

Homework 3

Use support vector machines (SVM) for the binary classification of images.

1 Dataset

The dataset consists of two classes (“airplane” and “bird”) sampled from the CIFAR-10 dataset. For simplicity, all RGB images have been converted to grayscale images.

All images have 32×32 pixels. The training set contains 10000 images, and the testing set contains 2000 images. Please see `X_train_sampled.npy` and `y_train_sampled.npy` for training samples and their labels. Similarly, `X_test_sampled.npy` and `y_test_sampled.npy` provides testing samples and their labels.

Please use the `get_data.py` file to load the data. See comments in the code for details.

2 Tasks

Train support vector machines (SVM) to solve a binary image classification problem by following steps:

- **Step 1.** Extract the Histogram of Gradient (HoG) features of the images (see page 14 of lecture 2). For each training image $x \in \mathbb{R}^{32 \times 32}$, the extracted HoG feature vector for each training image is denoted by $h \in \mathbb{R}^{324}$.

Please use the `HoG.py` file to extract the features. See comments in the code for details.

- **Step 2.** Train the SVM classifier to classify the HoG feature h . You can optionally implement the SVM using the SVC class of the scikit-learn library or using other libraries. See link: [SVC](#) for the reference document of the SVC class.

You need to train three SVM classifiers to classify images (probably having outlier samples, see page 13 of lecture 2):

1. Linear SVM
2. RBF kernel SVM
3. SVM with another type of kernel function, such as the polynomial kernel SVM.

You need to try different sets of hyper-parameters and find the hyper-parameters with relatively good performance. Please tell us which hyper-parameters are tuned.

Please provide the following results:

- Classification accuracies of the three SVM classifiers on the testing set. Optionally, you may report classification accuracies with different sets of hyper-parameters.
- Specifically, for the **Linear SVM** classifier, please find the support vectors used to calculate the parameter w (see page 7 of lecture 2 for the definition of support vector). Please provide the following results:
 1. How many support vectors are used to calculate the parameter w ? I.e., please count the number of training samples with $\alpha_i > 0$.
 2. How many positive samples and how many negative samples are among these support vectors?
 3. For both positive and negative samples, you need to visualize the top 20 images with the largest values of α_i and attach the value of α_i beside each image.

3 Tips

To clarify, you must write code by yourself. You should not copy the code from other students. Any plagiarized code will make you fail this class.

1. We do not rate the homework purely based on the performance of your SVM models. It doesn't mean that the higher classification accuracy will get the higher score. However, if the accuracy is much lower than accuracies of most other students' models, the code may have some bugs, which will affect the score.
2. 报告和源代码应分开提交，报告为 PDF 或 DOC 格式，代码打包成压缩文件。
3. You need to write some comments for your code to make it easier to understand.