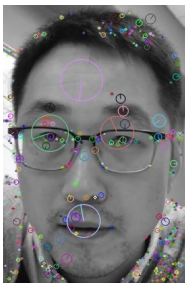
CSCI 5561 - Assignment 2 - Registration

SIFT Feature Extraction and Matching with Ratio filter

- Given an input image, openCV is used to extract SIFT keypoints and keypoint descriptors. Keypoint descriptors (SIFT features) are 128 dimension vectors in this case. SIFT keypoints are visualized in figure on left



  - For a given pair of images there exist two sets of SIFT features. Each feature in the first set can be matched with one in second set by finding the feature in the second set with minimum euclidean distance compared to all others
  - To filter outliers and noise we take the ratio of distance b/w nearest neighbour and second nearest neighbour and drop all correspondences with that ratio greater than a certain threshold (here = 0.7).
- This is because the two nearest neighbours are too close to confidently determine a correspondence
- The ratio filtered matches are visualized in the figure below

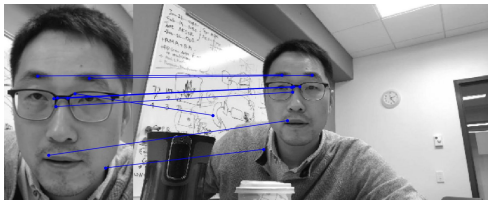
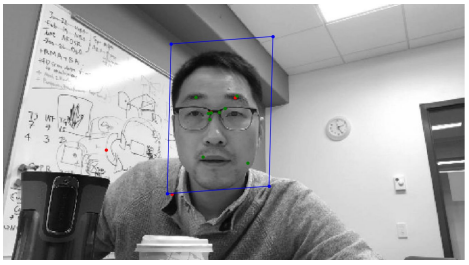


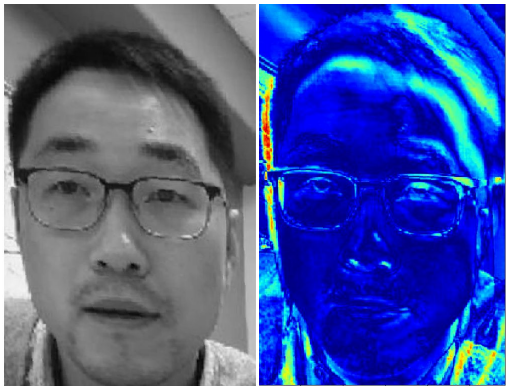
Image alignment using SIFT features and RANSAC

- Assuming an affine transformation b/w template and target image we need three correspondences to determine the warp function
- Using RANSAC we randomly sample 3 correspondances, determine affine transform, project all keypoints in template to target domain and find the outliers based on a given threshold



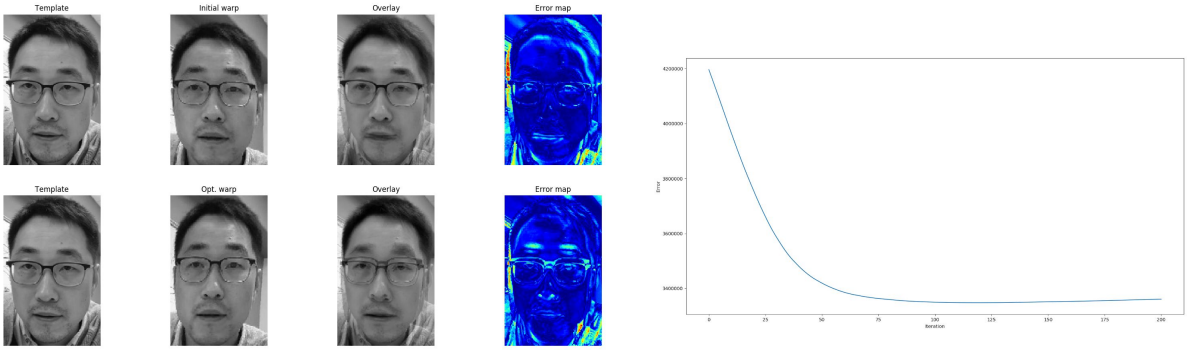
  - This is repeated for a given number of iterations while keeping track of the transformation that gives minimum number of outliers and finally that is chosen as the determining affine transform
  - The figure above shows the projection of four corners of template in the target domain and we can observe that this transform is pretty good

Inverse Image Warping

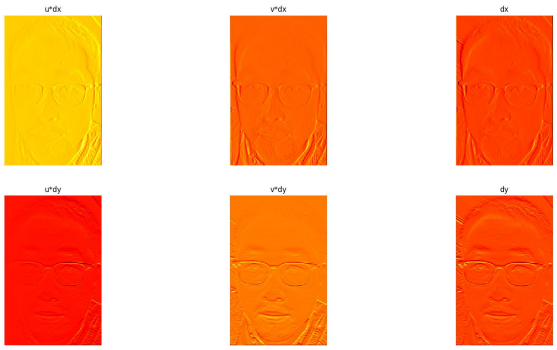


- Given a target image it is projected into template domain using inverse transform method coupled with bilinear interpolation
- The figures on the left shows the warped target image into template domain and the visualization of error i.e. difference b/w warped image and template

Refining image alignment using Inverse Compositional Alignment (IAC)



- The figures above show improved affine transform using IAC, decrease in norm of difference b/w warped target and template images in heatmap and graph
- In IAC algorithm Dell of template image and Jacobian of transformation are used to create steepest descent images (shown below), which is then used to calculate the Hessian matrix
- An initialization of transform, derived from SIFT keypoint matching is parametrized using a vector of numbers **p**
- Then using the norm of error **Δp** is generated and the transformation is updated
- This is repeated until norm of error is below a given threshold or for a fixed number of iterations and finally the improved transform can be collected



Alignment in multiple frames

- To track multiple frames a SIFT based affine transform initialization is made with a given template and first target image and refined using IAC
- Then template for second image is set to be the warped first target image and initial transform is taken as refined transformation of prev step and IAC is repeated
- This is repeated for all the frames
- The above figure visualizes the alignment (transform of template boundaries into target spaces) for four consecutive frames