Computer Vision

Automatic Signature Stability Analysis And Verification Using Local Features

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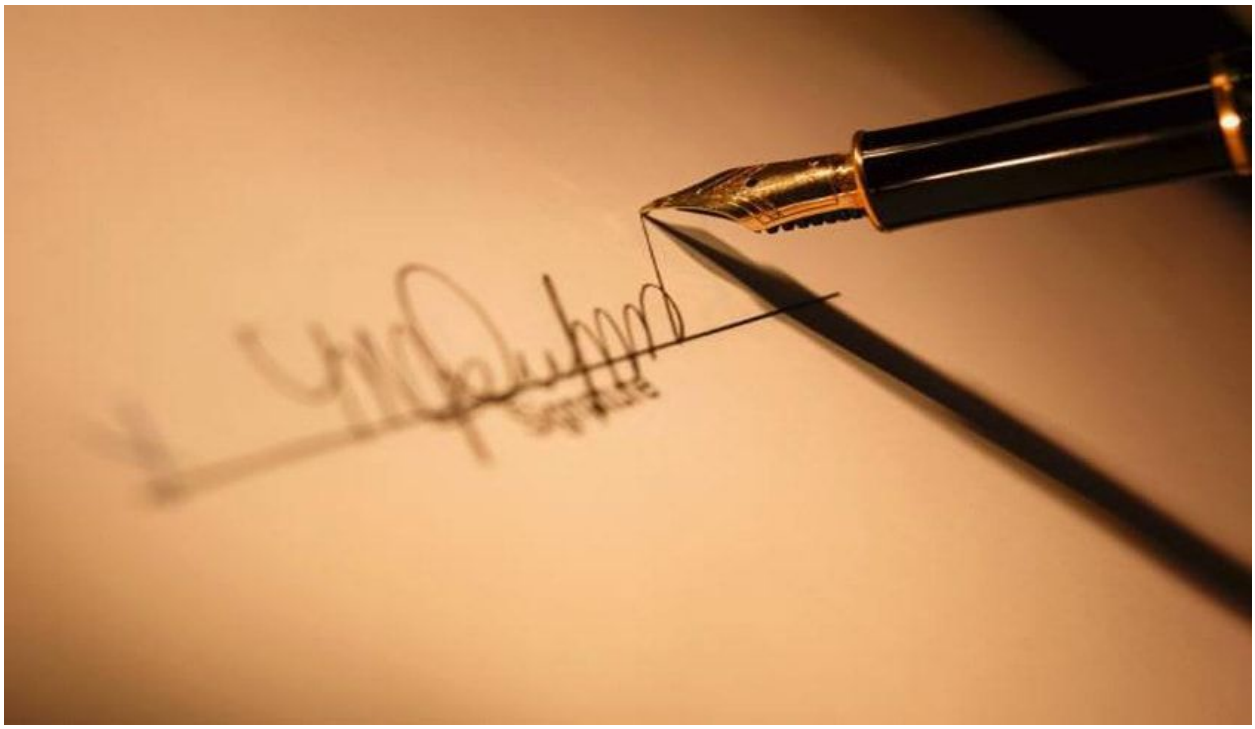
Github link: Signature_Stability_Analysis



Problem Statement:

- Classifying the signature from 4NSigComp2010 database into Genuine or fake (forged as well as disguised)

Link to the associated paper: Signature Stability Analysis

Classification Approach:

Two methods for classification are presented in the report:

- **Method I**: It is the method proposed by the paper, where we used SURF to obtain the keypoints and used averages of the distance of the reference points from each other to obtain the Reference set used for classification
- **Method II:** The second one is inspired by the bag of words/images (suggested by Aniruddha and Tarun) approach where we used K-Means clustering to obtain the reference points needed for the classification

The results obtained from both the methods are displayed. Both the methods have 3 steps:

- **Step I:** Obtaining the Keypoints from the training signature using SURF
- **Step II:** Using the obtained Keypoint set to build a Reference set of Keypoints and their descriptors for classification
- **Step III:** Using the Reference set to obtain appropriate threshold value used for the final classification

Steps I and III are common for both the methods and they differ in the second one.

Next we will be presenting all the steps in detail

Step I: Detecting Keypoints

The paper suggest two hypothesis:

- **H1:** The stability is not homogeneously distributed across the signature. In other words, keypoints from some areas will give more stable results than those from other areas
- **H2:** The stability behavior is generalizable to other authors i.e. different signatures

Therefore, we use SURF to detect keypoints from the training signature images

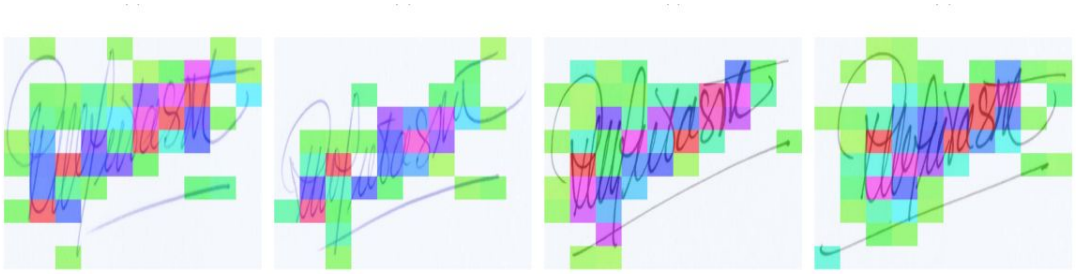


Figure 1. Heat maps of some example specimen (genuine) signatures from four different authors (one genuine author in each row) showing the most stable (green) and the most unstable (red) parts along with the moderately stable parts (colors varying from green to red through blue).

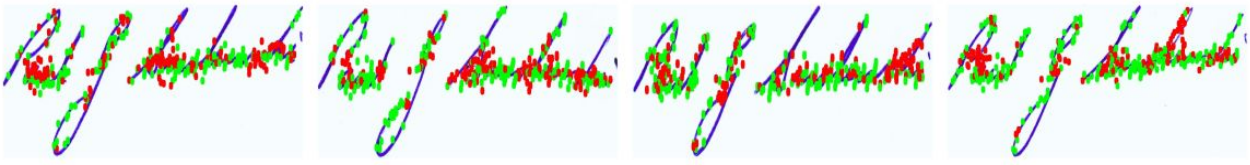
By inspecting the genuine specimen signatures of various authors, it is revealed that both H1 and H2 are partially true

Step II: Building the Reference Set

This is the step where the two methods differ from each other

Method I: We build the Reference set of stable keypoints using N-1 cross-validation as follows:

- Get the set of genuine signatures
- Split it into N-1 reference and 1 test set
- Use SURF to identify local keypoints of all the images, reference and test
- Match Keypoints of test signature with reference set to get stable keypoints
- Recompute new Stable points taking a different signature as test and rest as N-1 reference
- Take Stable points from all the iteration to build the final Stable Keypoints Database
- A point is considered a stable point if its average distance from all the other keypoints is less than the average of average distance of all the keypoints from all the other keypoint



(e) (f) (g) (h)

Figure 2. Example genuine reference signatures of one author. Green points are considered to be stable and are added to the reference keypoints database for performing verification. Red points are considered unstable and are not included in the reference keypoints database.

Method II: Here we used K-Means clustering to obtain the set of stable points

- Get the set of genuine signatures
- Use SURF to identify local keypoints of all the images
- Use K-Means clustering to cluster the keypoints for a given k (let say, 100)
- Calculate intra-cluster variance for each cluster
- Keep all the clusters where the intra-cluster variance is less than the average intra-cluster variance across all clusters
- The remaining clusters form our stable keypoint set called the Reference set

The Reference set along with another parameter theta, called the threshold value, is used to make the classification

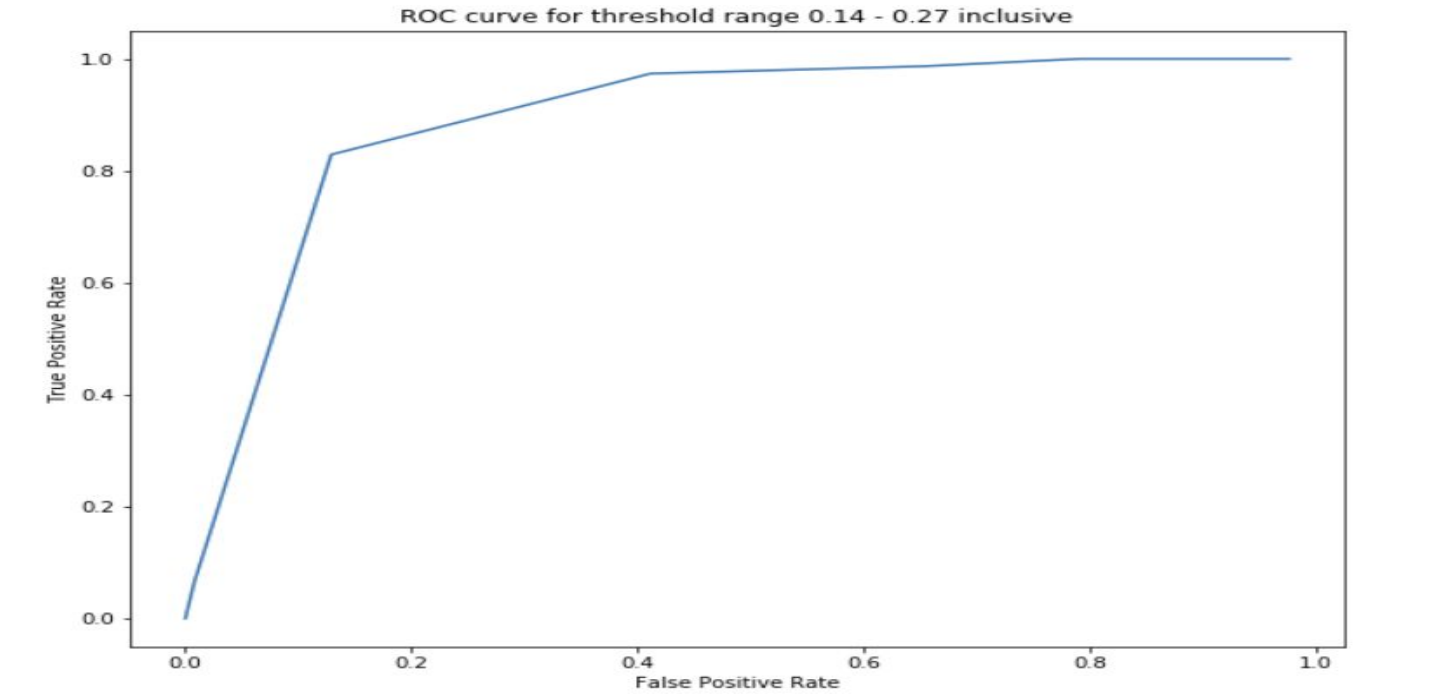
Steps III: Final Classification

The **Reference set** along with another parameter **theta**, called the threshold value, is used to make the classification

How is **theta** used?

