COMPUTER VISION
ASSIGNMENT 3

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1. **Categories Used for the task of classification**
   Experiments are performed twice with three different categories each time.
- First time Aeroplanes(800), Motorcycles(798) and Kangaroos(86) are used, in second time
- Aeroplanes(800), Motorcycles(798) and Faces(435) are used for the task of classification.

2. Extracting Local Features

SIFT was used to extract local features. The output which sift gives for each image is of for m*128, where m is the no of key points obtained by the algorithm in the image.

3. Dividing data into Train and Test

Data is split in two different ways in one half of the data is train and another half is test (0.5) and in other set of experiments 70 percent of the whole data is kept as training data and remaining 30 percent is used as testing data. The results of both are explained below.

4. Choosing value of K

Different values of K are tried for different datasets. To choose appropriate size of the cluster silhouette score was used. More details like how this score can be used are explained in Analysis section.

5. Classifiers used

For the purpose of classification three different classifiers are used. Normal Bayesian Classifier, Decision Trees and Support vector machines.

6. Metrics used for testing performance

Accuracy and Confusion matrix are used as metrics.

7. Results
(i) On Air Planes, Motorcycles and kangaroos dataset

- **silhouette scores for different number of clusters.**

('For n_clusters =', 5, 'The average silhouette_score is :', 0.061520014)
('For n_clusters =', 6, 'The average silhouette_score is :', 0.060388148)
('For n_clusters =', 7, 'The average silhouette_score is :', 0.063035868)
('For n_clusters =', 8, 'The average silhouette_score is :', 0.063475482)
('For n_clusters =', 9, 'The average silhouette_score is :', 0.052271485)
('For n_clusters =', 10, 'The average silhouette_score is :', 0.054533586)
('For n_clusters =', 11, 'The average silhouette_score is :', 0.055981103)
('For n_clusters =', 12, 'The average silhouette_score is :', 0.056794293)
('For n_clusters =', 13, 'The average silhouette_score is :', 0.054380249)
('For n_clusters =', 14, 'The average silhouette_score is :', 0.055212837)
('For n_clusters =', 15, 'The average silhouette_score is :', 0.055425197)
('For n_clusters =', 16, 'The average silhouette_score is :', 0.054742042)
('For n_clusters =', 17, 'The average silhouette_score is :', 0.054146308)
('For n_clusters =', 18, 'The average silhouette_score is :', 0.053749781)
('For n_clusters =', 19, 'The average silhouette_score is :', 0.054280665)
('For n_clusters =', 20, 'The average silhouette_score is :', 0.05445705)
('For n_clusters =', 21, 'The average silhouette_score is :', 0.053643834)
('For n_clusters =', 22, 'The average silhouette_score is :', 0.054242834)
('For n_clusters =', 23, 'The average silhouette_score is :', 0.054050066)
('For n_clusters =', 24, 'The average silhouette_score is :', 0.05389756)
('For n_clusters =', 25, 'The average silhouette_score is :', 0.054873906)
('For n_clusters =', 26, 'The average silhouette_score is :', 0.054756995)
('For n_clusters =', 27, 'The average silhouette_score is :', 0.055633966)
('For n_clusters =', 28, 'The average silhouette_score is :', 0.054735485)
('For n_clusters =', 29, 'The average silhouette_score is :', 0.05260114)

- **Silhouette_score graphs**
  Image path for 8 clusters: Aero_motor_Kangaroo/S_score8.png

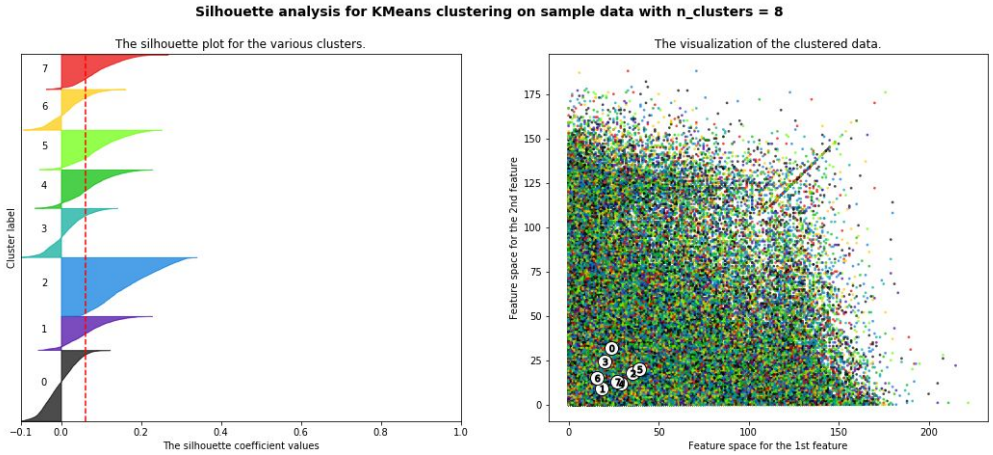


Image path for 12 clusters : Aero_motor_Kangaroo/S_score12.png
Image path for 19 clusters : Aero_motor_Kangaroo/S_score19.png
Image path for 24 clusters : Aero_motor_Kangaroo/S_score24.png

