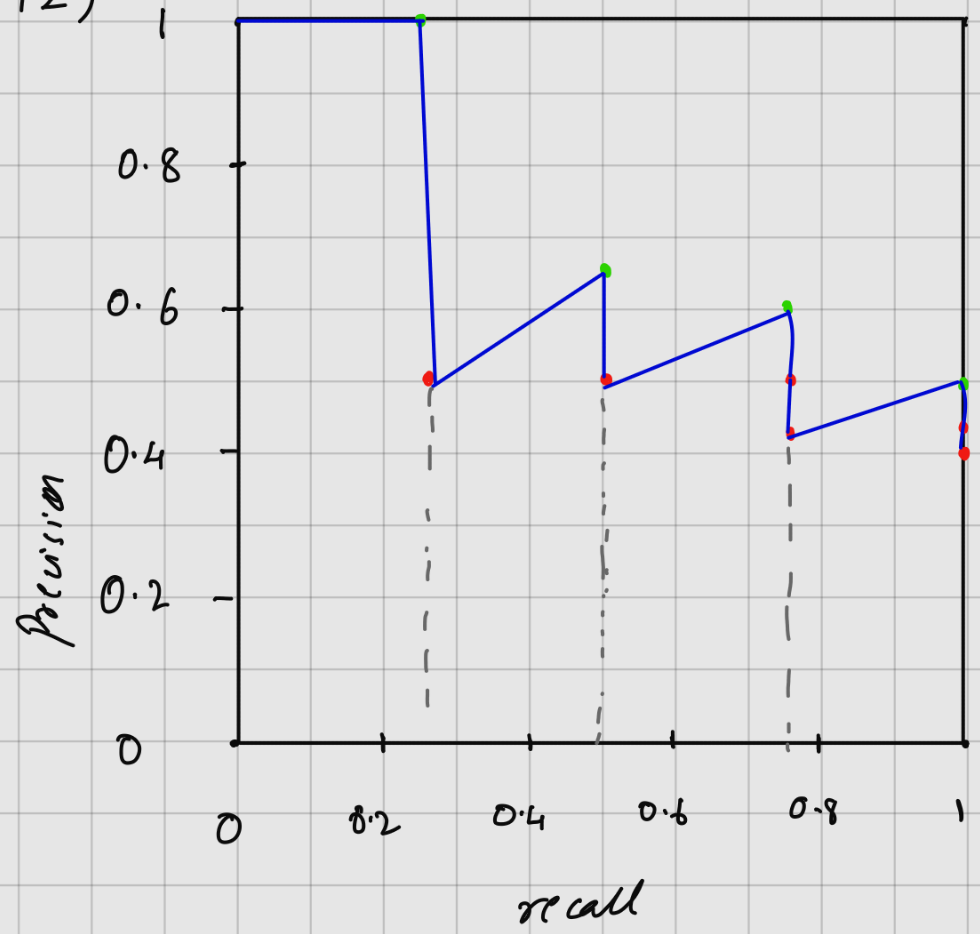
ECE 5554 : HW 4 — Hiten Kothari

P2)



Area under the curve =

$$(0.25 \times 1) + \left(0.25 \times 0.5 + \frac{1}{2} \times 0.25 \times 0.16\right) + \left(0.25 \times 0.5 + \frac{1}{2} \times 0.25 \times 0.1\right) + \left(0.25 \times 0.428 + \frac{1}{2} \times 0.25 \times 0.072\right)$$

$$\boxed{= 0.6485}$$

$$\text{precision} = \frac{\#\text{relevant}}{\#\text{returned}} \qquad \text{recall} = \frac{\#\text{relevant}}{\#\text{total relevant}}$$

Total relevant = 4

Response	Precision	Recall
TP	$1/1 = 1$	$1/4 = 0.25$
FP	$1/2 = 0.5$	$1/4 = 0.25$
TP	$2/3 = 0.66$	$2/4 = 0.5$
FP	$2/4 = 0.5$	$2/4 = 0.5$
TP	$3/5 = 0.6$	$3/4 = 0.75$
FP	$3/6 = 0.5$	$3/4 = 0.75$
FP	$3/7 = 0.428$	$3/4 = 0.75$
TP	$4/8 = 0.5$	$4/4 = 1$
FP	$4/9 = 0.44$	$4/4 = 1$
FP	$4/10 = 0.4$	$4/4 = 1$

(b) Average precision = area under the curve. = 0.6485

P3) (a) For stereo system

$$\begin{bmatrix} x \\ y \\ z \end{bmatrix} = \frac{B}{d} \begin{bmatrix} x_L' \\ y_L' \\ f \end{bmatrix}$$

