

Object Recognition with Local Feature Matching

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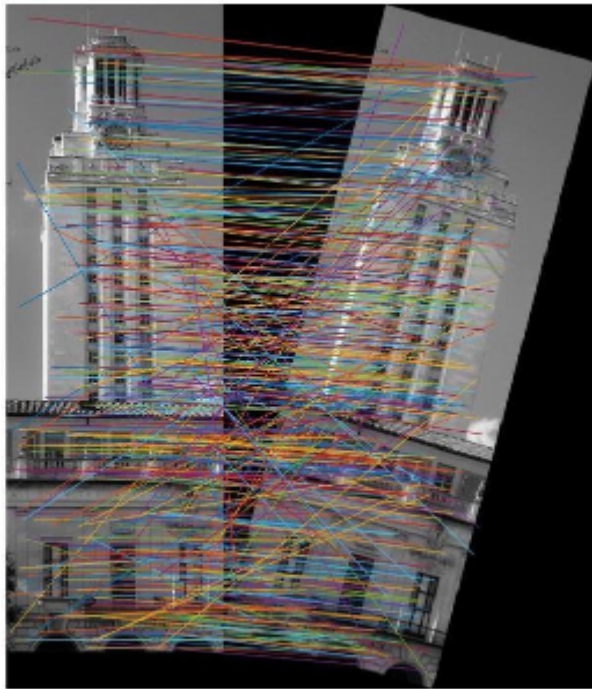
Overview

In this assignment we build a object recognition system based on local feature matching. We are using VLFeat library for detecting SIFT features. After detecting SIFT features we perform Nearest Neighbor based Thresholding followed by Lowe Elimination Test and RANSAC for eliminating false matches / outliers.

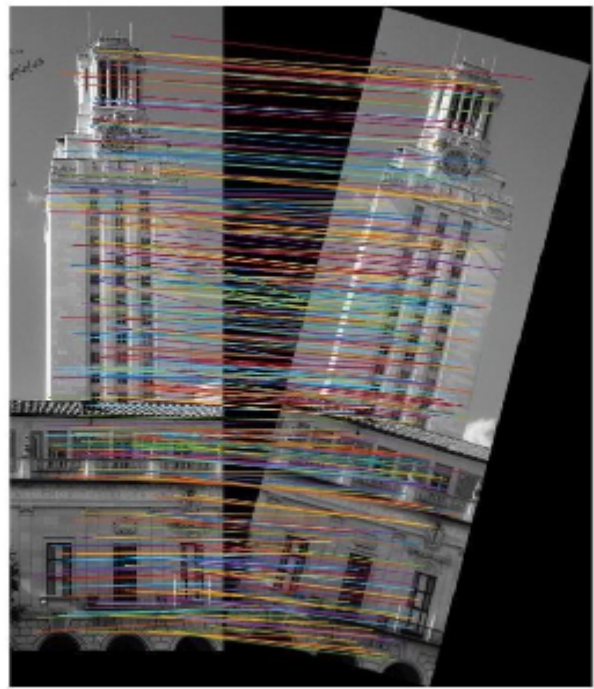
Outlier Detection

Since many SIFT features are local, we get many false matches. Thus for object recognition we need eliminate them using above mentioned techniques. As can be seen from experimental results below (Fig 1, 2, 3), nearest neighbor based thresholding removes quite a few false matches. However even after this step there are a significant number of false matches. Lowe's ratio test eliminate almost all of these false matches. Finally RANSAC removes outliers based on spatial matching.

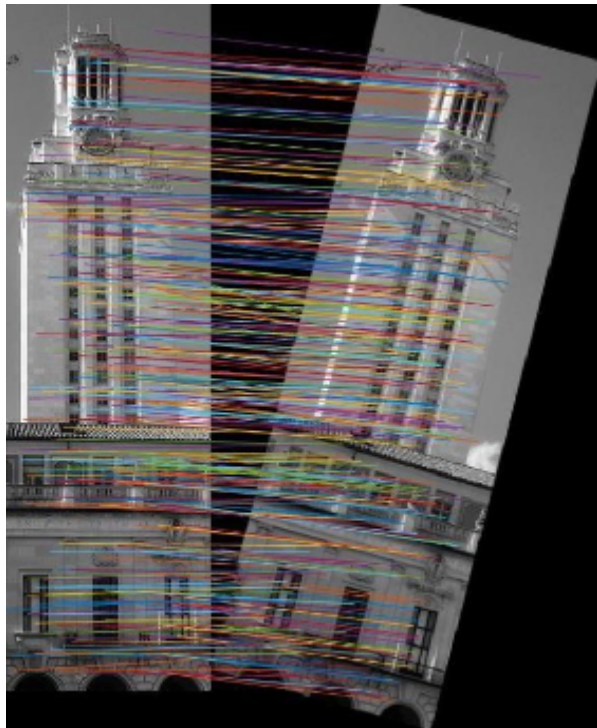
We used mean distance threshold as 0.8 for nearest neighbor based thresholding, lowe ratio of 0.6 and 100 iterations in RANSAC. We speed up the algorithm for cases like Fig 1 where number of matches is huge even after Lowe Elimination, we exit early from Ransac if we have already got a good model. For other cases (Fig 2, Fig 3) number of matches is quite less so 100 iterations complete very fast.



