Robotics Algorithms

Assignment 3 - Report

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Part 1: Simple Color Images:

Here we are given 6 images containing 3 photo negatives that can be passed through RGB filters to produce a colored image. The method I have used is simple. I took 3 negatives of an image, by splitting the main image into 3 parts. The divider slices the image into 3 images by taking the row length from the matrix and assigning them to 3 different variables red, blue and green depending on the row splits. I pass these separate variables to a final image finall into their respective filters and produce the final colored image.

Part 2: Aligning Images:

In this part, we are required to align the images to gain more clarity and we use two methods to do this. One is Sum of Squared Differences method in im_align1.m file and the other is Normalized Cross Correlation method in im_align2.m file. Both perform an exhaustive search over a window of possible displacements, and take the displacement that gives the best matching score.

In the SSD method, we find the squared differences of alignment of two filter images, in this case, Green being the reference filter, we find the difference between Green and Red, and Green and Blue. We take the dimensions of both images to calculate offsets. Over a window of iterations, [-10,10] we make use of the circshift function to shift the array by (i,j) positions on red filter and check the difference between the two filters. If the minimum threshold exceeds the squared difference, this new difference becomes the threshold for the next iteration and we take the dimension and index of this position. After checking the differences between the three filters, we concatenate them to produce a clearly aligned image.

In the NCC method, we find the dot product of two normalized vectors to align the images. Same as above, we calculate the offsets to crop the images between two color filters, in the first case, again Green and Red. We take the mean of each color and subtract the original positions with it. We then take the dot product of the two values as the numerator and the dot product of squares as the denominator to find the normal vector. If the normal exceeds a threshold, this position is the new threshold and we take the index and dimension values for proper alignment over a series of iterations. We concatenate the new color matrices to produce a clearly aligned image.

$$NCC = \frac{\boldsymbol{A}}{|A|} \cdot \frac{\boldsymbol{B}}{|B|} = \sum_i \frac{A_i}{|A|} \cdot \frac{B_i}{|B|}$$

Part 3: Feature based Alignment:

In this part, we use the Harris corner detector to compute the cornerness of two images and extract features. We first compute the derivatives of x and y of the image. The applying the Gaussian filter to find the convolution of the derivatives and compute the moment matrix [h1,h2] to apply the Gaussian window around each pixel. We find the response of the detector by applying the formula to find determinant and trace of matrix [h1,h2] which is M.

Measure of corner response:

$$R = \det M - k\left(\operatorname{trace} M\right)^2$$

$$\det M = \lambda_1 \lambda_2$$
$$\operatorname{trace} M = \lambda_1 + \lambda_2$$

(k is an empirically determined constant; $k = 0.04 - 0.06$)

We apply a statistical order filter to find sharp variations by using the ordfilt2 function and compute the Harris points by setting a minimum threshold and produce a resultant image with edges marked on it in yellow.

In the second part, we apply the RANSAC Algorithm to align the 3 images to produce a clear image based on feature detection. We find two points at random and select the best out of remaining points that remain within a certain threshold. If they are within the threshold, we pool them as inliers and calculate the pixel shift among them. Using the information gained from the difference in positions of pixels, we align the images to produce a clear image.

Images:

Original Image:

Simple Color Alignment:

Sum of Squared Differences:

Normalized Cross Correlation:

Harris Cornerness Detector: