Written Assignment 2

1. **Using "Rainier1.png" and "Rainier2.png" run RANSAC using a small number of iterations. How many iterations are necessary to reliably find the correct homography? What percentage of the matches are inliers? If only 5% of the matches were inliers, how many iterations of RANSAC would need to be run?**

   The number of samples required can be computed as follows:

   $$numSamples = (int)ceil\left(\frac{\log(1-p)}{\log(1-w^4)}\right)$$

   p = the probability that the RANSAC algorithm in some iteration selects only inliers from the input data set when it chooses four points from which the model parameters are estimated

   w = number of inliers in data / number of points in data

   So for 99% confidence we would have S= log(1 - 0.99)/log(1 - 0.05^4) = 736825 iterations.

   http://en.wikipedia.org/wiki/RANSAC

2. **Look at the function ComputeDescriptors. Is this descriptor invariant to intensity offset and intensity gain differences? Is it invariant to spatial translation, scale or rotation? If not, why?**

   a. The descriptor is invariant to offset. Intensity offset is eliminated by the subtraction step when calculating the descriptor.
   b. The descriptor is not invariant to gain. The effect of intensity gain will not be removed when calculating the descriptor and the larger the gain is the greater difference will be.
   c. The descriptor is invariant to spatial translation. The descriptor is calculated against pixels based on the relative distance to the central pixel which will be irrelevant to the location of the descriptor.
   d. The descriptor is not invariant to scale. The relative distance of surrounding pixels in scaled images will have different neighboring pixel , thus the descriptor will change.
   e. The descriptor is not invariant to rotation. The orientation calculated by the surrounding pixel is relevant to the descriptor.

3. **How would vignetting make image stitching more difficult? What artifacts might you see?**

   Vignetting is the effect whereby an image appears to be less saturated and less bright around the edges of an image when compared to the center. This means that there is a non-uniform brightness applying to the image and the same feature point may have different brightness gain applied in the two images. As the descriptor is not invariant to gain, vignetting wil make matching more difficult.

   If the images are successfully stitched together, the non-uniform brightness gain will also create obvious dark areas in the stitched image that makes it harder to create seamless panorama.

4. **If we wanted to stitch two images like "Hanging1.png" and "Hanging2.png" that are rotated relative to each other, how would the code need to be updated? What functions would you change?**

   In order to stitch two images that are rotated, it is necessary for the descriptors to be calculated in such a way that they are invariant to rotation. A simple way to change CalculateDescriptors to make it invariant to rotation is by shifting the descriptor based on biggest/smallest value of the descriptor. There are some techniques exist such as MOPS or SIFT are more resistant to rotation changes.The CalculateDescriptors would need to be updated.

5. **How would radial distortions (Szeliski, Section 2.1.6) of an image affect a panorama stitcher? What code would need to be changed?**

   Radial distortions lead to a visible curvature in the projection of straight lines, which will cause the descriptors unable to line up and match correctly. On the other hand, if the distortion is not corrected before stitching, the overlapped area also has ghosting artifacts.

   Radial distortion removal has to be done before calculating the descriptor, the way to correct radial distortion using the equation from the lecture given by Richard Szeliski

$$x'_n = \hat{x}/\hat{z} \qquad y'_n = \hat{y}/\hat{z}$$

$$r^2 = {x'_n}^2 + {y'_n}^2$$
$$x'_d = x'_n(1 + \kappa_1 r^2 + \kappa_2 r^4)$$
$$y'_d = y'_n(1 + \kappa_1 r^2 + \kappa_2 r^4)$$

$$x' = f x'_d + x_c \qquad y' = f y'_d + y_c$$

   http://en.wikipedia.org/wiki/Distortion_(optics)

6. **Look at the image "AllStitched.png". Why are the images on the end stretched and distorted?**

   Images on the edges are more stretched because they are being projected on the plane of the most central image. The images are more or less taken by rotating around a central location, each of those images has its own angle of incidence. The pictures stitched that are further from center-most picture will be projected onto a larger area, thus resulting in the warped and distorted images.