Ahmed Samir 8120

Youssef Awad 8179

Amr Samir 8211

Introduction

The objective is to build a binary image classification system to distinguish between husky and wolf images. The tasks include data loading, splitting, preprocessing (resizing, normalization, augmentation), model creation with hyperparameter tuning, and evaluation on a test set. Bonus tasks involve using Grad-CAM and addressing data leakage.

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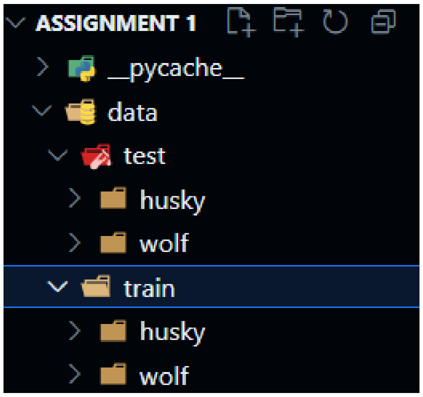
2. Dataset Description

The dataset contains images of huskies and wolves, divided into two classes: "husky" and "wolf". Initially, all images were in the data/train directory. A custom splitting function created an 80/20 train-test split, resulting in:

- Training set: 80 images (40 huskies, 40 wolves).
- Test set: 20 images (10 huskies, 10 wolves).
  The final structure is data/train/husky, data/train/wolf, data/test/husky, and data/test/wolf.



```
ASSIGNMENT 1
  __pycache__
  data
    test
      husky
      wolf
    train
      husky
      wolf
```

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3. Methodology

3.1 Data Loading

The load_data function loads images, converts them from BGR to RGB, resizes them to 256x256 pixels, and normalizes pixel values to [0, 1]. Labels are assigned as 0 (husky) and 1 (wolf). The function successfully loaded 80 training images and 20 test images.

3.2 Data Splitting

The dataset was split into training and test sets with an 80/20 ratio using scikit-learn's train_test_split with stratify to ensure balanced classes. Files were moved to data/test/husky and data/test/wolf.

Training Sample :

Test Sample :

3.3 Data Preprocessing

Preprocessing included:

- **Resizing**: All images were resized to 256x256 pixels.
- **Normalization**: Pixel values were scaled to [0, 1].
- **Augmentation**: Using albumentations, the following transformations were applied to all training images:
  - Rotation: ±20 degrees.
  - Horizontal Flip: 50% probability.
  - Random Resized Crop: Scale between 0.8 and 1.0.
    The augmented images doubled the training set size to 160 images (80 original + 80 augmented).

3.4 Model Creation and Hyperparameter Tuning

A Logistic Regression model was implemented using scikit-learn. Hyperparameter tuning was performed with GridSearchCV over:

- C: [0.01, 0.1, 1, 10, 100].
- penalty: ["l1", "l2"].

- max_iter: [100, 500, 1000].
  The model was trained on the extended training set (160 images), with 5-fold cross-validation to select the best parameters.

3.5 Evaluation

The best model was evaluated on the test set (20 images). A placeholder test_path = 'path/to/test' was added for custom test evaluation, which skips evaluation if the placeholder is detected, ensuring "Run All" compatibility.

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4. Results

4.1 Hyperparameter Tuning Results

The table below summarizes the cross-validation results for all hyperparameter combinations:

C	Penalty	Max Iter	Mean CV Accuracy	Std CV Accuracy
0.01	l1	100	0.5000	0.0000
0.01	l2	100	0.9125	0.0848
0.01	l1	500	0.5000	0.0000
0.01	l2	500	0.9125	0.0848
0.01	l1	1000	0.5000	0.0000
0.01	l2	1000	0.9125	0.0848
0.10	l1	100	0.5000	0.0000
0.10	l2	100	0.8875	0.1146
0.10	l1	500	0.5000	0.0000
0.10	l2	500	0.8875	0.1146
0.10	l1	1000	0.5000	0.0000
0.10	l2	1000	0.8875	0.1146
1.00	l1	100	0.8750	0.1046
1.00	l2	100	0.9000	0.1225
1.00	l1	500	0.8750	0.1046
1.00	l2	500	0.9000	0.1225
1.00	l1	1000	0.8750	0.1046
1.00	l2	1000	0.9000	0.1225
10.00	l1	100	0.8250	0.1649

C	Penalty	Max Iter	Mean CV Accuracy	Std CV Accuracy
10.00	l2	100	0.9000	0.1225
10.00	l1	500	0.8250	0.1649
10.00	l2	500	0.9000	0.1225
10.00	l1	1000	0.8250	0.1649
10.00	l2	1000	0.9000	0.1225
100.00	l1	100	0.8250	0.1649
100.00	l2	100	0.8875	0.1392
100.00	l1	500	0.8250	0.1649
100.00	l2	500	0.8875	0.1392
100.00	l1	1000	0.8250	0.1649
100.00	l2	1000	0.8875	0.1392

4.2 Model Performance

- **Best Hyperparameters:** {'C': 0.01, 'max_iter': 100, 'penalty': 'l2'}
- **Test Accuracy:** 0.95
- **Classification Report:**
  precision recall f1-score support
  husky 1.00 0.90 0.95 10
  wolf 0.91 1.00 0.95 10
  accuracy 0.95 20
  macro avg 0.95 0.95 0.95 20
  weighted avg 0.95 0.95 0.95 20
- **Confusion Matrix:**
  [[9 1]
  [0 10]]

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5. Discussion

The Logistic Regression model achieved a test accuracy of 95%, indicating strong performance. The l2 penalty consistently outperformed l1, with the best C value of 0.01 yielding a mean cross-validation accuracy of 0.9125.