- **Accuracies For 0.7 Split**

With 8 Clusters

Classifier Used	**Accuracy**
Normal Bayesian	0.74703557312252966
Decision Tree	0.82213438735177868
SVM	0.85968379446640319

With 12 Clusters

Classifier Used	**Accuracy**
Normal Bayesian	0.79051383399209485
Decision Tree	0.78260869565217395
SVM	0.87944664031620556

With 19 Clusters

Classifier Used	**Accuracy**
Normal Bayesian	0.76679841897233203
Decision Tree	0.80237154150197632
SVM	0.89723320158102771

With 24 Clusters

Classifier Used	**Accuracy**
Normal Bayesian	0.78853754940711462
Decision Tree	0.81225296442687744
SVM	0.91699604743083007

With 100 Clusters

Classifier Used	**Accuracy**
Normal Bayesian	0.8755556486544565
Decision Tree	0.91454132549534315
SVM	0.93942992874109266

- **Accuracies For 0.5 Split**

With 8 Clusters

Classifier Used	**Accuracy**
Normal Bayesian	0.7543303334333333
Decision Tree	0.80760095011876487

SVM	0.87173396674584325

With 12 Clusters

Classifier Used	**Accuracy**
Normal Bayesian	0.77434679334916867
Decision Tree	0.80760095011876487
SVM	0.88836104513064129

With 19 Clusters

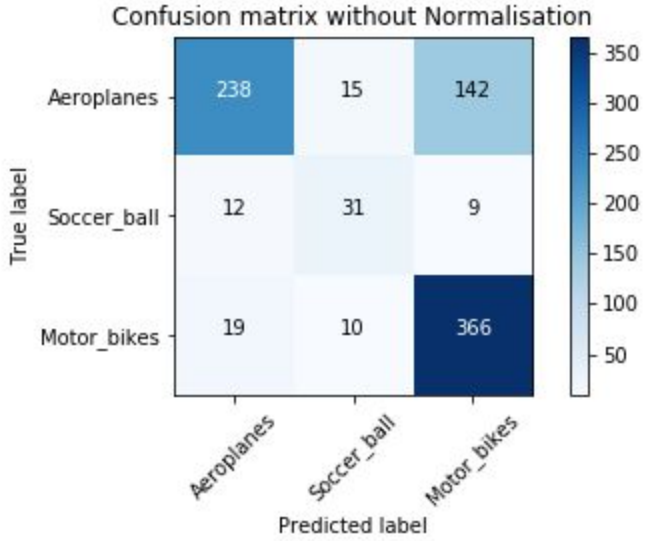
Classifier Used	**Accuracy**
Normal Bayesian	0.7779097387173397
Decision Tree	0.78503562945368166
SVM	0.89073634204275531

With 24 Clusters

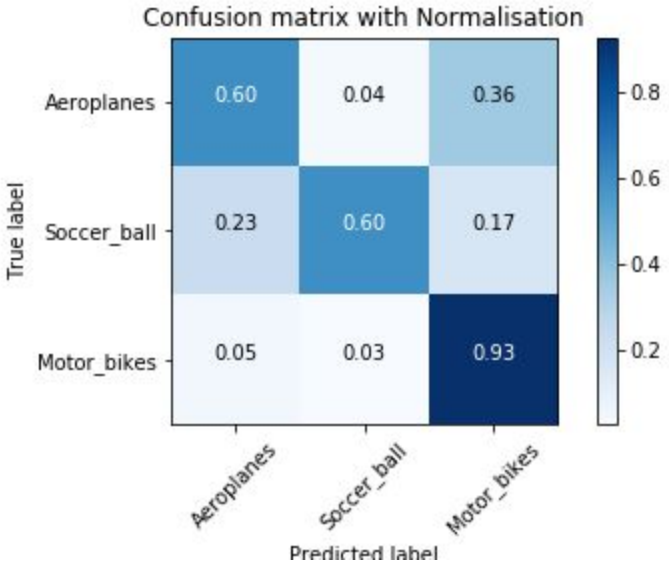
Classifier Used	**Accuracy**
Normal Bayesian	0.80997624703087889
Decision Tree	0.78859857482185269
SVM	0.90736342042755347

- **Confusion Matrix for 0.7 split**

With 8 Clusters
Normal Bayesian



Without Normalisation



With Normalisation

Decision Trees

With Normalisation :

Aero_motor_kangaroo/CL_8_Split_7/Tree_Confusion_matrix_with_normalisation.png

Without Normalisation :

Aero_motor_kangaroo/CL_8_Split_7/Tree_Confusion_matrix_without_normalisation.png

SVM

With Normalisation :
Aero_motor_kangaroo/CL_8_Split_7/SVM_Confusion_matrix_with_normalisation.png
Without Normalisation :
Aero_motor_kangaroo/CL_8_Split_7/SVM_Confusion_matrix_without_normalisation.png

With 12 Clusters

Normal Bayesian

With Normalisation :
Aero_motor_kangaroo/CL_12_Split_7/NB_Confusion_matrix_with_normalisation.png
Without Normalisation :
Aero_motor_kangaroo/CL_12_Split_7/NB_Confusion_matrix_without_normalisation.png

Decision Trees

With Normalisation :
Aero_motor_kangaroo/CL_12_Split_7/Tree_Confusion_matrix_with_normalisation.png
Without Normalisation :
Aero_motor_kangaroo/CL_12_Split_7/Tree_Confusion_matrix_without_normalisation.png

SVM

With Normalisation :
Aero_motor_kangaroo/CL_12_Split_7/SVM_Confusion_matrix_with_normalisation.png
Without Normalisation :
Aero_motor_kangaroo/CL_12_Split_7/SVM_Confusion_matrix_without_normalisation.png

With 19 Clusters

Normal Bayesian

With Normalisation :
Aero_motor_kangaroo/CL_19_Split_7/NB_Confusion_matrix_with_normalisation.png
Without Normalisation :
Aero_motor_kangaroo/CL_19_Split_7/NB_Confusion_matrix_without_normalisation.png

Decision Trees

With Normalisation :
Aero_motor_kangaroo/CL_19_Split_7/Tree_Confusion_matrix_with_normalisation.png
Without Normalisation :
Aero_motor_kangaroo/CL_19_Split_7/Tree_Confusion_matrix_without_normalisation.png

SVM

With Normalisation :
Aero_motor_kangaroo/CL_19_Split_7/SVM_Confusion_matrix_with_normalisation.png
Without Normalisation :
Aero_motor_kangaroo/CL_19_Split_7/SVM_Confusion_matrix_without_normalisation.png

With 24 Clusters

Normal Bayesian

With Normalisation :
Aero_motor_kangaroo/CL_24_Split_7/NB_Confusion_matrix_with_normalisation.png
Without Normalisation :
Aero_motor_kangaroo/CL_24_Split_7/NB_Confusion_matrix_without_normalisation.png

Decision Trees

With Normalisation :
Aero_motor_kangaroo/CL_24_Split_7/Tree_Confusion_matrix_with_normalisation.png
Without Normalisation :
Aero_motor_kangaroo/CL_24_Split_7/Tree_Confusion_matrix_without_normalisation.png

SVM

With Normalisation :
Aero_motor_kangaroo/CL_24_Split_7/SVM_Confusion_matrix_with_normalisation.png
Without Normalisation :
Aero_motor_kangaroo/CL_24_Split_7/SVM_Confusion_matrix_without_normalisation.png

With 100 Clusters

Normal Bayesian

With Normalisation :
Aero_motor_kangaroo/CL_100_Split_7/NB_Confusion_matrix_with_normalisation.png
Without Normalisation :

Aero_motor_kangaroo/CL_100_Split_7/NB_Confusion_matrix_without_normalisation.png

Decision Trees

With Normalisation :
Aero_motor_kangaroo/CL_100_Split_7/Tree_Confusion_matrix_with_normalisation.png
Without Normalisation :
Aero_motor_kangaroo/CL_100_Split_7/Tree_Confusion_matrix_without_normalisation.png

