Computer Vision
Assignment - 2

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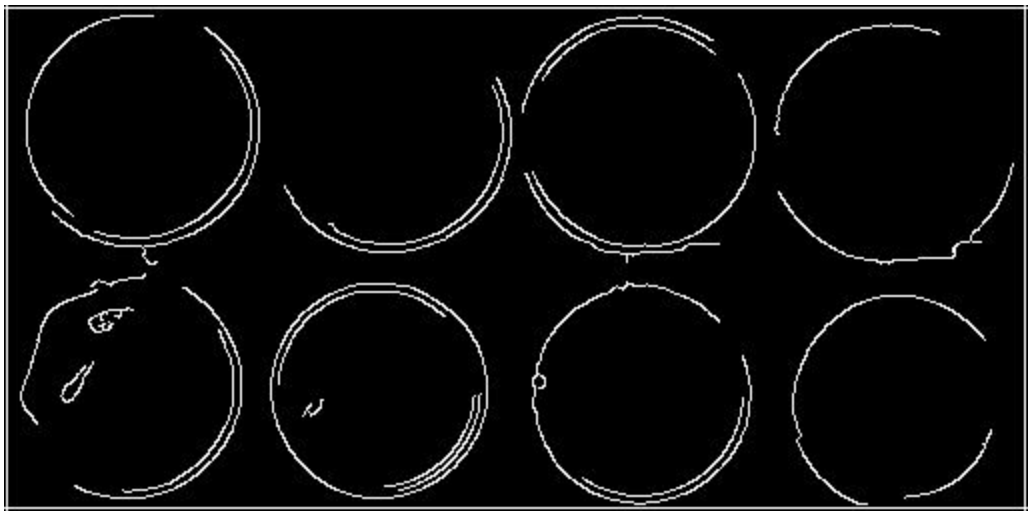
Question 1 - Hough Transform

I implemented hough transform for images containing circles. I downsampled my image by 2 then converted the image to grayscale then applied gaussian blur to smoothen the image and remove noise. Then i applied Canny Edge Detector on gaussian blurred image to find edges. After finding the edge image, i applied Hough Transform. Radius Range is [30, min(Image_heigth, Image_width)/2]. Circle can be as big as min of height/2 or width/2 of the input image. *Assumption- All radius in image will be greater than 30 pixels.*

For hough Transform, iterate over all pixel values. If a pixel value is 255 (white) then find circle point for all theta values in parametric form, keep vote for all Radius values in Accumulator matrix. Then set threshold depending on the image, such that all circle are detected. Assumption: Thresholds are image dependent, need to change for every image.

Gaussian Blur Image



Canny Edge Detector Image

Hough Transform Result

Question 2 - Camera Calibration

Generate 3D points for given images, based on these 3d and 2d points calibrate camera.

1) Intrinsic Parameters

Focal length, skew and principal points

Parameters	Value
Fx	538.1178573
Fy	493.9982605
Skew	0
Cx	328.25119145
Cy	249.91249584

2) Extrinsic Parameters

Image\Para	Rx	Ry	Rz	Tx	Ty	Tz
Left1.bmp	-0.03442755	0.09103046	-0.01577683	-4.51265377	-5.31373069	15.5220736
Left2.bmp	-0.03634608	0.10372135	-0.00518211	-4.88814011	-5.29552287	16.3835789
Left4.bmp	-0.16120593	0.42282827	0.9660066	2.49943705	-8.09106733	22.5509478
Left5.bmp	0.49218348	-0.20811504	1.34338358	7.32123079	-4.24610483	17.1554693
Left6.bmp	0.46710466	0.55725803	1.50980899	13.5694977	-3.42508932	26.3676188
Left7.bmp	0.39735132	0.80377954	1.5507719	8.7819834	-0.18729403	34.3803809

Left9.bmp	0.0407269	-0.81762122	-0.02364989	-1.62618969	-5.63373462	17.1988824
Left12.bmp	-0.01734266	0.31918912	-0.03856701	-3.12477751	-5.68479633	18.7054607
Left13.bmp	-0.08044694	0.28333866	-0.04793964	-1.23831445	0.24308383	42.0431010
Left14.bmp	-0.26769971	0.48976805	0.08026179	-1.07359635	-3.83975661	30.5331967
Left15.bmp	-0.36793972	-0.36600751	0.01767917	-10.2767478	3.8797991	55.0180398

