

2 Can you fix it? Yes you can!

As you undoubtedly noticed (or will soon notice) from Section 1, **clustering many thousands of 128 dimensional SIFT descriptor vectors can be time consuming**. So much so that this severely limits the utility of the algorithm as described; indeed it is rather futile to apply it to the full 25 class dataset. For this reason, you must now devise an algorithm (either an improved version of what you have already, or something new entirely) that is capable of handling increased dataset sizes while still accomplishing the image classification goal.

2.1 Algorithm Implementation Revisited

7.5 points

You should aim to handle the 25 class dataset in its entirety. If practicality should dictate otherwise, use as many classes as you are able. In any case, how you go about improving upon your existing classification algorithm is up to you. Remember that you are allowed to use code from other sources, so long as you explicitly state in your report what those sources were and what code you used. However, it is not allowed to use extra data. As a result, deep learning techniques are not recommended here since it is unfair to use pre-trained models or transfer learning. What follows are some targeted suggestions intended to improve performance with larger datasets, at least one of which you must implement:

2.1.1 Reduce the dimensionality of the feature descriptors

Smaller dimensional feature descriptors vastly reduce the degrees of freedom of the clustering problem, and can provide other benefits such as faster feature matching. The data reduction they afford should therefore allow for the handling of more training data for classification.

- PCA-SIFT can be thought of as a means of compressing the traditional SIFT feature descriptor from 128 dimensions to about 20. It accomplishes this by applying Principal Component Analysis to the normalized gradient patches.
<http://www.cs.cmu.edu/~yke/pcasift/>
- *Speeded Up Robust Features* (SURF) is a technique to find and describe image features which diverges from SIFT significantly. It can find and describe features which are invariant to scale and rotation, and can offer significant dimensionality reduction (the extent of which is adjustable). Moreover, it enables faster feature detection while meeting or exceeding the feature matching performance of SIFT.
<http://www.vision.ee.ethz.ch/~surf/papers.html>
- *oFAST + rBRIEF* (ORB) is yet another technique for finding feature locations and descriptors. It is, unsurprisingly, the combination of the two algorithms from which it gets its name. Its feature descriptors are specially designed to actually be binary

sequences, which offer rather striking speed gains during feature acquisition and matching operations.

https://willowgarage.com/sites/default/files/orb_final.pdf

2.1.2 Speed up the clustering algorithm

- *Very Fast SIFT* (VF-SIFT) is a technique which modifies the SIFT framework by increasing the dimension of the SIFT descriptor. This extra data, stored as 4 pairwise angles, is used as a robust predictor for feature similarity. Rather than using the 128 SIFT dimensions directly during matching operations, these 4 extra dimensions are first compared to remove improbable matches. Likewise, during clustering operations, these 4 extra datum could be used in lieu of or in addition to the 128 dimensional SIFT descriptors.

<http://www.iat.uni-bremen.de/sixcms/media.php/81/VF-SIFT.pdf>

- *Vocabulary Tree Clustering* uses a hierarchically quantized cluster tree to enable scalable clustering and recognition of **millions of images**. The traditional 128 dimensional SIFT feature descriptor is used. Recognition or classification is performed by running down the tree with each test image feature and scoring based on branch traversal. It is a significant architectural departure from the algorithm outlined in Section 1. Not for the faint of heart.

http://www.vis.uky.edu/~stewe/publications/nister_stewenius_cvpr2006.pdf

2.2 Technical Write-up: Results and Discussion

7.5 points

- Describe the salient features of your improved classification framework.
- Explain how your method conceptually compares with other algorithms mentioned above.
- Clearly and cogently document your methods and results.
- Include and interpret a (12×12) and a (25×25) confusion matrix (for your results on the classes with IDs 006-045 and the full dataset). If you were unable to use the full 25 classes, provide your results for the largest dataset used. In either case, comment on the issues you faced handling larger datasets.

2.3 Competition

5 points

Following the same procedure stated in the first question, report the total accuracy on the classes with IDs 006-045 (total 12). Also report the accuracy of your classifier for all 3 classes (entire dataset).

This part of the grade is based on your classifier's performance compared to the classifiers trained by your peers in the class.

Note: Failure to report any of these two numbers will automatically award you zero points and reporting wrong numbers is against the honor code.

3 Grad Credits: Support Vector Machines for Image Classification

3.1 Reading

2 points

Support Vector Machines (SVMs) are discriminative image classifiers just like the KNNs you have implemented in this assignment. Unlike KNNs, which do not have any training time, SVMs need to first train a classifier (function) on the input data. However, once trained, SVMs typically have smaller run time compared KNNs. SVMs are also robust to noise and outliers in the data and have better generalization (less error) compared to KNNs.

For Grad credits, you should read the attached paper (Section 2.4, 2.5 are not required) and write a coherent summary of your understanding of the same. The paper has a decent amount of math, but try not to include equations in the write up unless you think it is absolutely necessary. Your summary should include a higher level overview of what SVMs are learning from the data, how they handle noise, outliers, and non-linearities. You should also comment on how SVMs are used by the authors of this paper for image classification, how they handled multi-class and dimensionality. Finally, based on your learnings in this assignment, what would you do differently compared to this paper.

3.2 Train SVM on 3 class dataset

1.5 points

Train an SVM on 3 class dataset. You can use Matlab's inbuilt functions or other packages available online. Cite them appropriately though. You can choose your own feature representation, kernel, and the procedure used to extend SVMs for multiple classes. However, explain the reasoning behind the choices. Provide a technical writeup similar to the one in the previous questions and also provide a confusion matrix.

3.3 Competition

1.5 points

Following the same procedure stated in the first question and report the accuracy of your classifier. This part of the grade is based on your classifier's performance compared to the classifiers trained by your peers in the class.

Note: Failure to report this number will automatically award you zero points and reporting wrong numbers is against the honor code.

Submission Instructions

Every student must submit following 2 files:

- An organized report submitted as a PDF document. The report should describe the implementation, issues (problems encountered, surprises), and an analysis of the test results (interpretation of effects of varying parameters, different image results). Intermediate and final results must be provided.
- A ZIP file containing the necessary codes.

The heading of the PDF file should contain the assignment number and topic. Also, attach a photo of yourself at top-left of the PDF along with your name and department.

Late Submission Policy

Assignments are expected to be submitted on the due date. Each student gets a total of 3 late days that can be used however you wish. For examples, all 3 days can be used towards 1 assignment or 1 day late for 3 assignments or other combinations. Late submissions beyond that will be penalized as below:

- One day late will be penalized 25% of the credit.
- Two Days late will be penalized 50%.
- Submissions more than 2 days late will not be considered for credit.

I will be ruthless in enforcing this policy. There will be no exceptions

Collaboration Policy

I encourage collaboration both inside and outside class. You may talk to other students for general ideas and concepts but the programming must be done independently. For mid-term and final examination there will be no collaboration permitted.

Plagiarism

Plagiarism of any form will not be tolerated. You are expected to credit all sources explicitly. If you have any doubts regarding what is and is not plagiarism, talk to me.