SVM

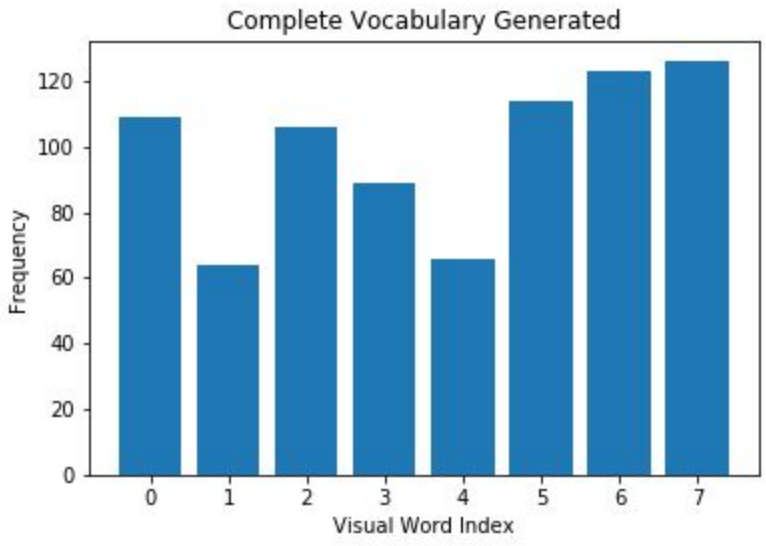
With Normalisation :
Aero_motor_kangaroo/CL_100_Split_7/SVM_Confusion_matrix_with_normalisation.png
Without Normalisation :
Aero_motor_kangaroo/CL_100_Split_7/SVM_Confusion_matrix_without_normalisation.png

NOTE : Similarly All the results with Split 0.5 can be found in
Aero_motor_kangaroo/CL8
Aero_motor_kangaroo/CL12
Aero_motor_kangaroo/CL19
Aero_motor_kangaroo/CL24
Aero_motor_kangaroo/CL100

7. Vocabulary Diagrams

This represents the histograms of the clusters with entire training set, they can be found in
Aero_motor_kangaroo/CL8
Aero_motor_kangaroo/CL12
Aero_motor_kangaroo/CL19
Aero_motor_kangaroo/CL24
Aero_motor_kangaroo/CL8_Split_7
Aero_motor_kangaroo/CL12_Split_7
Aero_motor_kangaroo/CL19_Split_7
Aero_motor_kangaroo/CL24_Split_7

There are both Normalised and unnormalised version of this this. One Such Normalised vocabulary is shown below.



8. Similarly all the results for different dataset i.e Aeroplanes, Motor Cycles and Faces are there in Aero_motor_Faces folder.

Accuracies for 0.7 Split : Aero_motor_Faces/Accuracies7
Accuracies for 0.5 Split : Aero_motor_Faces/Accuracies

Similarly Silhouette score pictures for different clusters and Confusion matrix pictures and vocabulary diagrams can be found in
Aero_motor_Faces/CL8
Aero_motor_Faces/CL12
Aero_motor_Faces/CL19
Aero_motor_Faces/CL24
Aero_motor_Faces/CL8_Split_7
Aero_motor_Faces/CL12_Split_7
Aero_motor_Faces/CL19_Split_7
Aero_motor_Faces/CL24_Split_7

9. Analysis

- **Silhouette Score use**

The Silhouette Coefficient is calculated using the mean intra-cluster distance (a) and the mean nearest-cluster distance (b) for each sample. The Silhouette Coefficient for a sample is (b - a) / max(a, b). To clarify, b is the distance between a sample and the nearest cluster that the sample is not a part. The best value is 1 and the worst value is -1. Values near 0 indicate overlapping clusters. Negative values generally indicate that a sample has been assigned to the wrong cluster, as a different cluster is more similar.

Silhouette Score will be little high if the number of clusters are small like 2 or 3 after that it tends to decrease and at some points in tends to increase and drop again we can choose this local maximas as desired number of clusters to get good results. Normally computing Silhouette Scores for different cluster sizes is computationally expensive so it is computed by taking only some random sample of the data. Only for one experiment full dataset was used it was done using a data mining tool called Orange. Output of that can be found here
S_Scores.pdf

Note : Elbow Method can also be used but it won't word properly for higher dimensional data like what we are using here(128)

- **Normalising the histogram**

As number of keypoints will be different for different images if we just take the histogram obtained after clustering it won't be a good thing because if we do this the relative values of different bins loose significance and the absolute value will matter.
For example for image having 5 descriptors and 3 bins assume representation is like this.

2 2 1

For different image with 100 descriptors the representation may be like this
50 34 16

So here the model takes absolute values and doesn't generalise well. So we have to normalise.

- **Performance of Different models.**

One problem that is common to all three classifiers is class imbalancing i.e all this models tends to prefer classes which have more training examples. Out of the three models SVMs outperform the other two classifiers in both categories. Decision trees tends to overfit to training data and small variations of the data can create completely different trees and completely different results will be obtained. When the split of the data of the data is such that number of training instances are more then the model tends to perform better this is because the model reduces overfitting it the training data is more and it will have more examples to learn the classification task and it generalises well.