School of Electrical and Engineering

MSc *Computer Vision Robotics and Machine Learning*

Surrey University

Computer Vision and Pattern Recognition Assignment

Visual Search of an Image Collection

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Abstract

The assignment is based writing a visual search for an image collection. The program will accept have a query which will return a list of several images ranked according to similarly. The visual search system will only display a certain amount of top ranked images.

Acknowledgments

I am very thankful for Microsoft Research team for their research and dataset. I would also like to take this time to thank the Supervisors in the lab and John Collomosse for this module.

Introduction

Digital image collections are image collections that are traditionally searched and used by search engines such as Google and social media platforms. They are more efficient for visualizing an image as opposed to text.

For this assignment my objective is to write a program that will visually search an image collection. The collection will contain a dataset of 591 images (which will be the Microsoft Research dataset) and within the dataset a search query will be used which will return a list of images according to rank. The ranking will be based on their similarity and will only display the top 15 images.

Implementation of Visual Techniques

Global Colour Histogram

After setting up the directory for the visual search and compute descriptors the first step to implement the global colour histogram using Euclidean distance metric. The global colour was creating using the knowledge from lecture 7 slides (4,5). I created my own Hist function which is a histogram array which counts all the bins and its 1 to the histogram bin. the function also normalises the histogram area to 1 using the sum.

With the descriptor created, it is then passed through the compute descriptor where it will compute all the 591 and their RGB values before getting passed through the visual search. Below is the result in Figure1.

Figure 1: Global Histogram Results: Showing ranks

PCA & Distance Descriptors

PCA(Principle Component Analysis) is a procedure that express data in a high dimensional space and allows us to observe data. The first step is to check the dimensions of the image using size (ALLFEAT). This allows us to check the dimensions which is 64 and the number of images in the dataset. With that two key information we can find the Eigenvalues using the Eigen_Build function. The result is shown below in figure 2.

```
>> size(ALLFEAT)
 e=Eigen_Build(ALLFEAT);
 e.val

ans =

   591    64


ans =

    1.2823
    0.3085
    0.2228
    0.1720
    0.1271
    0.0362
    0.0265
    0.0213
    0.0183
    0.0099
    0.0091
    0.0065
    0.0059
    0.0056
    0.0047
    0.0031
```

Figure 2: PCA Global Histogram: Finding the Eigenvalues

With the Eigen values found, the next step is to find the first 3 eigenvectors. To do these we use the Eigen_Deflate script(provided by the lab)to compute the distance and data from the eigen model before using the Eigen_Project to reveal the eigenvectors. The result is shown below in figure 3.

```
 e=Eigen_Deflate(e,'keepn',3);
 ALLFEATPCA=Eigen_Project(ALLFEAT,e)';
size(ALLFEATPCA)

ans =

    64     3

>> ALLFEATPCA

ALLFEATPCA =

    3.8369    2.6216   -2.3565
   -0.3599   -0.0608   -0.0131
    0.5029   -0.0079   -0.2749
   -0.3115   -0.0074   -0.0493
   -0.3578   -0.0613   -0.0168
   -0.3533   -0.0477   -0.0295
   -0.3645   -0.0647   -0.0123
   -0.3636   -0.0655   -0.0123
    0.1153    0.2037   -0.1862
   -0.3608   -0.0623   -0.0161
    6.8289   -2.7027   -0.0832
   -0.0395   -0.0287    0.0653
    0.4329   -0.4963   -0.0729
    0.0157    0.0454    0.2200
```

Figure 3: PCA Global Histogram: Finding the Eigenvalues

The Eigenvalues is then visualised by using a plot below in figure 4.

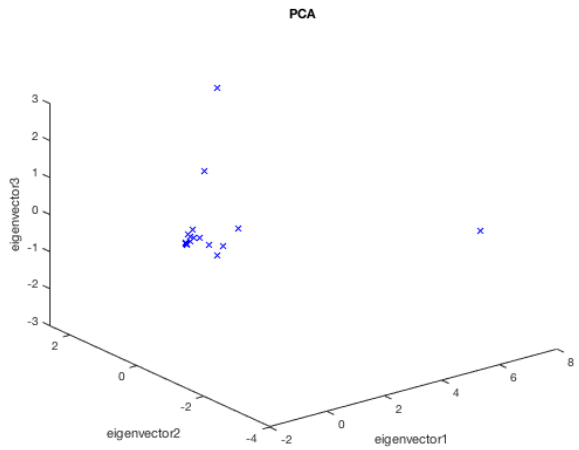

Figure 4: PCA Plot for the Global Histogram

From what is observed in figure 4 there is barely any spread and there isn't much data to work with. This indicates that the descriptor isn't descriptive enough and the dimension is low.

Spatial Grid(Colour)

Spatial Grid Colour an alternative method to colour match the query with the results. Unlike Histogram which relies on the overall colour of an image, the grid does the same but in each cell in a grid. What this means is the accuracy will improve as there are more dimensions. Below is the end of result.

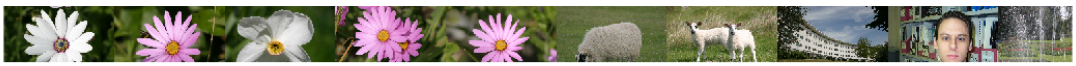

Figure 5: Spatial Colour Descriptor Results: Showing the rank

In shown above in figure 5 there is a much bigger improvement. However, we need a much clearer indication in the difference between the two. We can check what it looks like in the higher dimensional space using the PCA below in figure 6.

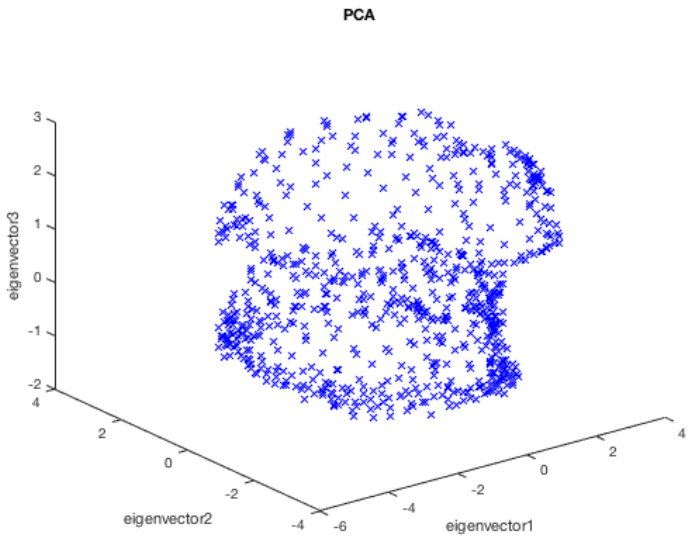

Figure 6: PCA Plot for the Colour Grid

Based on the result above the spread is certainly much bigger then it was previously in figure 4. Since the dimensions are high, reducing it will reduce the spread which will improve the performance of the visual search.

Testing Results

In this section I will be talking about the tests that were in the assignment. One of testing that was done is the different levels of RGB Quantization. In order to experiment with the Quantization levels, different values have been applied using the Q variable in the Global Histogram. Below in figure 7 shows a PCA plot of a Level

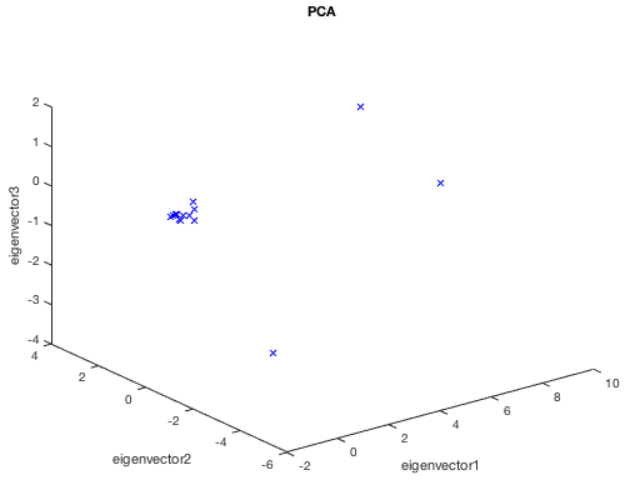

Figure 7: PCA showing Histogram Quantization level 3

As you can see in Figure 7 above the dimension have decreased slightly. To test to see if the dimensions reduce further, I tested the other Quantization levels 2,1. Below are the outcomes in figure 8 and 9.

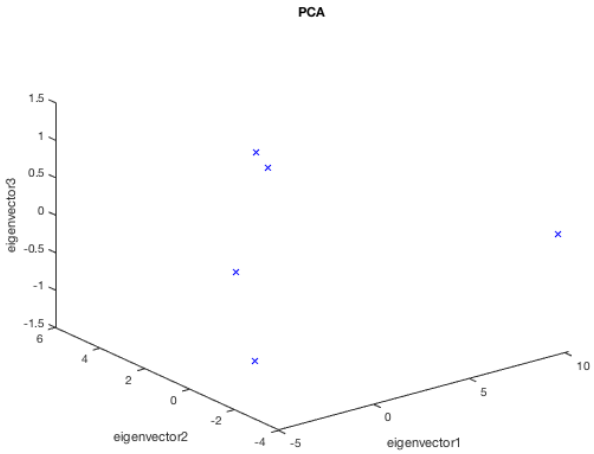

Figure 8: PCA showing Histogram Quantization level 2

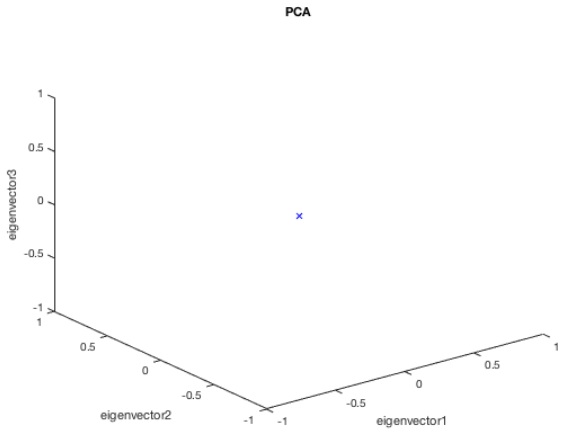

Figure 9: PCA showing Histogram Quantization level 1

The next section is to test and analysis the other queries in the

Testing the different Queries.

My first query is to test the range of flowers by using descriptors. The two descriptors I am using is the global histogram and the colour grid.

Below are the Global Histogram results for several queries

Index Flower 25

Index 25 flower			
Rank	Correct?	Precision	Recall
1	TRUE	1	0.031
2	FALSE	0.5	0.031
3	FALSE	0.3	0.031
4	FALSE	0.25	0.031
5	FALSE	0.2	0.031
6	FALSE	0.16	0.031
7	FALSE	0.14	0.031
8	TRUE	0.25	0.0625
9	FALSE	0.2	0.0625
10	FALSE	0.2	0.0625

Figure 10: Histogram Index 25 flower Analysis Results

Index 17 flower			
Rank	Correct?	Precision	Recall
1	TRUE	1	0.31
2	TRUE	1	0.0625
3	TRUE	1	0.09375
4	FALSE	0.75	0.09375
5	TRUE	0.8	0.125
6	FALSE	0.6	0.125
7	FALSE	0.57	0.125
8	TRUE	0.625	0.15625
9	FALSE	0.5	0.15625
10	TRUE	0.6	0.1875

Figure 11: Histogram Index 17 flower Analysis Results

Despite having low dimensions, the results for the two flowers turns out to be slightly less accurate. The index 17 flower also turned out the best although both flowers could get improves with different descriptors.

Below are some experiments using queries in the Cow Category.

Index 461 Cow			
Rank	Correct?	Precision	Recall
1	TRUE	1	0.31
2	FALSE	0.5	0.31
3	FALSE	0.3	0.31
4	FALSE	0.25	0.31
5	FALSE	0.2	0.31
6	FALSE	0.16	0.31
7	FALSE	0.14	0.31
8	FALSE	0.125	0.31
9	FALSE	0.1	0.31
10	TRUE	0.2	0.0625

Figure 12: Histogram Index 461 Cow Analysis Results

Index 465 Cow			
Rank	Correct?	Precision	Recall
1	TRUE	1	0.31
2	FALSE	0.5	0.31
3	TRUE	0.6	0.31
4	FALSE	0.5	0.0625
5	FALSE	0.4	0.0625
6	FALSE	0.3	0.0625
7	FALSE	0.2857	0.0625
8	FALSE	0.25	0.0625
9	FALSE	0.2	0.0625
10	TRUE	0.3	0.09375

Figure 13: Histogram Index 465 Cow Analysis Results

Unlike the flowers the cows didn't turn out to be very accurate. Quite a few times other animals were picked up such as horses since they have similar colour to the cows. This means for this particular search a more sophistic descriptor such as Spatial Grid colour and Texturing to pick out define features to separate the two. Next is to use the Colour grid descriptor to see if the results improve. Below is the following results.

Colour Grid

Index 17 flower			
Rank	Correct?	Precision	Recall
1	TRUE	1	0.31
2	FALSE	0.5	0.31
3	FALSE	0.3	0.31
4	FALSE	0.25	0.31
5	FALSE	0.2	0.31
6	FALSE	0.16	0.31
7	FALSE	0.142	0.31
8	FALSE	0.125	0.31
9	FALSE	0.1	0.31
10	FALSE	0.1	0.31

Figure 14: Colour Grid Index 17 Flower Analysis Results

Index 25 flower			
Rank	Correct?	Precision	Recall
1	TRUE	1	0.31
2	FALSE	0.5	0.31
3	FALSE	0.3	0.31
4	TRUE	0.5	0.31
5	FALSE	0.4	0.31
6	FALSE	0.3	0.31
7	FALSE	0.2857	0.31
8	FALSE	0.25	0.31
9	FALSE	0.2	0.31
10	FALSE	0.2	0.31

Figure 15: Colour Grid Index 25 Flower Analysis Results

The colour grid gave a poorer result for the flowers. Mainly because other sources of colour information are picked up such as grass and other features. Below are more tests on a different query which is Cows.

Index 461 Cow			
Rank	Correct?	Precision	Recall
1	TRUE	1	0.31
2	FALSE	0.5	0.31
3	FALSE	0.3	0.31
4	FALSE	0.25	0.31
5	FALSE	0.2	0.31
6	FALSE	0.16	0.31
7	FALSE	0.142	0.31
8	FALSE	0.125	0.31
9	FALSE	0.1	0.31
10	FALSE	0.1	0.31

Figure 16: Colour Grid Index 461 Cow Analysis Results

Index 465 Cow			
Rank	Correct?	Precision	Recall
1	TRUE	1	0.31
2	FALSE	0.5	0.31
3	FALSE	0.3	0.31
4	FALSE	0.25	0.31
5	FALSE	0.2	0.31
6	FALSE	0.16	0.31
7	FALSE	0.142	0.31
8	FALSE	0.125	0.31
9	FALSE	0.1	0.31
10	FALSE	0.1	0.31

Figure 17: Colour Grid Index 465 Cow Analysis Results

The results haven't improved and the same as the flowers. Other techniques like testing measures and descriptors have to be considered.

Conclusion

For this assignment I have implemented some of the features required such as PCA, Global Colour Histogram, PCA and Evaluation of the descriptors and other experiments

From the experiments and other tests that have been performed my conclusion is that dimensions as well as the type of descriptors will improve the accurate of this visual search.

Although the implementation of the Global Histogram and PCA helped with the analysing of the descriptors I believe further testing in a variety of categories and exploring with descriptors such in depth into the texturing and angular quantization for Spatial Grid descriptors would make it easier for the search to pick out specific features that were missing during this assignment. Also having a better category and ground truth set up would help to produce a robust system.

After conducting tests using the Eigen Model, Precision and Recall calculations and running a visual search I believe the exploring other techniques such as texturing, angular quantitation will

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