
Shape of y: (300,)
```

```
Number of dog images: 150
Number of cat images: 150
```

Explanation

1. We're loading and preprocessing a balanced set of cat and dog images (150 each) from the specified directory.
2. Each image is resized to match the VGG16 input size (224x224) and preprocessed using Keras utilities.
3. We use the pre-trained VGG16 model to extract features from each image, flattening them for use with our classifier.
4. Labels are assigned (0 for cats, 1 for dogs) and stored alongside the extracted features.
5. We're implementing checks to ensure data is loaded correctly and providing informative prints about the dataset.
6. The resulting X (features) and y (labels) arrays are prepared for subsequent model training and evaluation.

In [ ]:

```python
from sklearn.model_selection import train_test_split
from sklearn.svm import SVC
from sklearn.metrics import accuracy_score , r2_score

# Check if X and y are not empty
if len(X) > 0 and len(y) > 0:
    # Split the dataset into training and testing sets
    X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random

    # Create an SVM classifier
    svm = SVC(kernel='linear', random_state=42)

    # Train the classifier
    svm.fit(X_train, y_train)

    # Predict labels for the test set
    y_pred = svm.predict(X_test)
    print(X_test.shape)
    # Calculate the accuracy
    accuracy = accuracy_score(y_test, y_pred)
    r2 = r2_score(y_test, y_pred)
    print('Accuracy:', accuracy)
    print('R2 Score:', r2)
else:
    print("Error: The dataset is empty. Please ensure that X and y contain data bef
```

```
(60, 25088)
Accuracy: 0.95
R2 Score: 0.7997775305895439
```

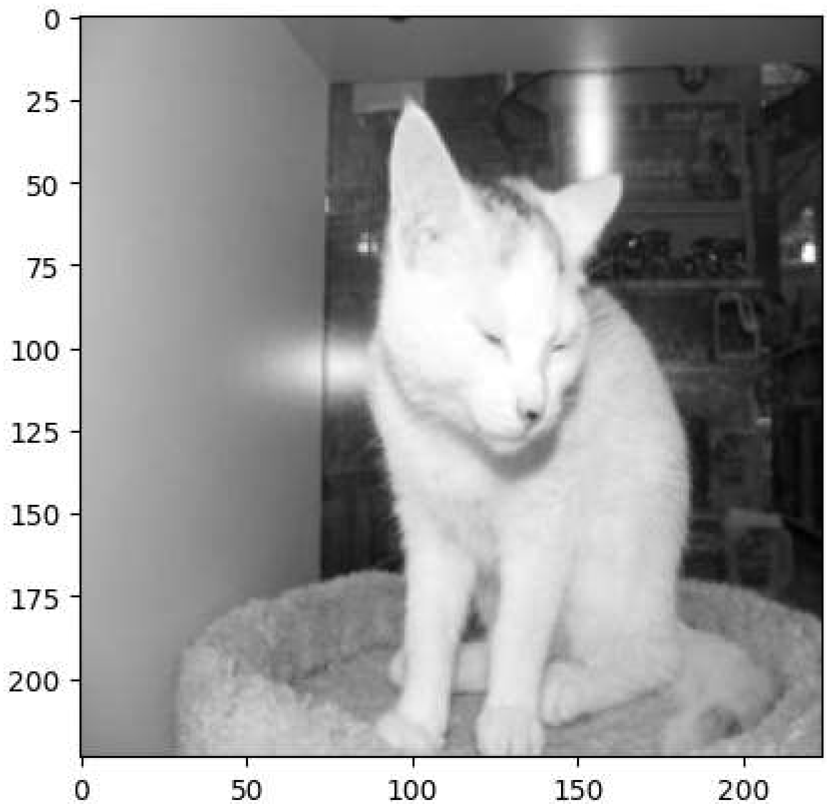
Explanation

1. We're splitting our dataset into training and testing sets to properly evaluate our model's performance.

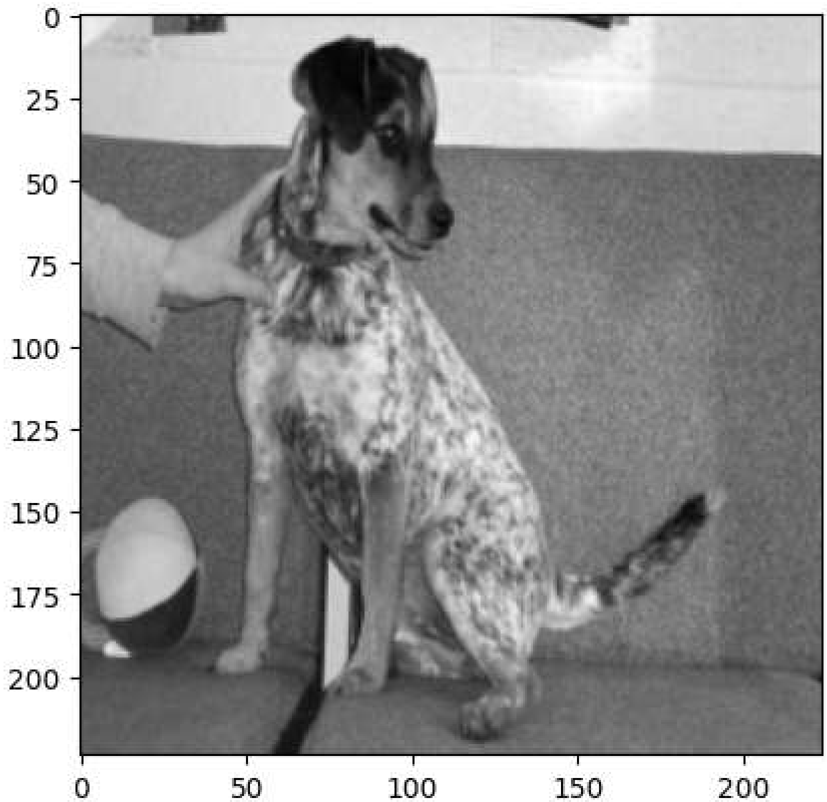
2. We're using a Support Vector Machine (SVM) classifier with a linear kernel for our binary classification task.
3. The SVM is trained on the features extracted by VGG16 from our cat and dog images.
4. We're predicting labels for the test set to assess how well our model generalizes to unseen data.
5. We calculate and display the accuracy score to measure the model's overall performance.
6. We also compute the R2 score, though it's worth noting that R2 is typically more relevant for regression tasks than classification.
7. We've included error handling to ensure the dataset isn't empty before proceeding with the training process.

In [ ]:
```
import matplotlib.pyplot as plt
import numpy as np
from PIL import Image
from tkinter import filedialog
import tkinter as tk

# Function to open file dialog and get file path
def get_file_path():
    root = tk.Tk()
    root.withdraw()
    file_path = filedialog.askopenfilename()
    return file_path

# Process two images
for i in range(2):
    # Get file path from user
    file_path = get_file_path()

    # Read the image using PIL
    image = Image.open(file_path).convert('L')

    # Resize the image to the desired shape
    resized_image = image.resize((224, 224))

    # Display the resized image
    plt.imshow(resized_image, cmap='gray')
    plt.show()

    # Convert grayscale image to RGB
    image_rgb = resized_image.convert('RGB')

    # Convert PIL image to numpy array and expand dimensions
    new_image = np.expand_dims(np.array(image_rgb), axis=0)
    new_image = preprocess_input(new_image)
    print(new_image.shape)

    # Extract features using VGG16
    features = vgg_model.predict(new_image)
    features = features.flatten()
```

```
    # Make prediction with SVM model
    svm_predict = svm.predict([features])

    # Print the prediction
    if svm_predict[0] == 1:
        print('The image is predicted to be a dog.')
    else:
        print('The image is predicted to be a cat.')
```



```
(1, 224, 224, 3)
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 640ms/step
The image is predicted to be a cat.
```



```
(1, 224, 224, 3)
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 734ms/step
The image is predicted to be a dog.
```

Conclusion

In this project, we successfully implemented a machine learning model to classify images of cats and dogs. Here's a summary of what we accomplished:

1. We used a pre-trained VGG16 model as a feature extractor for our images.
2. We trained an SVM classifier on these extracted features to distinguish between cats and dogs.
3. We created a user-friendly interface using tkinter to allow users to select their own images for classification.
4. The model processes the selected images, resizing and preprocessing them as necessary.
5. Finally, it predicts whether the input image is a cat or a dog and outputs the result.

This project demonstrates the power of transfer learning and how we can leverage pre-trained models to create effective classifiers with relatively small datasets. It also showcases the integration of machine learning models with user interfaces, making the technology accessible to end-users.

Future improvements could include:

- Expanding the dataset to improve accuracy
- Fine-tuning the VGG16 model for our specific task
- Implementing a more sophisticated UI with batch processing capabilities
- Extending the classifier to recognize more animal species

Overall, this project provides a solid foundation for image classification tasks and can be easily adapted for various other binary classification problems.