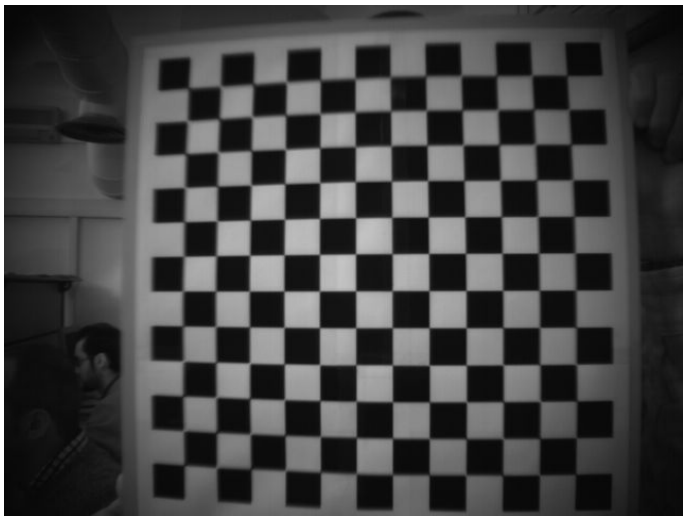
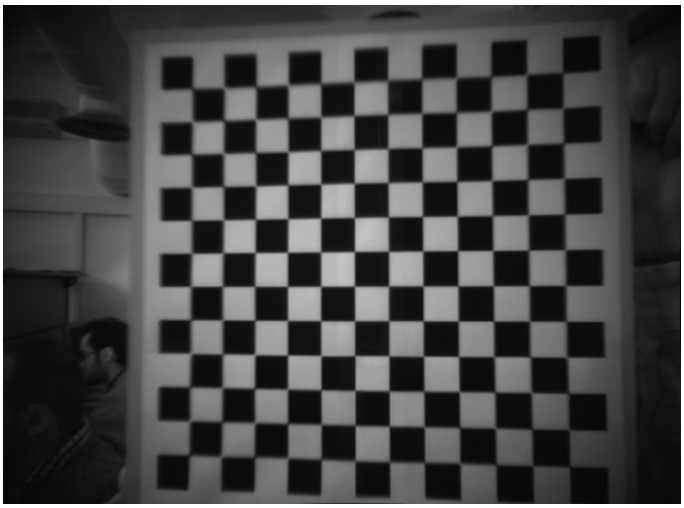
3) Distortion Coefficients

Parameters	Value
K1	-0.18805465
K2	0.00155603
P1	0.00735325
P2	0.00049309
K3	0.1400232

4) Reprojection Error and Mean Error

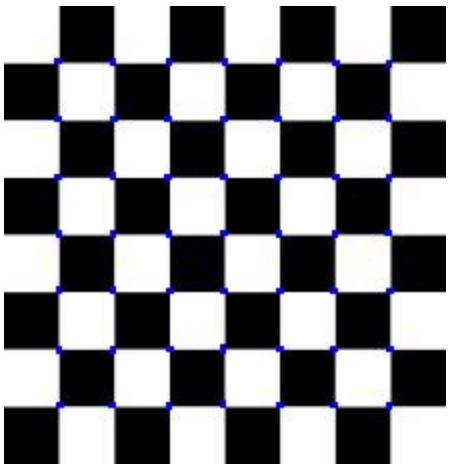
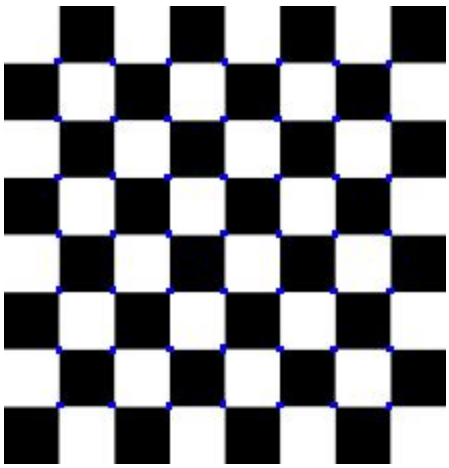
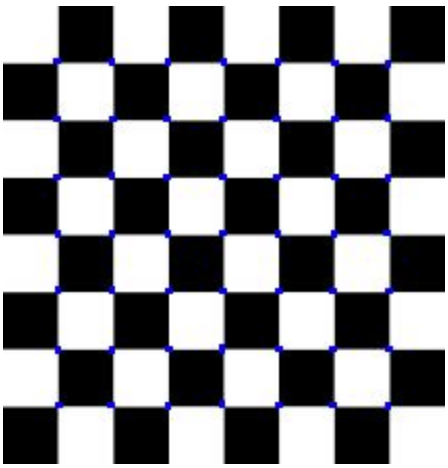
Image	Error
Left1.bmp	0.03846700862895267
Left2.bmp	0.027302261323137404
Left4.bmp	0.0630259471307111
Left5.bmp	0.030858197469598933
Left6.bmp	0.03226222469211951
Left7.bmp	0.33431141826365873
Left9.bmp	0.2912240883308437
Left12.bmp	0.10980370413299616
Left13.bmp	0.3036072968911244
Left14.bmp	0.05005313079392814
Left15.bmp	0.3712769368942513
Mean Error	0.15019929223193837

