HOMEWORK 7 - Object Recognition
CS 281B : Advanced Computer Vision
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OBJECTIVE

This is the mini project for the Advanced Computer Vision Class. The objective was to select a training dataset and recognize objects to solve a real world problem. Moreover, the classification scheme is evaluated and parameters are varied to get varied accuracies. Here I am using the Caltech 101 dataset to **Recognize different marine animals** .

CRUCIAL STEPS

1. Collection and Selection of Training Data.
2. Design And Implementation of Feature Extraction and Classification Scheme.
3. Training Using the appropriate Classifier Parameters and Training Parameters .
4. Validation of Classifier and determining Generalization error.
5. Deploying to actually identify animals in images .

STEP 1 : COLLECTION AND SELECTION OF TRAINING DATA

The dataset used in CALTECH 101 [1] . As the main objective is to detect marine animals, from this dataset, the image groups pertaining to this are what have been selected .

The following image sets with 34 images in each has been used :

* Image set 1: crab.
* Image set 2: crayfish.
* Image set 3: dolphin.
* Image set 4: hawksbill.
* Image set 5: lobster.
* Image set 6: octopus.
* Image set 7: sea_horse.
* Image set 8: starfish.
* Image set 9: platypus.

The image sets are partitioned so that all image sets hold the same number of images . Each of these image sets are then separated into validation and training sets in a set ratio.

STEP 2 : DESIGN AND IMPLEMENTATION OF FEATURE EXTRACTION AND CLASSIFICATION SCHEME

The feature extraction and classification is done using the Bag of Words technique . The term “Words” is analogous to Image features here.

Every group of images of the same object (here the image sets) is called a class. Every image of the same object can be different , dependent on illumination or maybe just the variations in the object type. One image set can hold a variety of the object of the same type. This is called intraclass variation .In this system, the system learns about a particular class, and then we test that system .

Bag of features :

1. Recognizes the feature (SIFT DETECTOR OR GRID) set in a class of images and takes a local patch around the same .
2. Derivation of a descriptor (SIFT) for each of the local patch.
3. Perform K- Mean Clustering on the descriptor.
4. Each of these cluster is called a “Word” for the system
5. Representation of the image sets as a histogram of these “Words” .

K- Mean Clustering Algorithm [3]

Place K points into the space represented by the objects that are being clustered. These points represent initial group centroids.
Assign each object to the group that has the closest centroid.
When all objects have been assigned, recalculate the positions of the K centroids.
Repeat Steps 2 and 3 until the centroids no longer move. This produces a separation of the objects into groups from which the metric to be minimized can be calculated.
The output of this is fed into the Classifier .

STEP 3 : TRAINING

The training is based on MultiClass Linear SVM Classifier.The function trains a support vector machine (SVM) multiclass classifier using the error correcting output codes (ECOC) framework.

STEP 4 : VALIDATION

The validation is evaluated using the validation dataset , which gives the confusion matrix, hence estimating the accuracy of the recognition system .

The overall average accuracy is calculated by averaging the accuracies over 10 runs of the code .

RESULTS :

CASE 1 : All default presets

Confusion Matrix for the Training SET :

```
                                                          PREDICTED
KNOWN        | crab   crayfish   dolphin   hawksbill   lobster   octopus   sea_horse   starfish   platypus
--------------------------------------------------------------------------------------------------------------
crab         | 1.00   0.00       0.00      0.00        0.00      0.00      0.00        0.00       0.00
crayfish     | 0.00   1.00       0.00      0.00        0.00      0.00      0.00        0.00       0.00
dolphin      | 0.00   0.00       1.00      0.00        0.00      0.00      0.00        0.00       0.00
hawksbill    | 0.00   0.00       0.00      1.00        0.00      0.00      0.00        0.00       0.00
lobster      | 0.00   0.00       0.00      0.00        0.90      0.10      0.00        0.00       0.00
octopus      | 0.00   0.00       0.00      0.00        0.00      1.00      0.00        0.00       0.00
sea_horse    | 0.00   0.00       0.00      0.00        0.00      0.10      0.90        0.00       0.00
starfish     | 0.00   0.00       0.00      0.00        0.00      0.00      0.00        1.00       0.00
platypus     | 0.00   0.00       0.00      0.00        0.00      0.00      0.00        0.00       1.00

* Average Accuracy is 0.98.
```