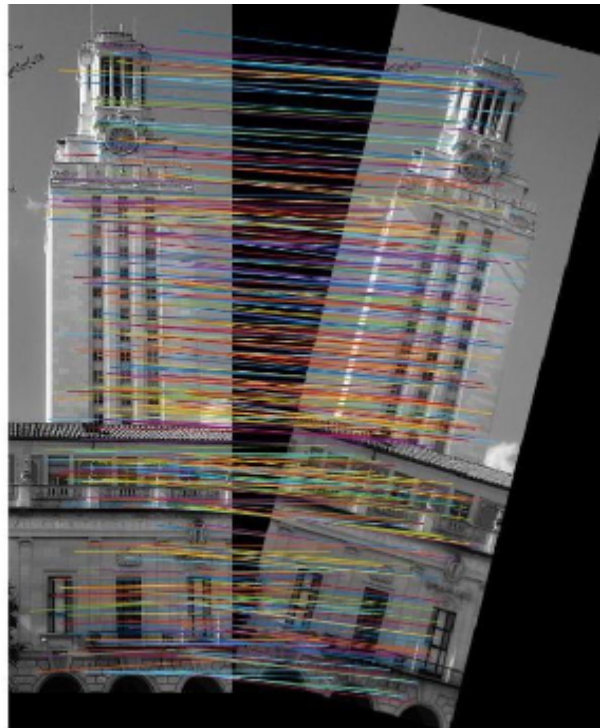
Initial Matches



After Nearest Neighbor Thresholding



After Lowe Elimination



After Ransac

Fig 1: Matches after various phases of pipeline for Rotated Template

This case demonstrates that SIFT is invariant to rotation but can lead to some false matches even if scene image is just a rotated version of template (**this was surprising**) !! Also this eg shows the effectiveness of nearest neighbor based thresholding. Observe that almost all false matches are

removed after this phase. Since scene image is a rotated version of template image, as expected we get very high number of matches finally.

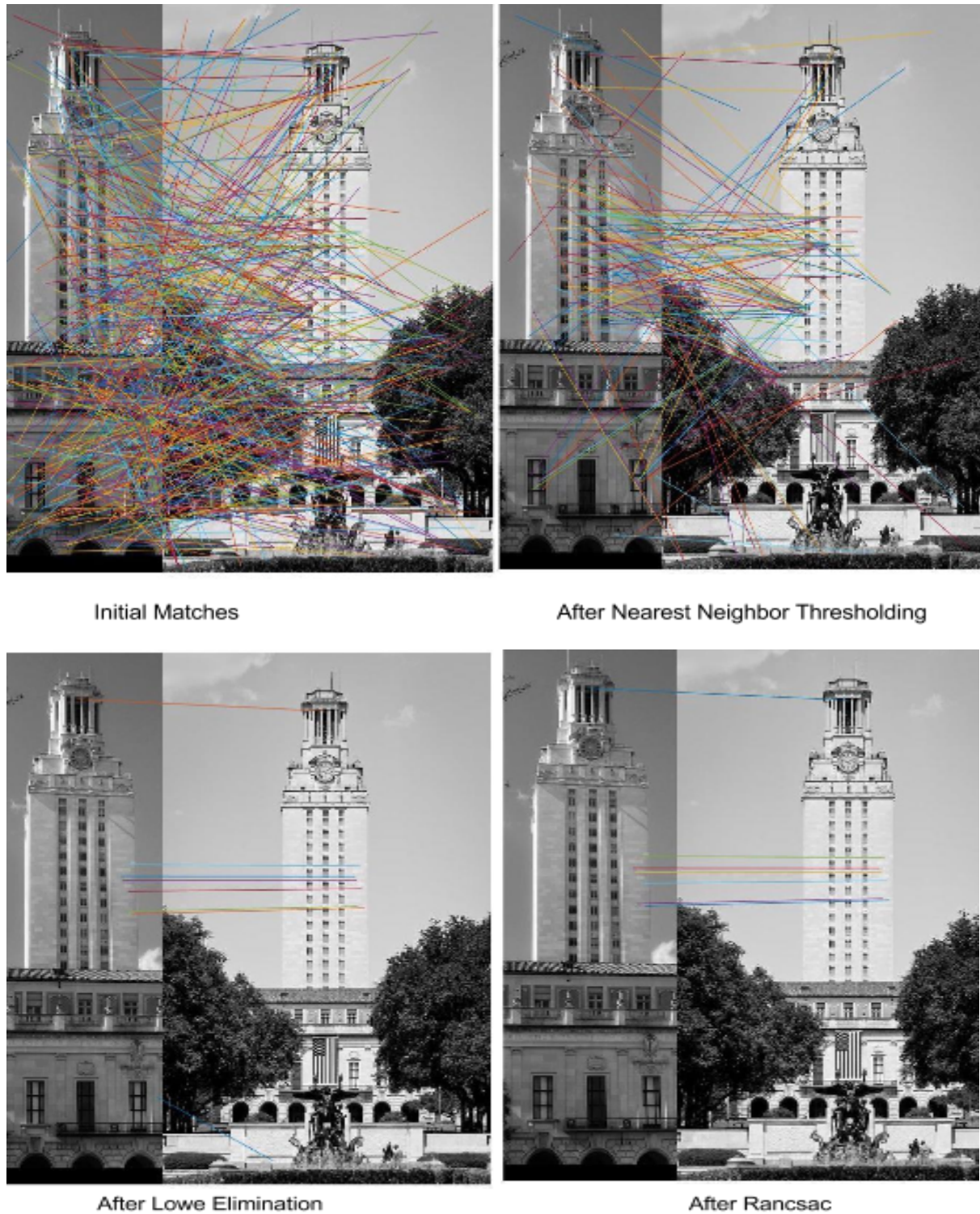


Fig 2: Matches after various phases of pipeline for Scene 1

This case demonstrates shows that SIFT can have high number of false matches if there is a view point changes and why we need elimination phases. We can also see the effectiveness of Lowe Elimination in removing almost all false matches in this case. Finally we can observe that RANSAC

removes one outlier (blue line matching a tower point to fountain) which was not spatially conformant with other matches.

