CS6790
Geometry and Photometry in Computer Vision
Assignment 1

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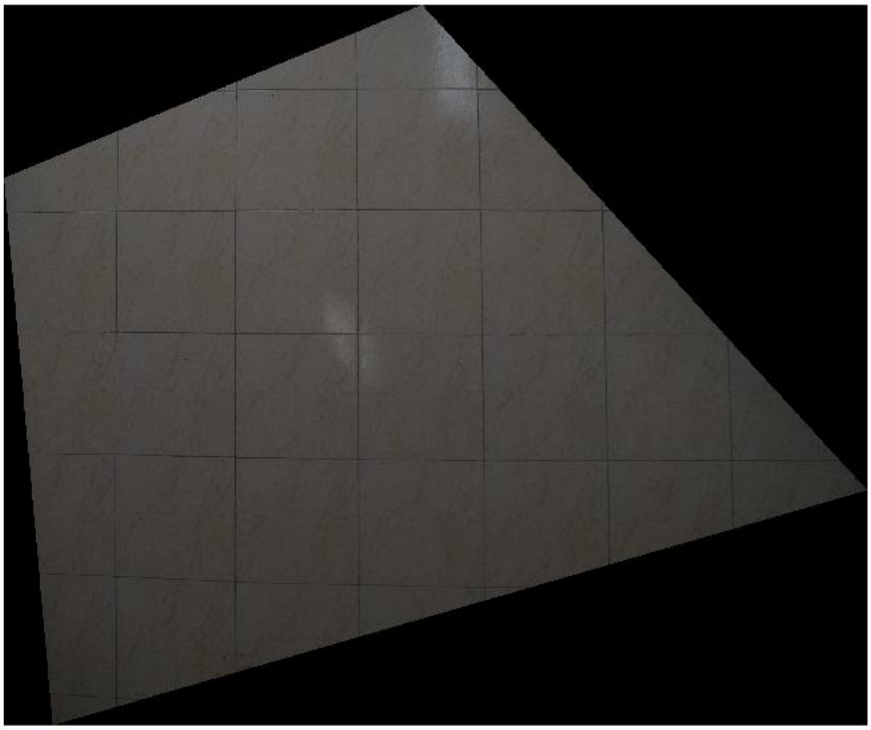
1 Introduction

The objective of this assignment is to rectify images(removing projective distortion from the perspective image of the 3D world) by various methods and evaluate the results. The first part of the assignment requires us to compute the transformation matrix directly using 4 points and their corrected positions. In the other 3 parts of the assignment, projective and affine distortions are removed from camera images by 3 different methods. The code has been written in matlab.

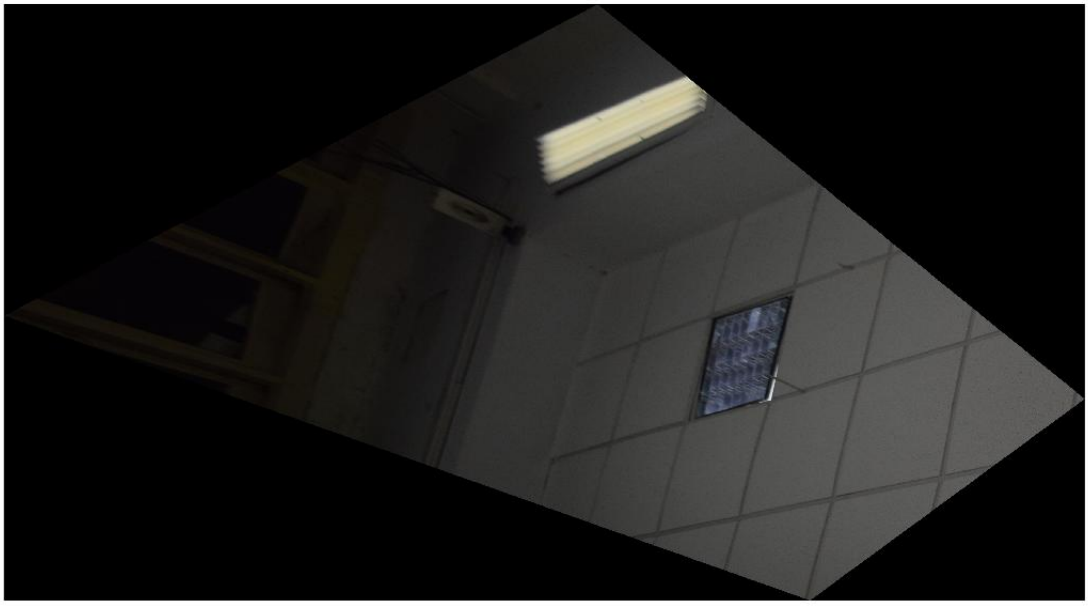
2 Question1

Compute the transformation matrix directly and rectify the given image using four points and some transformed corrected co-ordinates for these points.
In each image, we take 4 points(no 3 points on the same line), take their corrected positions into consideration and find the transformation.
We know that x' = Hx. H has 8 free parameters, each point correspondence gives us 2 equations to solve and hence H can be computed using 4 pairs of points. Let's call the corresponding points p1,p2,p3,p4,p1n,p2n,p3n,p4n. Then the 8*9 matrix whose null space gives us the solution is:
A is given as
[p1(1) p1(2) 1 0 0 0 -(p1n(1)*p1(1)) -(p1(2)*p1n(1)) -p1n(1);
0 0 0 -p1(1) -p1(2) -1 (p1n(2)*p1(1)) (p1(2)*p1n(2)) p1n(2);
p2(1) p2(2) 1 0 0 0 -(p2n(1)*p2(1)) -(p2(2)*p2n(1)) -p2n(1);
0 0 0 -p2(1) -p2(2) -1 (p2n(2)*p2(1)) (p2(2)*p2n(2)) p2n(2);
p3(1) p3(2) 1 0 0 0 -(p3n(1)*p3(1)) -(p3(2)*p3n(1)) -p3n(1);
0 0 0 -p3(1) -p3(2) -1 (p3n(2)*p3(1)) (p3(2)*p3n(2)) p3n(2);
p4(1) p4(2) 1 0 0 0 -(p4n(1)*p4(1)) -(p4(2)*p4n(1)) -p4n(1);
0 0 0 -p4(1) -p4(2) -1 (p4n(2)*p4(1)) (p4(2)*p4n(2)) p4n(2)];

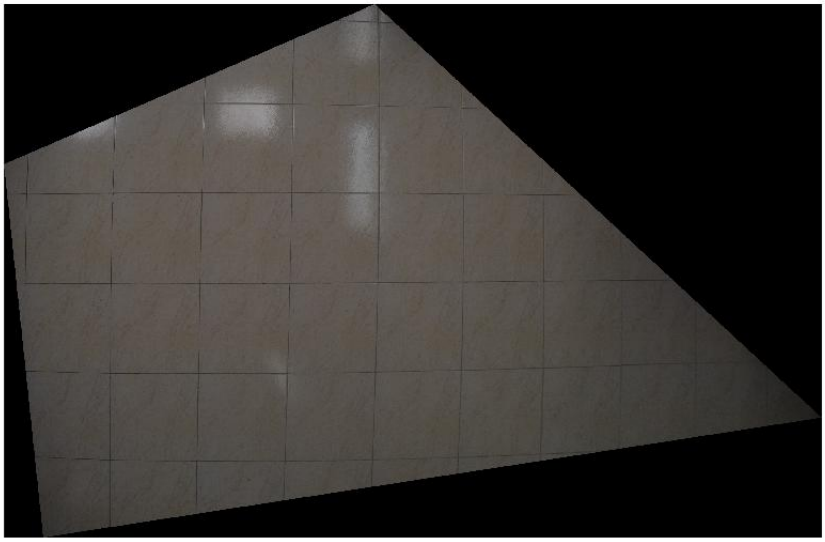
The solution is in the right null space of A. This is found by taking the svd of A, the solution is the last column of V matrix. This transformation is then applied on the original image to get the rectified image. The results on various images are as below:
Image1: Floor



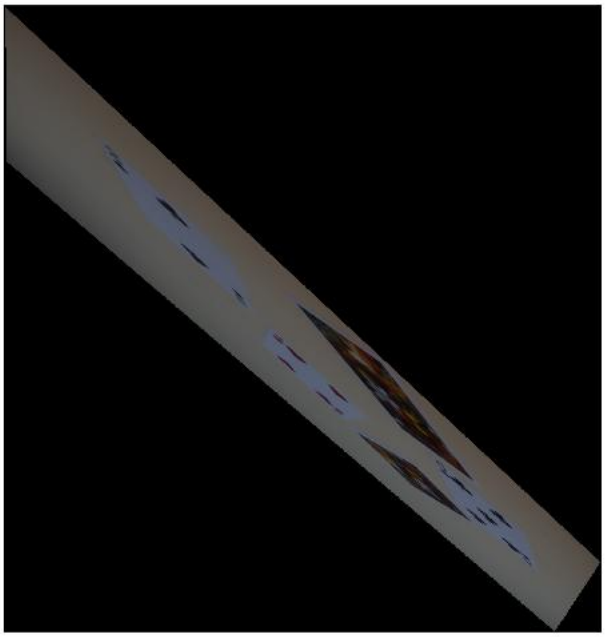
Here, the four points we have taken into consideration are the four sides of a square.
Image2: Ceiling