Confusion Matrix for the Validation SET :

```
                                                          PREDICTED
KNOWN        | crab   crayfish   dolphin   hawksbill   lobster   octopus   sea_horse   starfish   platypus
--------------------------------------------------------------------------------------------------------------
crab         | 0.25   0.08       0.17      0.25        0.04      0.00      0.04        0.04       0.12
crayfish     | 0.21   0.17       0.12      0.08        0.04      0.17      0.00        0.12       0.08
dolphin      | 0.08   0.00       0.62      0.00        0.04      0.17      0.00        0.04       0.04
hawksbill    | 0.08   0.04       0.29      0.42        0.00      0.04      0.00        0.12       0.00
lobster      | 0.17   0.12       0.00      0.08        0.17      0.08      0.08        0.04       0.25
octopus      | 0.17   0.04       0.08      0.04        0.00      0.25      0.17        0.08       0.17
sea_horse    | 0.04   0.00       0.00      0.04        0.00      0.08      0.58        0.21       0.04
starfish     | 0.29   0.00       0.04      0.04        0.00      0.17      0.08        0.25       0.12
platypus     | 0.17   0.00       0.12      0.00        0.04      0.08      0.17        0.00       0.42

* Average Accuracy is 0.35.
```

Average Accuracy over 10 runs

Run Number	Training Set Accuracy	Validation Set Accuracy
1	0.94	0.35
2	0.97	0.40
3	0.97	0.37
4	0.99	0.37
5	1.00	0.32
6	1.00	0.38
7	0.98	0.35
8	0.99	0.36
9	0.98	0.37
10	0.98	0.35
Average	0.98	0.362

CASE 2 : Using SIFT detector for point selection and 90% of the strongest features.

Confusion Matrix for the Training SET :

KNOWN	crab	crayfish	dolphin	hawksbill	lobster	octopus	sea_horse	starfish	platypus
					PREDICTED				
crab	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
crayfish	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
dolphin	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
hawksbill	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
lobster	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
octopus	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
sea_horse	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
starfish	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
platypus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00

* Average Accuracy is 1.00.

Confusion Matrix for the Validation SET :

KNOWN	crab	crayfish	dolphin	hawksbill	lobster	octopus	sea_horse	starfish	platypus
					PREDICTED				
crab	0.17	0.04	0.08	0.08	0.21	0.17	0.00	0.17	0.08
crayfish	0.17	0.21	0.12	0.08	0.17	0.12	0.04	0.04	0.04
dolphin	0.00	0.08	0.29	0.17	0.04	0.08	0.08	0.04	0.21
hawksbill	0.04	0.04	0.00	0.71	0.00	0.04	0.08	0.04	0.04
lobster	0.00	0.08	0.17	0.00	0.29	0.25	0.04	0.04	0.12
octopus	0.08	0.00	0.08	0.08	0.08	0.58	0.04	0.00	0.04
sea_horse	0.00	0.00	0.00	0.08	0.04	0.08	0.71	0.04	0.04
starfish	0.00	0.08	0.08	0.29	0.00	0.17	0.08	0.25	0.04
platypus	0.00	0.29	0.08	0.08	0.12	0.12	0.08	0.00	0.21

* Average Accuracy is 0.38.

Average Accuracy over 10 runs

Run Number	Training Set Accuracy	Validation Set Accuracy
1	1.00	0.37
2	1.00	0.32
3	1.00	0.45
4	1.00	0.38
5	1.00	0.37
6	1.00	0.38
7	1.00	0.33
8	1.00	0.40
9	1.00	0.39
10	1.00	0.36
Average	1.00	0.375

CASE 3 : Using SIFT detector for point selection and all features.

Confusion Matrix for the Training SET :

					PREDICTED				
KNOWN	crab	crayfish	dolphin	hawksbill	lobster	octopus	sea_horse	starfish	platypus
crab	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
crayfish	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
dolphin	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
hawksbill	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
lobster	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
octopus	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
sea_horse	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
starfish	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
platypus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00

* Average Accuracy is 1.00.