Camera Calibration result

Original	Camera Calibration Result
	

Question 3 - Corner Detection

Note: Thresholds for given question were not clear, so i have taken threshold as [100, 1000, 10000]
Chess Image, 3D image rotation won't be counted. As i'm able to rotate 2D image using numpy.

		
Threshold = 100	Threshold = 1000	Threshold = 10000

Change is not observable in chess board image

Flower Image

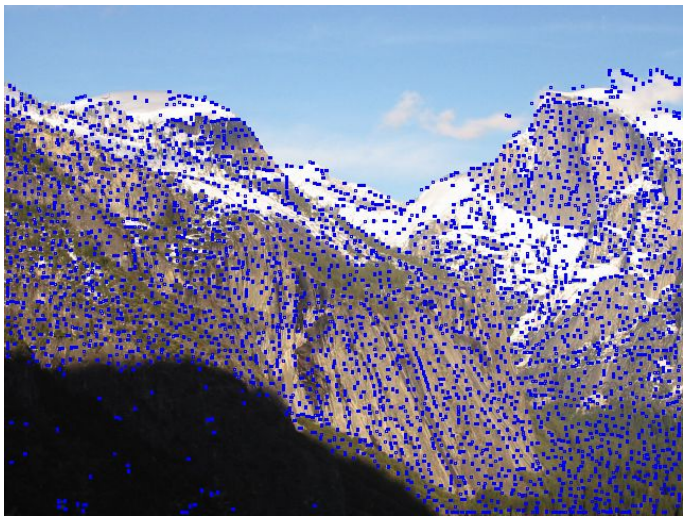
Threshold = 100

Threshold = 1000

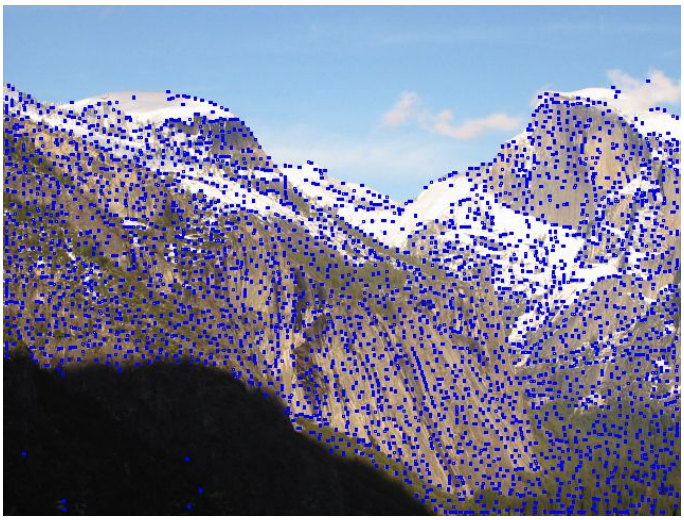
Threshold = 10000

We can clearly see the change for all threshold

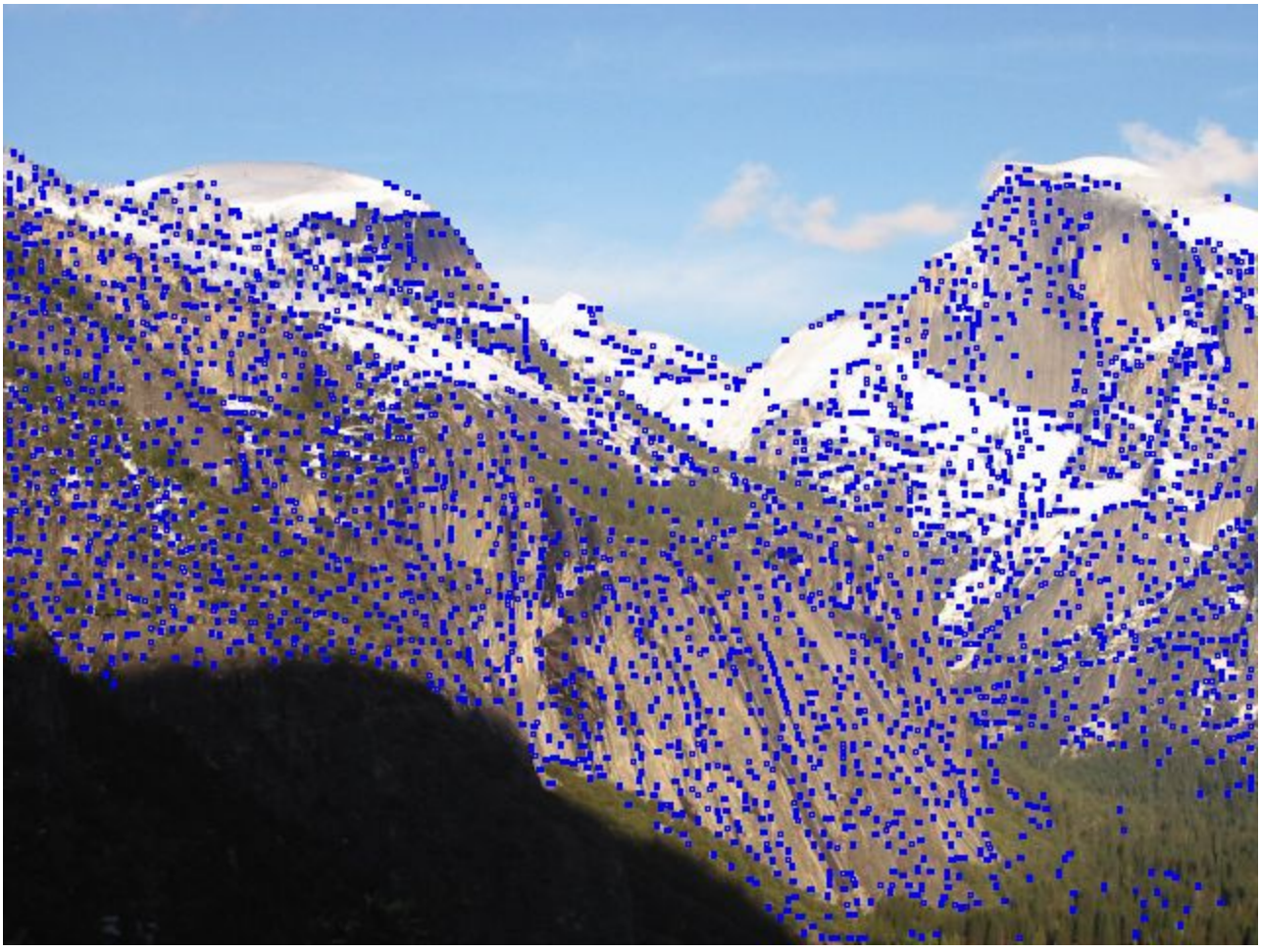
Yosemite



Threshold = 100



Threshold = 1000



Threshold = 10000

For first image, more number of points were detected as corner. It visible that corners are present there what that portion seems dark because of cloud shadow.
For second threshold less number of corner were detected, same with threshold 3.

Q3 Part 2

a) Rotated Image

Threshold = 100

Threshold = 1000

Threshold = 10000

Corner Detection Algorithm is not affected by the rotation of the image, thus it only affect the gradient in both direction but final result is same.

b) Compressed Image

Threshold = 100

Threshold = 1000

Threshold = 10000

For above compressed image, more number of corners are detected for each of the threshold. After downsampling the image, continuous pixel intensity difference must have increased for some number of pixels, this must have caused more gradient change and increased number of corners.