Here, the four points we have taken into consideration are the four sides of a square.
Image3: Floor

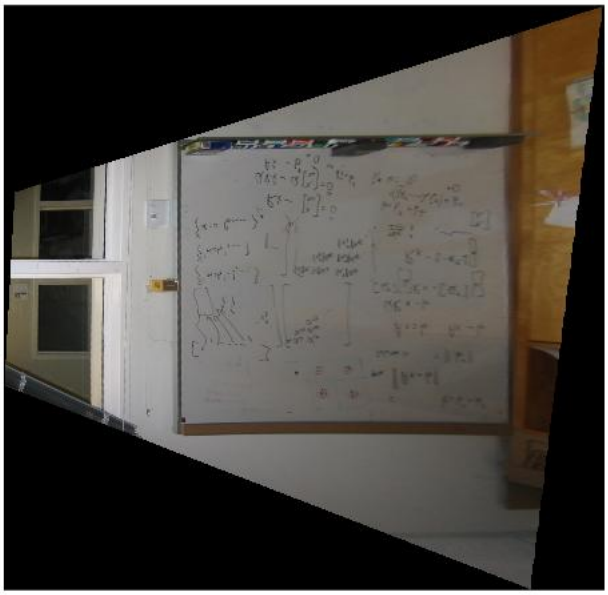


Here, the four points we have taken into consideration are the four sides of a square.
Image4: Cards:



Here, the four points we have taken into consideration are the four sides of a single card.
Image5: Computer

Here, the four points we have taken into consideration are the four sides of the computer.
Image6: Board



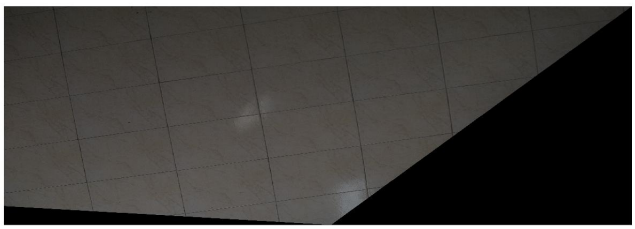
Here, the four points we have taken into consideration are the four sides of the board.

3 Question2

Rectify the image up to similarity in two stages by rst computing the line at innity by connecting two points at innity and then computing dual conic to the circular points using two perpendicular directions/lines.
Step 1: Find 2 pairs of parallel lines in the image. Find the point where each of the pairs intersect. The line through these 2 points is the line at infinity(linfi). Hp = [1 0 0;0 1 0;linfi] is the transformation matrix which when applied on the original image gives the correction up to affinity.
Step 2: On this affine corrected image, find two pairs of perpendicular lines. Now, given 2 perpendicular lines l and m,

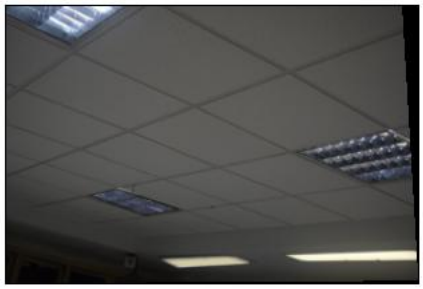
l(1)*m(1) (l(1)*m(2)+l(2)*m(1)) l(2)*m(2)

s gives one equation. s represents a symmetric matrix, as the scaling factor is not important, there are only 2 free parameters. Therefore, 2 equations will help us in finding the parameters of s. The dual conic is then [S 0;0 0 0]. SVD of this dual conic gives us a U matrix which is the transformation which corrects the image up to similarity.
Results on various images:
Image1: Floor
Step1



Step2

Image2: Ceiling
Step1:



Step2:

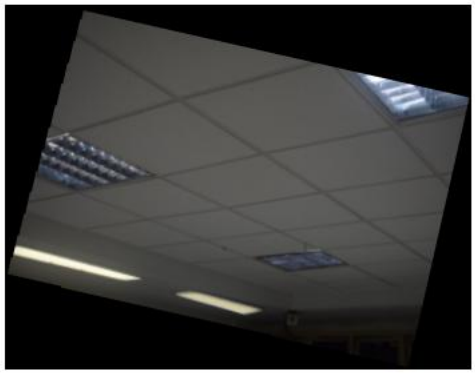


Image3: Floor
Step1:

Step2:

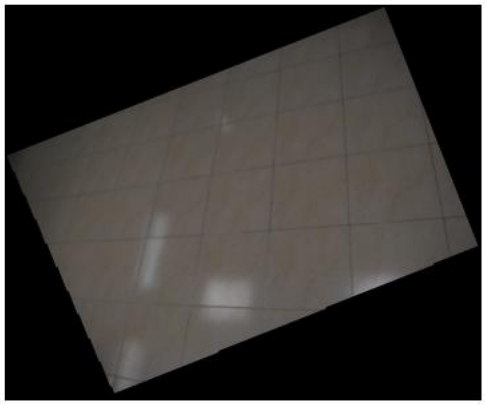


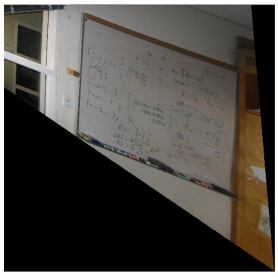
Image4: Cards
Step1:

Step2:

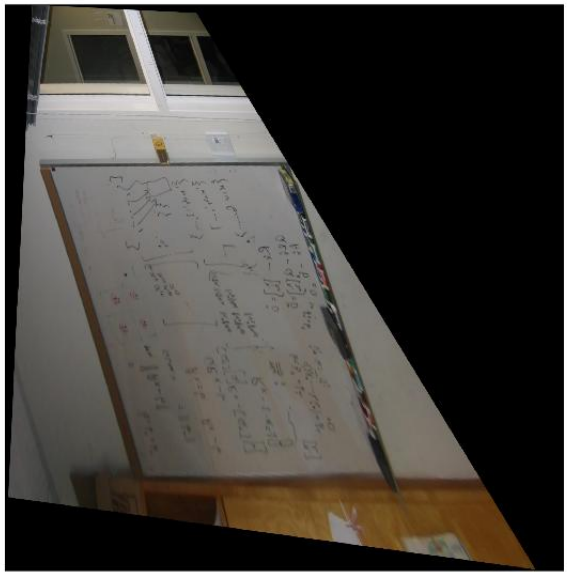
Image5: Computer
Step1:

Step2:

Image6: Board
Step1



Step2



4 Question3

Rectify the images up to similarity in a single step by using 4 or 5 perpendicular directions/lines.
Here, we take 5 pairs of perpendicular lines.Let's say l and m are perpendicular.
(l1m1,(l1m2 + l2m1)/2,l2m2,(l1m3 + l3m1)/2,(l2m3 + l3m2)/2,l3m3)c =0
gives one equation. c is a column vector which has all the 6 conic equation parameters as its elements. 5 pairs of perpendicular lines give us 5 equations. Using these, we determine the equation of the dual conic up to a scale factor. Then, the SVD of the dual conic is computed. The transformation which rectifies the image up to similarity is given by U.Results on various images is given below:
Image1: Floor