Confusion Matrix for the Validation SET :

					PREDICTED				
KNOWN	crab	crayfish	dolphin	hawksbill	lobster	octopus	sea_horse	starfish	platypus
crab	0.29	0.08	0.04	0.08	0.08	0.12	0.08	0.12	0.08
crayfish	0.21	0.08	0.17	0.21	0.12	0.04	0.08	0.08	0.00
dolphin	0.04	0.12	0.50	0.08	0.00	0.04	0.04	0.04	0.12
hawksbill	0.17	0.08	0.08	0.50	0.00	0.00	0.04	0.08	0.04
lobster	0.21	0.17	0.04	0.04	0.25	0.00	0.08	0.04	0.17
octopus	0.08	0.04	0.00	0.00	0.04	0.50	0.29	0.04	0.00
sea_horse	0.00	0.00	0.00	0.08	0.04	0.08	0.67	0.12	0.00
starfish	0.17	0.00	0.08	0.04	0.00	0.12	0.08	0.46	0.04
platypus	0.08	0.04	0.12	0.17	0.00	0.04	0.04	0.00	0.50

* Average Accuracy is 0.42.

Average Accuracy over 10 runs

Run Number	Training Set Accuracy	Validation Set Accuracy
1	1.00	0.42
2	1.00	0.45
3	1.00	0.37
4	1.00	0.32
5	1.00	0.37
6	1.00	0.38
7	1.00	0.40
8	1.00	0.40
9	1.00	0.40
10	1.00	0.44
Average	1.00	0.395

MAIN CODE

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%% Object Recoginition (Marine Animal Recognition)

%% Getting the data set ready
% Loading all the images
rootFolder = fullfile('101_ObjectCategories');

% Constructing image sets required for designing a marine animal
% recognition system.
ImageSets = [ imageSet(fullfile(rootFolder, 'crab')), ...
        imageSet(fullfile(rootFolder, 'crayfish')), ...
        imageSet(fullfile(rootFolder, 'dolphin')) , ...
        imageSet(fullfile(rootFolder, 'hawksbill')), ...
        imageSet(fullfile(rootFolder, 'lobster')), ...
        imageSet(fullfile(rootFolder, 'octopus')) , ...
        imageSet(fullfile(rootFolder, 'sea_horse')), ...
        imageSet(fullfile(rootFolder, 'starfish')), ...
        imageSet(fullfile(rootFolder, 'platypus')) ];

% Segregating or Partioning Image sets into Training and Validation Sets.
SetCount = min([ImageSets.Count]); % determine the smallest amount of images in a category
ImageSets = partition(ImageSets, SetCount, 'randomize');% Use partition method to trim the set.
[trainingSets, validationSets] = partition(ImageSets, 0.3, 'randomize');% Seperating training and validation sets (30%, 70%)

%% Feature Extraction and Classification Scheme using the bagOfFeatures function.
bag = bagOfFeatures(trainingSets);
% Parameters that can be varied here
% VOCBULARY SIZE (500), STRONGEST FEATURE (0.8),POINTSELECTION (DETECTOR OR GRID), GRIDSTEP([8
8]),BLOCKWIDTH([32 64 96 128])

%% Training the Classifier using the trainImageCatergoryClassfier function .(Multiclass Linear SVM Classifier)
categoryClassifier = trainImageCategoryClassifier(trainingSets, bag);
% (LEARNER OPTIONS - OPT ( written using templateSVM function))
% TEMPLATESVM  : 'BoxConstraint', 1.1, 'KernelFunction', 'gaussian' -- example

%% Calculating or Evaluating the Classifier performance using the evaluate function (gives the confusion matrix)
%  Training Set
confMatrix = evaluate(categoryClassifier, trainingSets);
%  Validation Set
confMatrix = evaluate(categoryClassifier, validationSets);
% Computing accuracy .
mean(diag(confMatrix));

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
```

References :

1. http://www.vision.caltech.edu/Image_Datasets/Caltech101/
2. https://www.youtube.com/watch?v=iGZpJZhqEME
3. http://home.deib.polimi.it/matteucc/Clustering/tutorial_html/kmeans.html
4. http://www.maia.ub.es/~sergio/linked/aisp2012.pdf
5. http://www.mathworks.com/help/vision/ref/trainimagecategoryclassifier.html