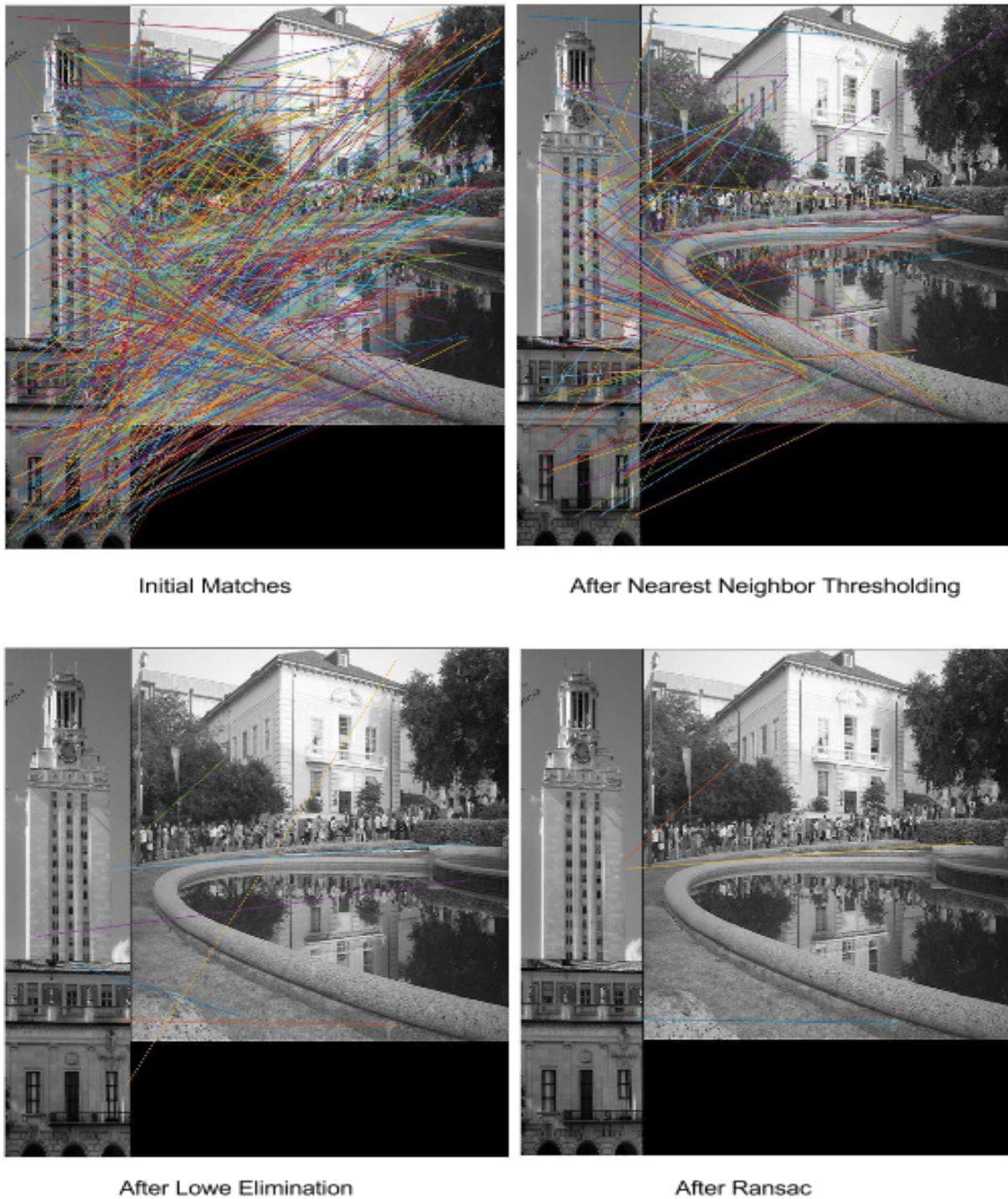


Fig 3: Matches after various phases of pipeline for Scene 2

This case demonstrates the need for spatial verification (RANSAC). We can see that only 3 points remain after Ransac. Note that since we using 3 points to predict the model, we will always get atleast 3 matches if there were more than 3 matches before this phase.

Object Detection

After performing outlier detection described in previous section, we check if we have greater than 3 inliers for the affine transformation model predicted by RANSAC. If we have sufficient inliers satisfying this criteria then we draw a rectangle by projecting the corners of template image to scene image using the obtained transformation.



Fig 4 : Match for Rotated Template

This case demonstrates that SIFT is robust to object rotations and hence if there are no other variations then we are able to find a very good match.

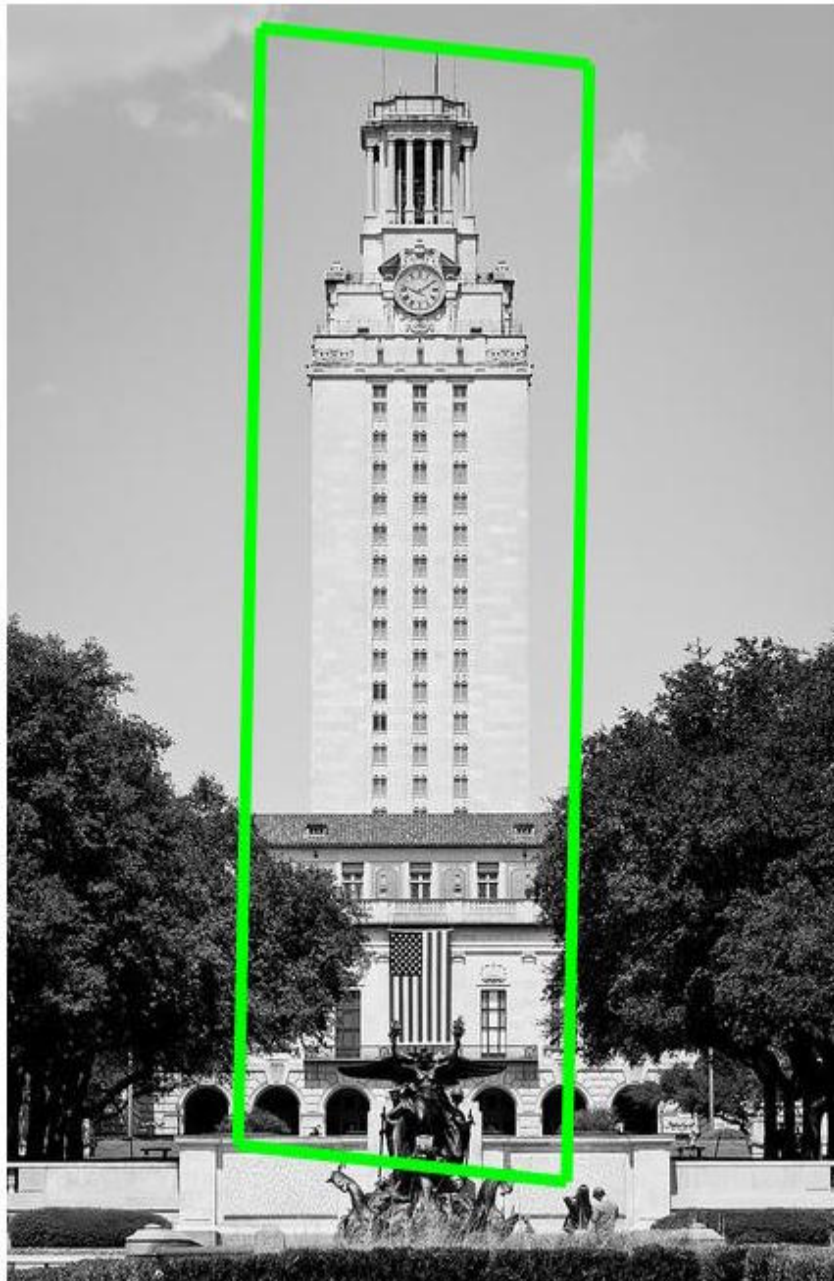
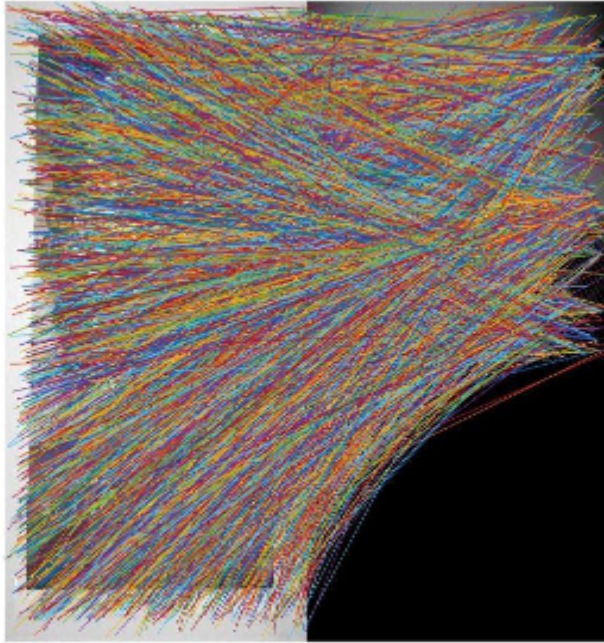