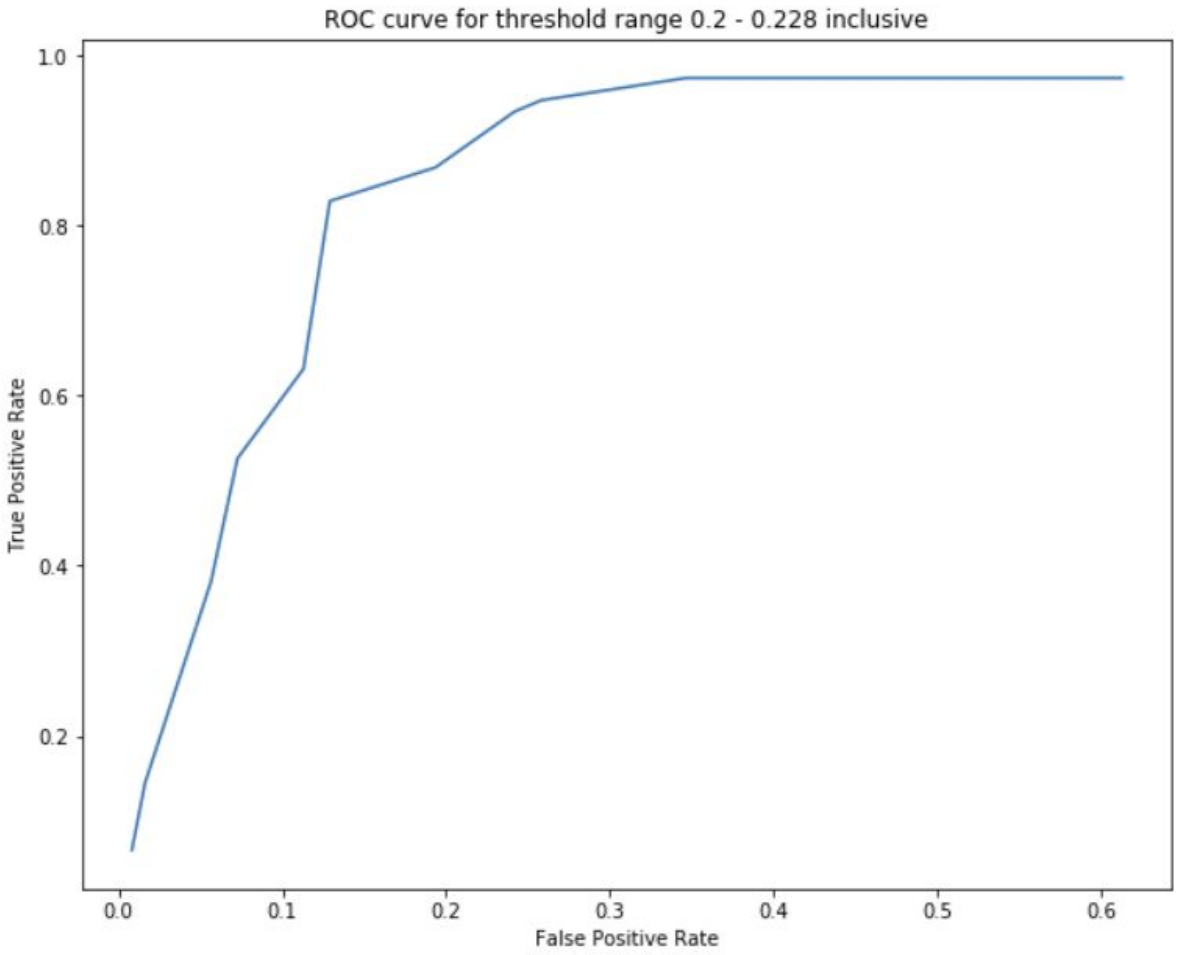
- The threshold value, **theta**, is a distance
- A query Keypoint (a Keypoint from the image undergoing classification) whose distance from K keypoints in the Reference set is less than theta is called a good keypoint
- If the ratio of good points to total number of points is greater than 0.75 then the signature is classified as Genuine else its fake
- The best threshold value, theta is selected using the ROC curve

ROC curves for different values of theta: (**Method I**)



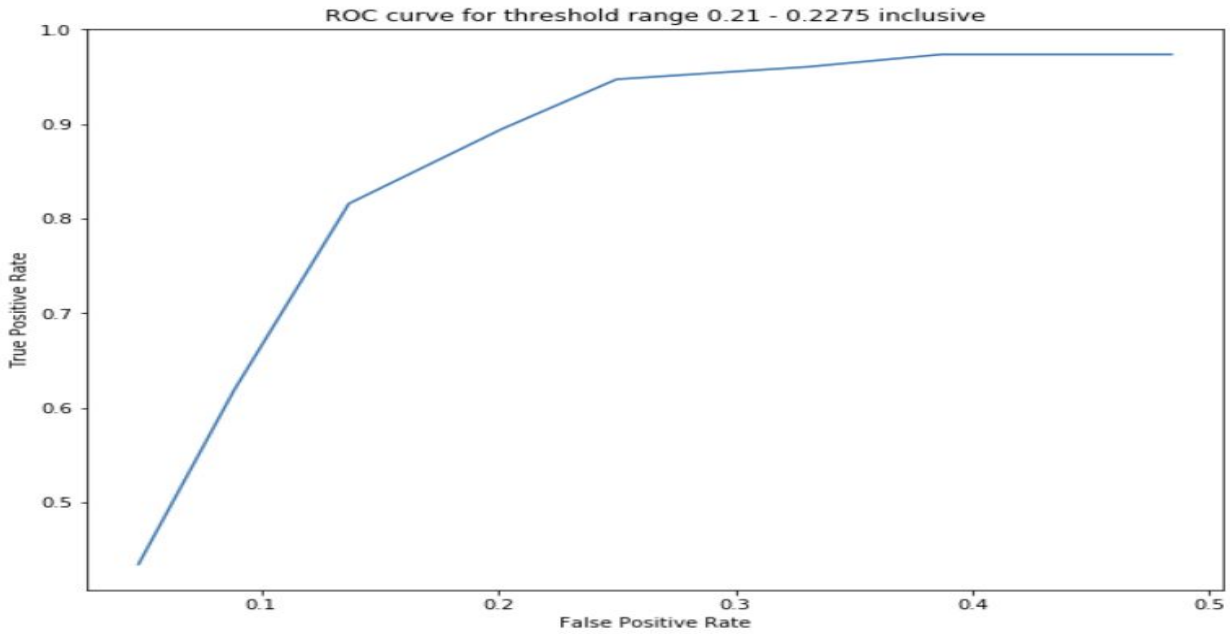
The Step size for the above ROC curve was 0.01

Following is the ROC curve with a step-size of 0.002

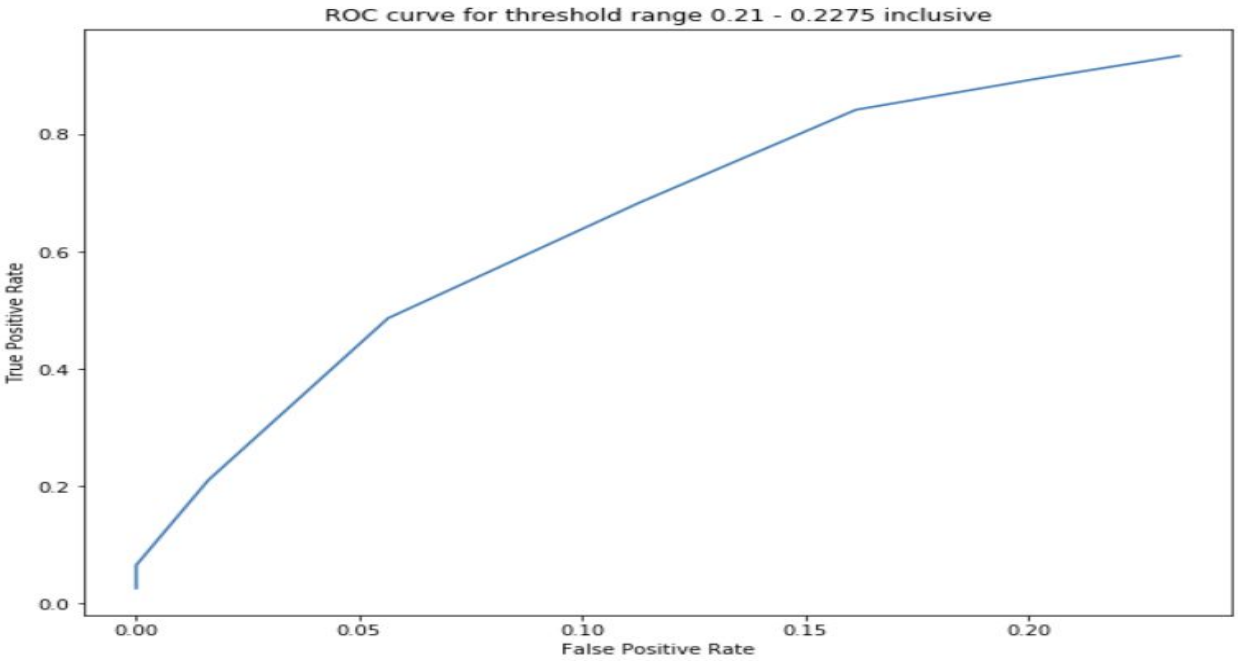


- In the paper the decision whether a point is Good or not is based on the nearest neighbour of the query point
- We tried for different ROC curve by increasing the number of neighbours and following were the results

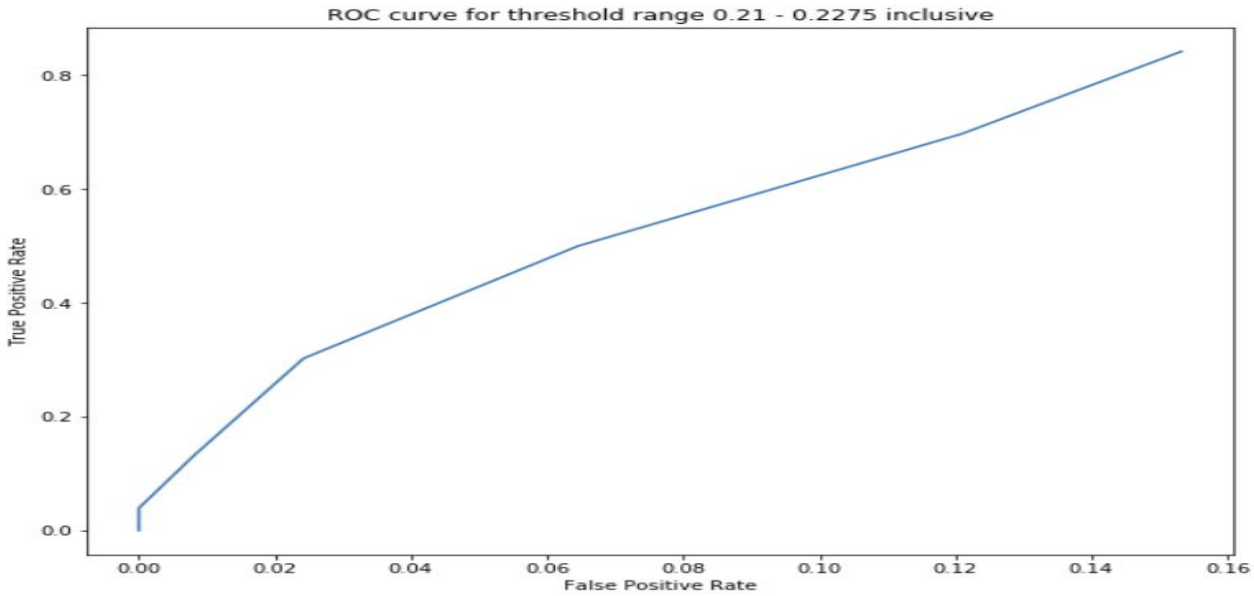
For K = 2, 4, 6, 8 and 10:



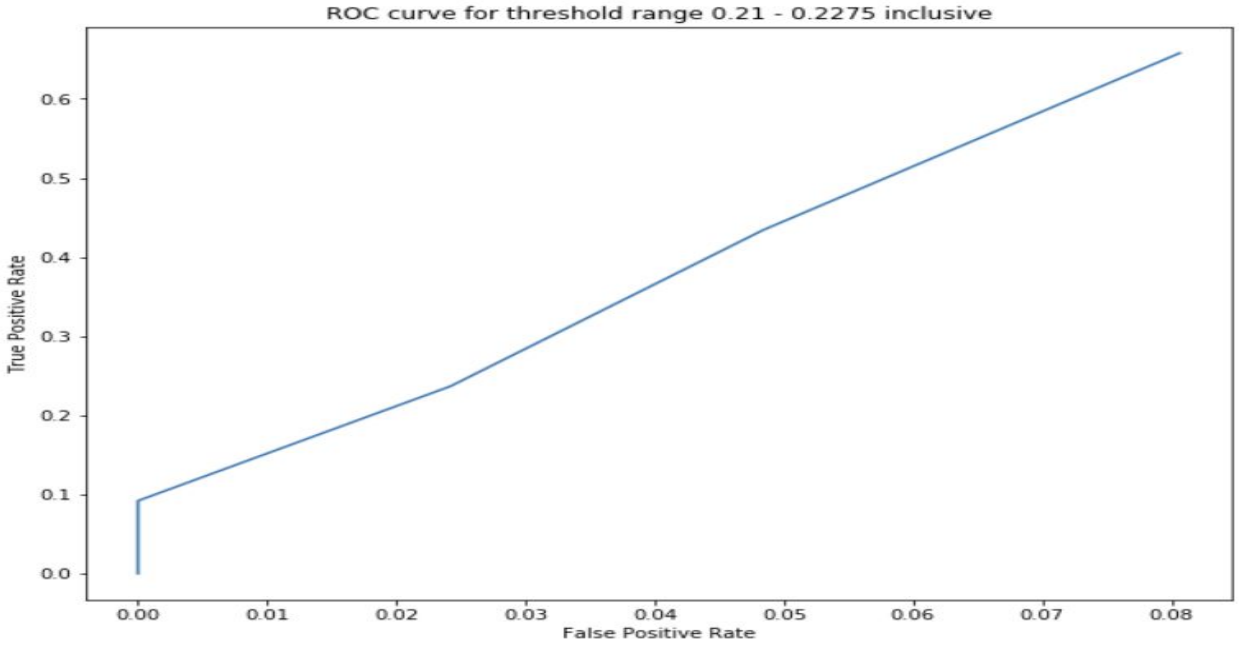
K = 4



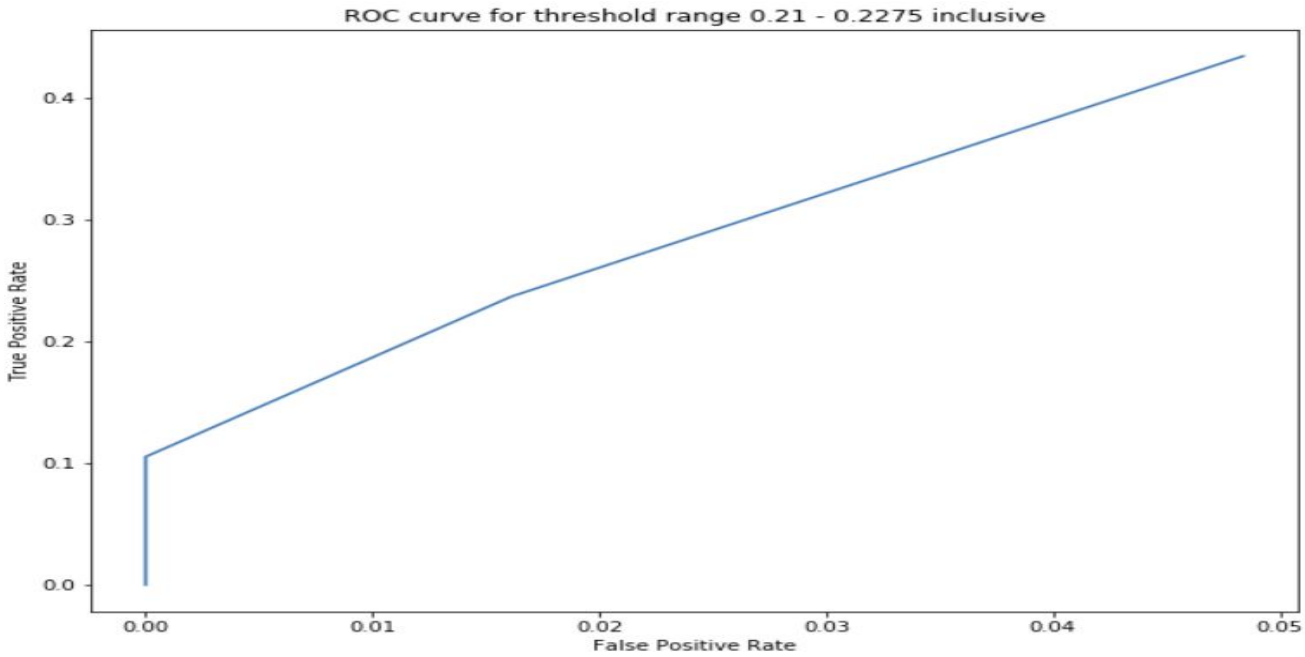
K = 6:


ROC curve for threshold range 0.21 - 0.2275 inclusive
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14
0.16

K = 8


ROC curve for threshold range 0.21 - 0.2275 inclusive
True Positive Rate
False Positive Rate
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.00
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08

K = 10:

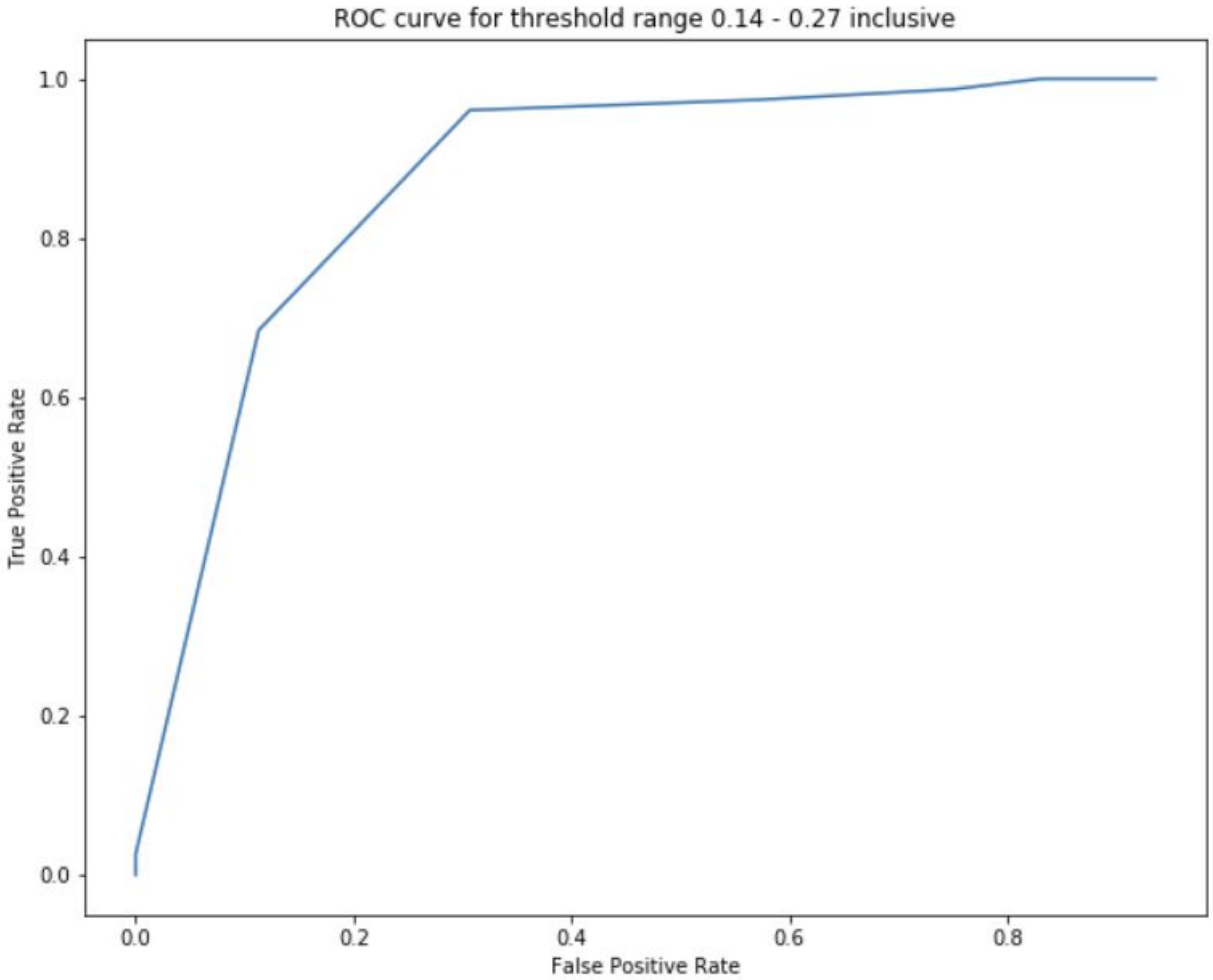


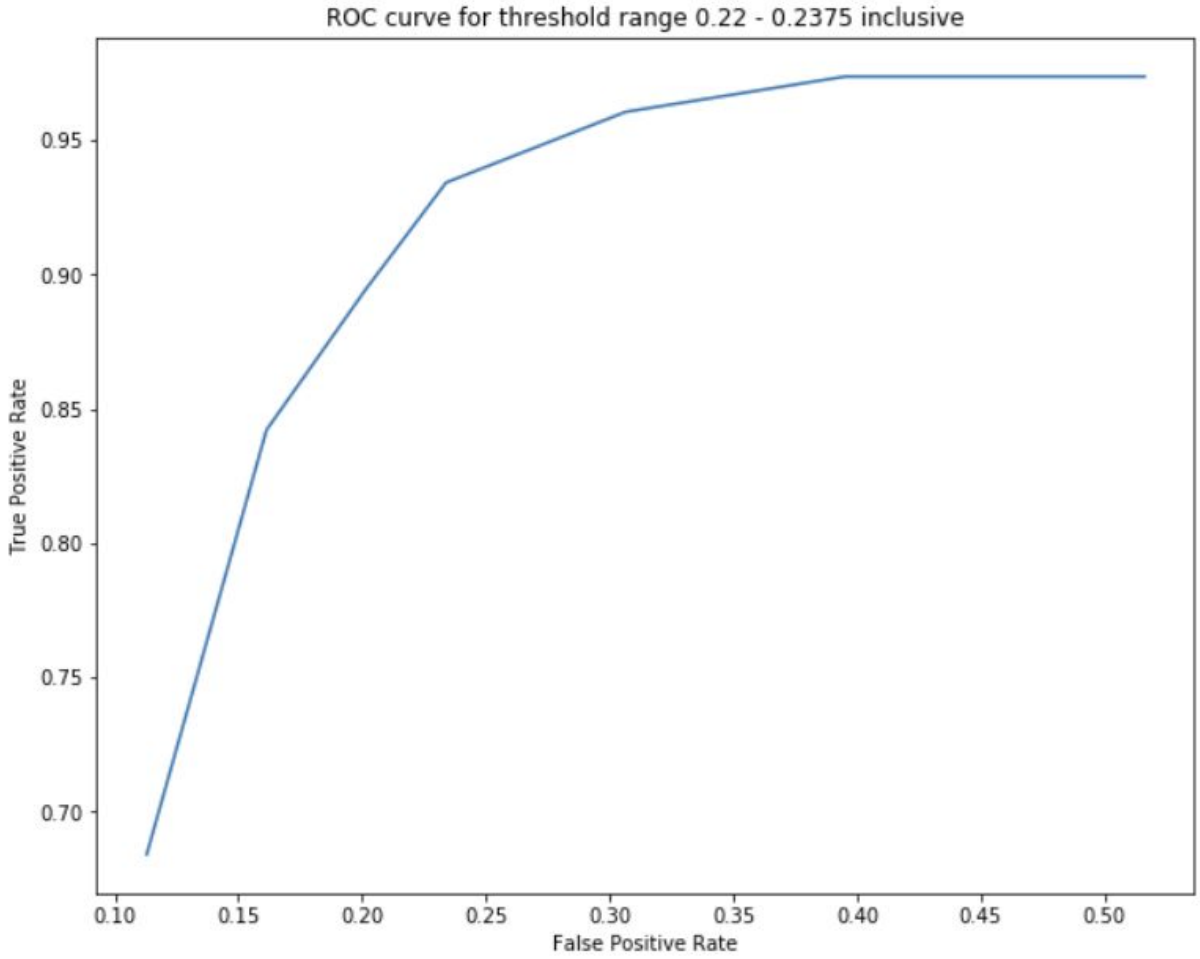
The above result were obtained using the method suggested in the paper. The following are the results obtained using the K-mean Reference set

Method II: Even in method 2 we have applied two approaches:

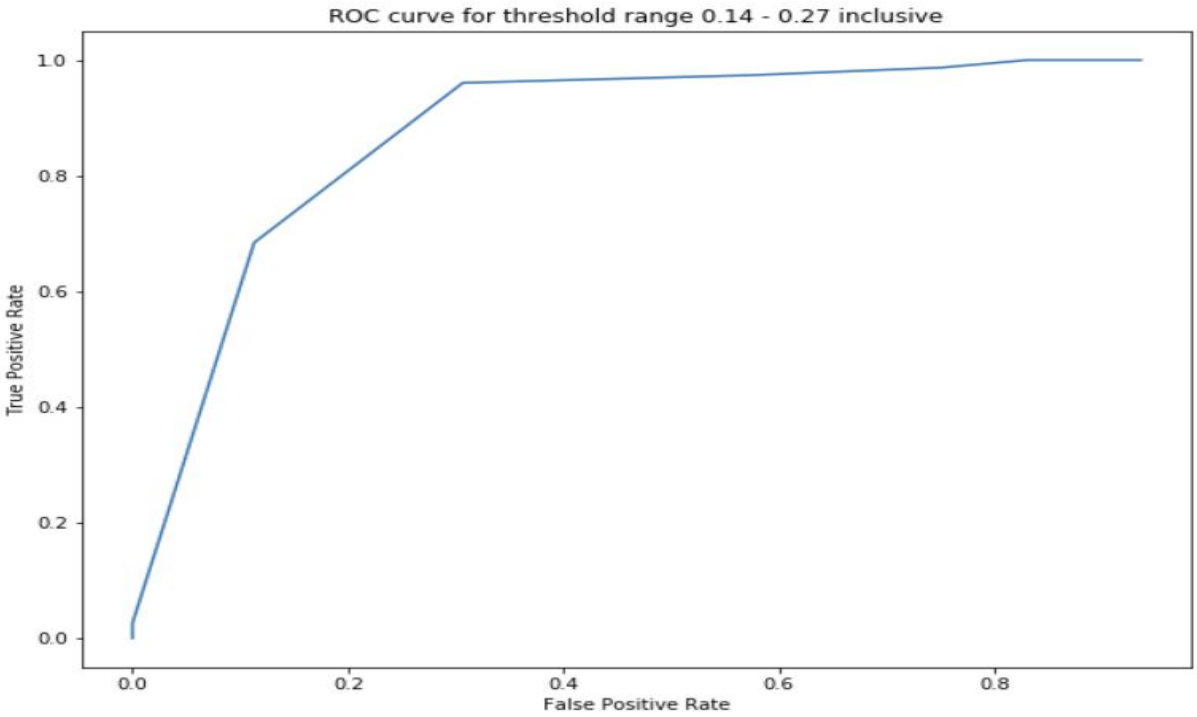
- **Approach I:** We considered all the Keypoints from the obtained clusters as the Reference set
- **Approach II:** We used just the centroids of the clusters as the Reference set to make the decision

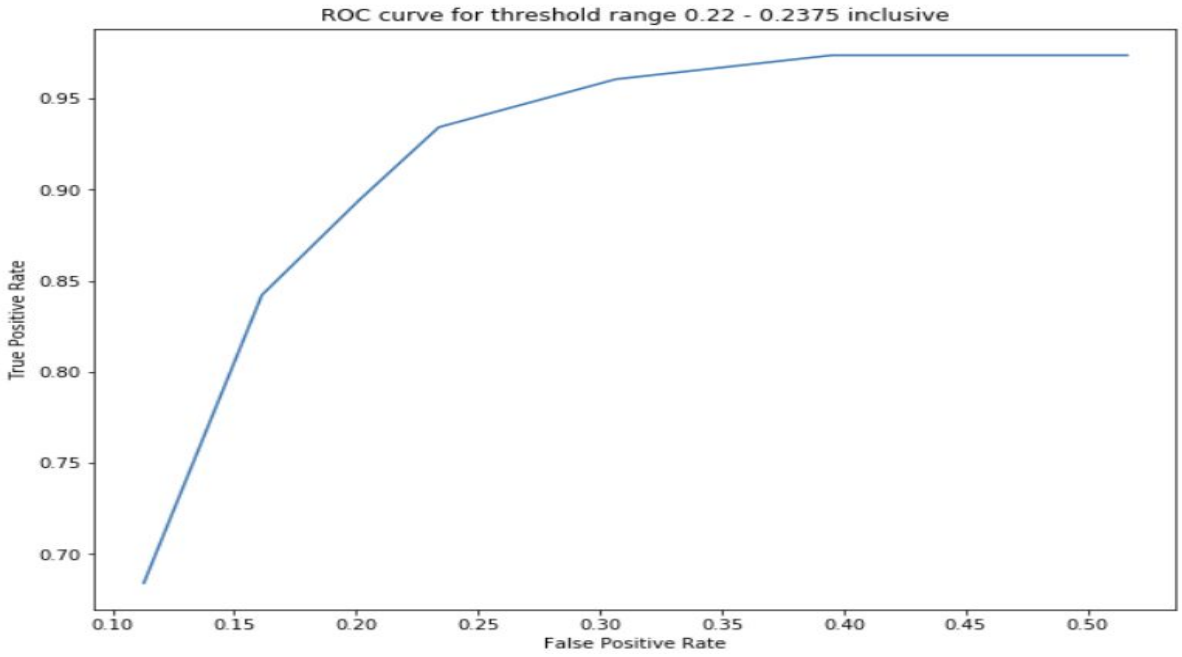
Results from Approach I are as follows:




ROC curve for threshold range 0.22 - 0.2375 inclusive
True Positive Rate
False Positive Rate
0.95
0.90
0.85
0.80
0.75
0.70
0.10
0.15
0.20
0.25
0.30
0.35
0.40
0.45
0.50

Approach ll Result:





Conclusions:

Following were the conclusions drawn from the experiments:

- Both Method l, the approach mentioned in the paper, and Method ll, using K-means to generate the Reference set, performed almost equally well for the given database
- The best value of K = 1 for determining if the query keypoint is good. We kept the same criterion for classifying a point as Good/stable across all the values of K
- For Method ll both Approaches l and ll performed equally well. The Approach ll had smaller space complexity compared the first