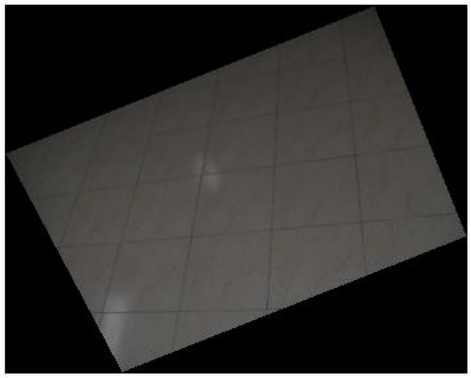


Image2: Ceiling

Image3: Floor

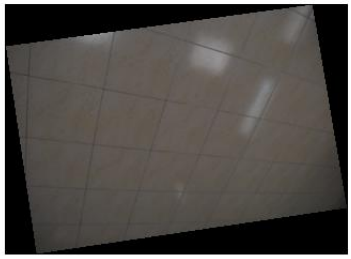


Image4: Cards

Image5: Computer

Image6: Board

5 Question 4

Rectify the images upto similarity by nding a transformed circle and directly nding the circular points by intersecting it with the line at innity.
Our first task here is to find a transformed circle on the image which represents a circle in the 3D world. For this, 4 corners of a square through which a circle can pass through, a circular arc formed by the LAN cable(as in Image 5), etc can be taken. 3 points uniquely determine a circle. Now, determine the line at infinity as in step 1 of question 2. Let the transformed circle in the image and line at infinity intersect at I and J.
Then, I*J'+J*I' gives us the 3*3 dual conic matrix using which the transformation which corrects the image up to similarity can be found. Results on a various images is as given below:
Image1: Floor

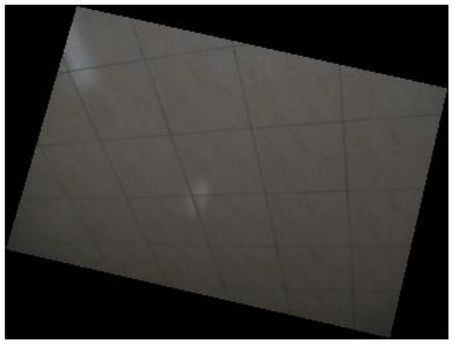


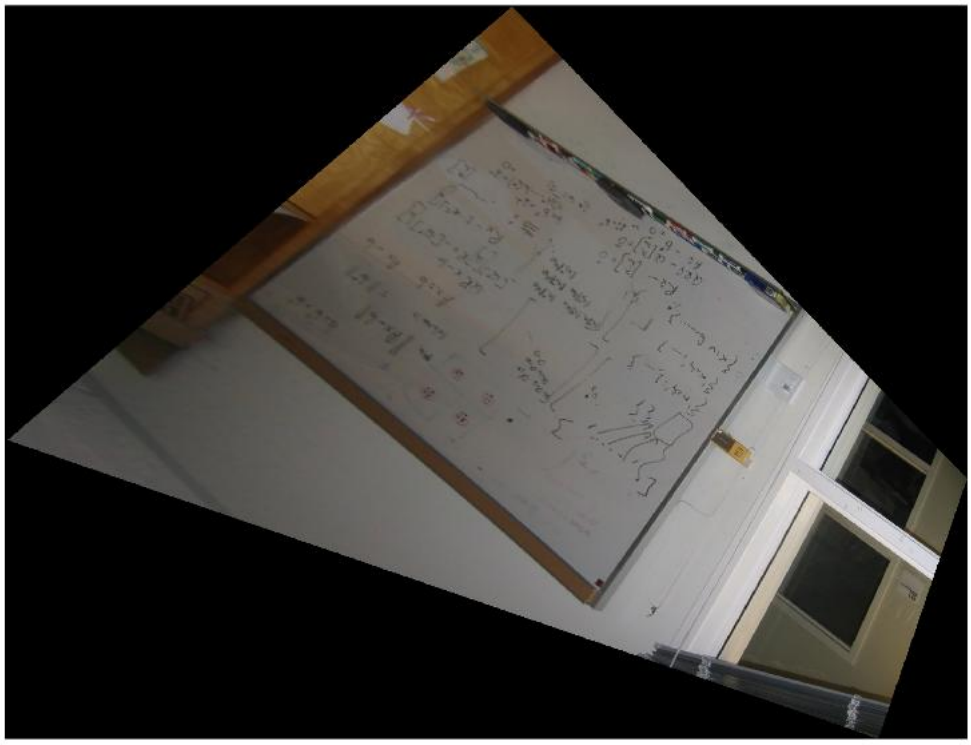
Image2: Ceiling

Image3: Floor

Image4: Cards

Image5: Computer

.jpg
Image6: White Board



One good sanity check to see our result is good: SVD of the dual conic gives us 3 matrices U,D,V.Ideally, the values of the D matrix should be 1,1,0. A good result would be that the first two diagonal values are comparable to each other while the third value is far far lesser than these.

Limitations:
In Q1, we are asked to assume the corrected coordinates. This is pretty hard in case of image 5 and 6 where the length and breadth of the computer and board are hard to determine. In Q4, a transformed circle needs to be found which is hard in image 5 and image 6. The perspective from which image 5 and image 6 have been shot made it difficult to rectify them. Better and correct parameters(length and breadth of the rectangle, circles,etc.) will give more accurate results.