Fig 5 : Match for Scene 1

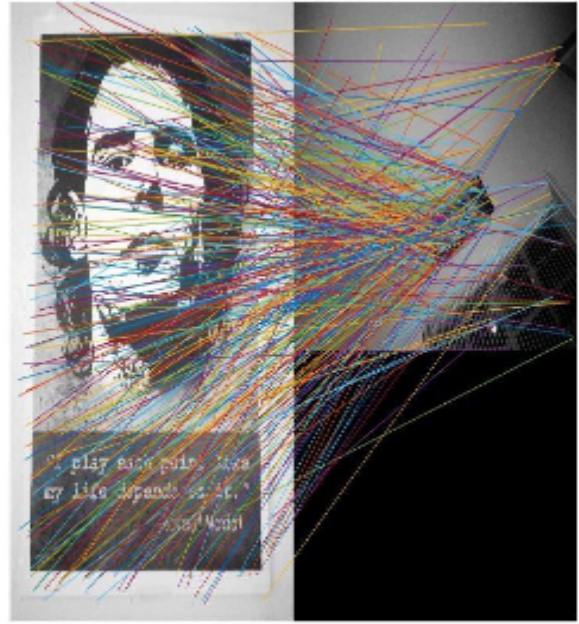
This case demonstrates that SIFT is robust to changes scale and small changes in view-point, illumination etc..

Extra Credit (Harder Cases)

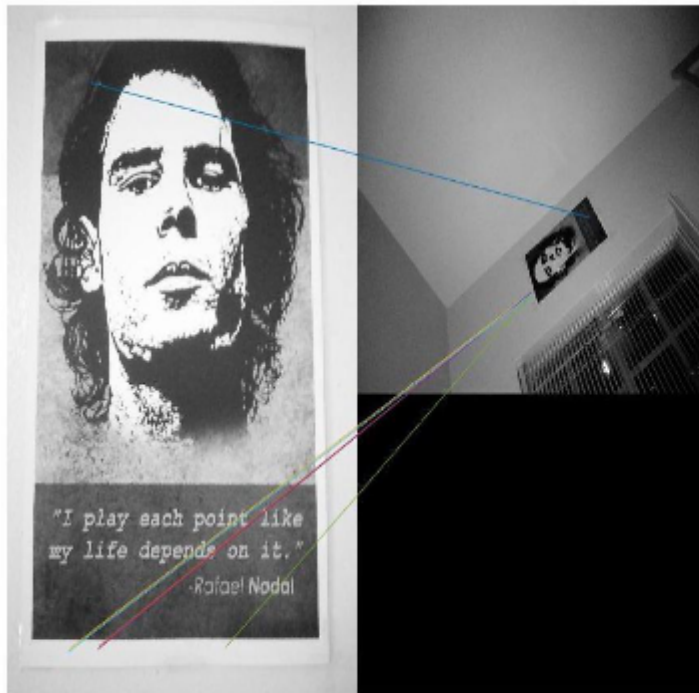
In this section we analyze the results obtained on scene images with stronger variations in scale, rotation, illumination etc. First we look at results for 2 different scenes for an object (one with milder variations and other with very strong variations). After that we present a case where Nearest Neighbor thresholding is not that effective but RANSAC helps in eliminating the false matches.



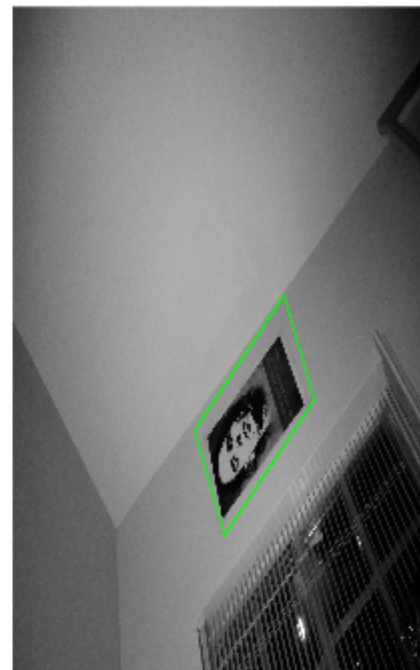
Matches after Neighbor Thresholding



Matches after Lowe Elimination



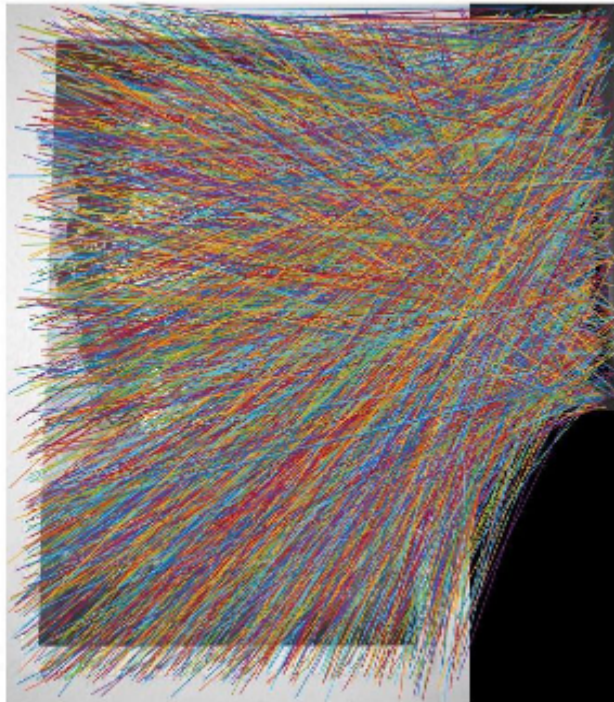
Matches after Ransac



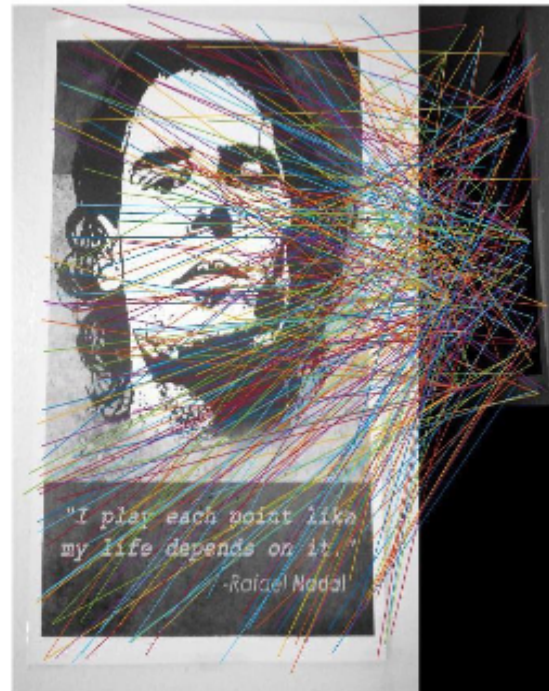
Template Match

Fig 6 : Matches after various phases for Scene 3

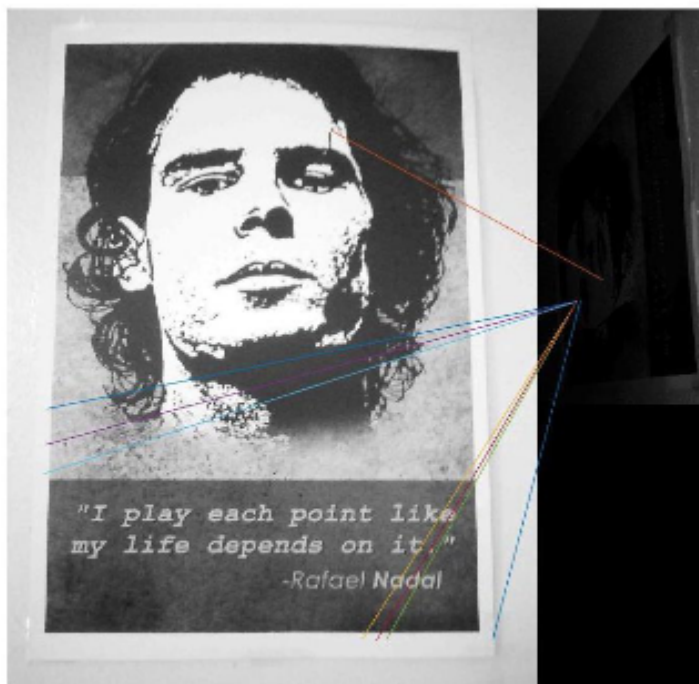
These results demonstrate a case where there is a significant change in scale, rotation, illumination but still our pipeline is able to find a reasonable match. Next we modify these parameters further in scene 4 to test how well SIFT performs for larger variations.



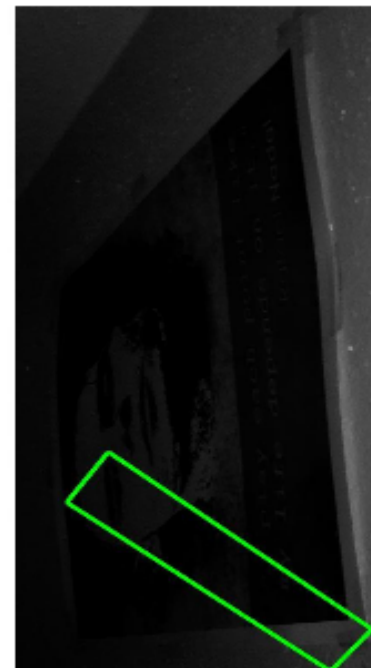
Matches after Nearest Neighbor Thresholding



Matches after Lowe Elimination



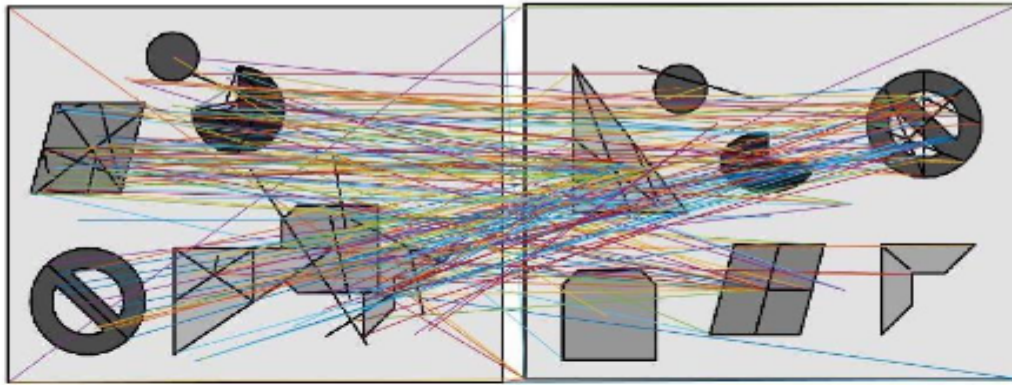
Matches after Ransac



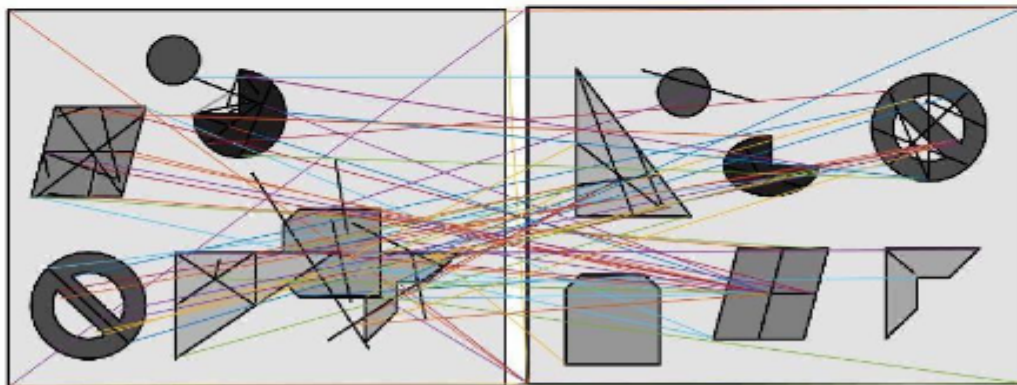
Template Match

Fig 7 : Matches after various phases for Scene 4

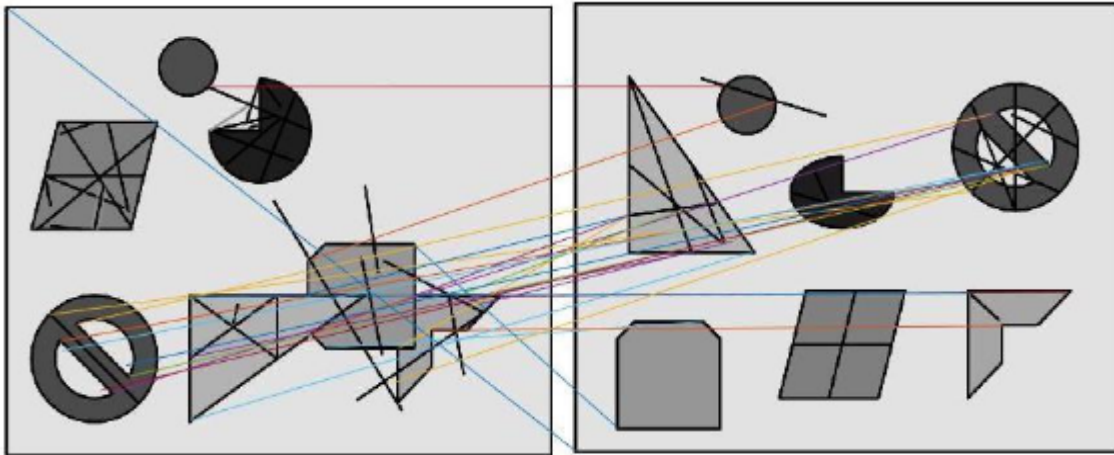
As can be seen from figures, there are many false matches even after multiple phases of outlier elimination. Infact most of the points after RANSAC phase are bad, hence we get a very bad match.



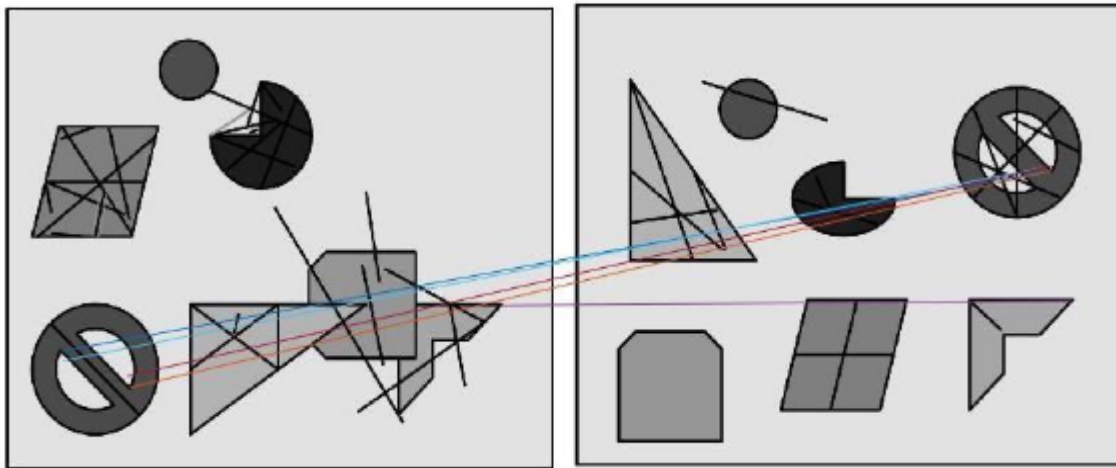
Initial Line Matches



Line Matches after Neighbor Thresholding



Line Matches Lowe Elimination



Line Matches After Ransac

In this eg we see that even after Lowe's elimination there are a lot of matches but after RANSAC there are only 5 matches. So if we choose a reasonable threshold of 6 then RANSAC doesn't detect the object template.