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Computer Vision: Project 1

**Linear Locality Constraints**

Scene classification is a classical problem in computer vision. One aspect of scene classification that is often considered is the problem of classifying images based on semantic categories. In our project we approach this problem using the spatial pyramid and linear the locality constraint algorithms.

**Implementation Overview:** We implement image classification using LLC where our project modifies the provided spatial pyramid code by Lazebnik et al using Matlab. Our code is run by executing the respective main\_\*.m files. There are two versions of main: main\_LLC and main.m which we use to run the LLC and spatial pyramid algorithms respectively. We implement LLC by modifying the provided spatial pyramid code which include the following modifications.

1. Modifying the hard codeword assignment used by the spatial pyramid algorithm to locality constrained linear coding as used by the LLC algorithm as in the paper. This required modifying the BuildHistograms class.
2. Modifying the sum pooling used by the spatial pyramid algorithm to max pooling used by the LLC algorithm. This required modifying the CompilePyramid class.

**Procedure:** To perform classification on scene categories, a directory is provided. From each scene category, 100 images are selected from each category for training and the rest are used for testing. The SIFT descriptors are then computed for each image and is then represented as a feature vector. The set is then clustered using k-means with a given number of centers to form a codebook. Using the codebook, a histogram is constructed constructed for every image and the image pyramid is constructed using their own respective methods to generate the final image representation.

**Spatial Pyramid:** Spatial pyramid matching works by placing a grid over a feature space in a sequence of increasing coarseness. The weighted sum of the number of matches, which is are two points that occur in the same cell of the grid, at each level of resolution is taken with finer resolution matches given a higher weight. Specifically, SPM tries to solve the following optimization problem:

Each level of the “pyramid” is then pooled together using the sum pooling method, whereby the codes for each sub-region is concatenated by summing the codes together.

**Linear Locality Constraint:** The LLC algorithm instead tries to solve the following constraint problem:

In our LLC procedure we concatenate the sub-regions together by using the max pooling method, whereby the max of the codes is taken as the representative of the sub-region. We also normalize the codes in our procedure using both sum normalization and L2-normalization.

**Classification:** We classify the features that were extracted using the spatial pyramid and LLC algorithms using a SVM. The SVM implementation that we use is LIBLINEAR in Matlab which supports multi-class classification. For each semantic category we train a model on our training data and use the model to classify our test data.

**Experiments**

**Results:** Using the spatial pyramid for classification we obtain the following confusion matrix when classifying over the scene categories in our dataset.

When we classify the scene categories using the LLC algorithm we obtain the following matrix

**Extensions**

1. **Parallelization**
2. **Parameter Variation**

We compare and contrast the results given by LLC by varying the size of the codebook and the number of pyramid level. For the codebook size, we use a size of 200 which is suggested to be optimal for the SPM method and 1024 which is suggested to be optimal for the LLC method.

1. **Optimized Codebook**

We implemented a batch processing method to produce and optimized codebook obtained by solving LLC. This is done by first computing a codebook using k-means then computing the LLC for each descriptor representation of the image to update the codebook. BuildHistograms and CompilePyramid is then run on the LLC codebook.

**File List:** The list of files we submit include:

1.