$f = 0.025\,m$

$B = 0.05\,M$

$\&\ d = x_L' - x_r'$

$= 0.001\,M$

$$\therefore \begin{bmatrix} x \\ y \\ z \end{bmatrix} = 50 \begin{bmatrix} 0.006 \\ 0.002 \\ 0.025 \end{bmatrix}$$

$$\therefore \begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} 0.3 \\ 0.1 \\ 1.25 \end{bmatrix}$$ (in metres)

(b) Suppose there's an $\Delta x'$ error for x_r'

$\therefore$ Actual $x_r' = x_r'' = x_r' + \Delta x'$

$\therefore$ Horizontal disparity $= d' = x_L' - x_r'' = x_L' - x_r' - \Delta x'$

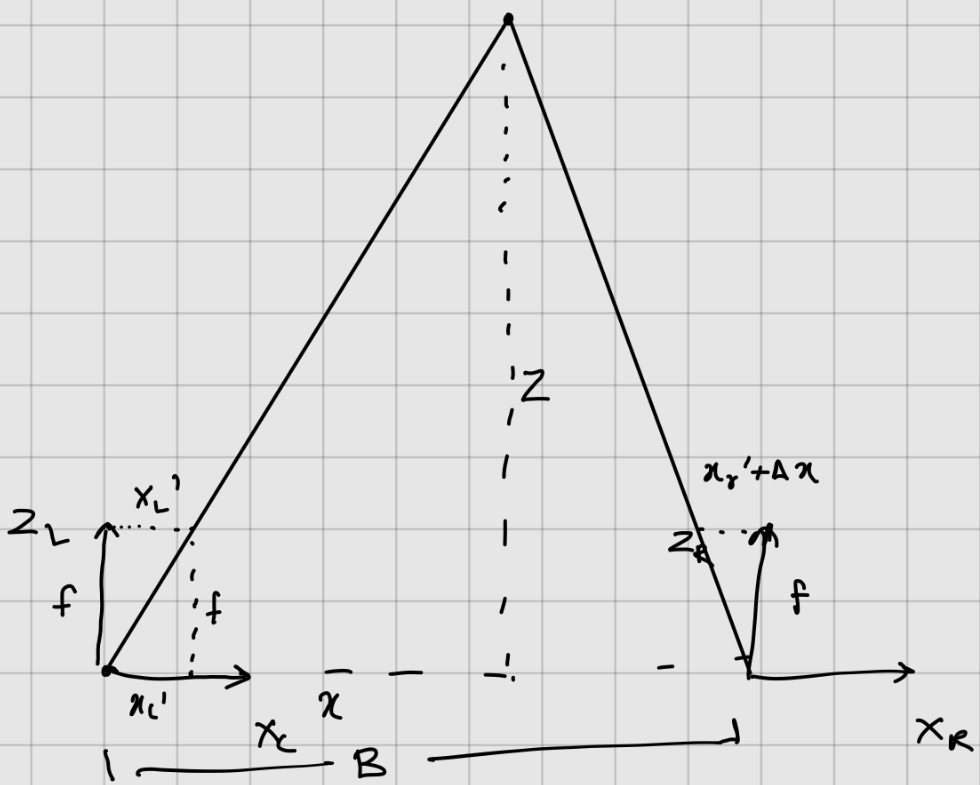
$$\begin{bmatrix} x \\ y \\ z \end{bmatrix} = \frac{B}{x_L' - x_r''} \begin{bmatrix} x_L' \\ y_L' \\ f \end{bmatrix}$$

$$= \left[\frac{B}{x_L' - x_r' - \Delta x'}\right] \begin{bmatrix} x_L' \\ y_L' \\ f \end{bmatrix} = \begin{bmatrix} \dfrac{B x_L'}{d - \Delta x'} \\ \dfrac{B y_L'}{d - \Delta x'} \\ \dfrac{B f}{d - \Delta x'} \end{bmatrix}$$

where $d = x_L' - x_r'$

(C) If there's an $\Delta y'$ error in y_r'
Then, horizontal disparity stays same $d = x_L' - x_r'$

$$\therefore \begin{bmatrix} x \\ y \\ z \end{bmatrix} = \frac{B}{d} \begin{bmatrix} x_L' \\ y_L' \\ f \end{bmatrix}$$



$$\frac{x_L'}{f} = \frac{x}{z} \qquad \frac{y_L'}{f} = \frac{y}{z} \qquad \frac{x_r' + \Delta x}{f} = \frac{B - x}{z}$$

$$-\frac{(x_r' + \Delta x)}{f} = \frac{B}{Z} - \frac{x_L'}{f}$$

$$\therefore Z = \frac{fB}{d - \Delta x'} \qquad \therefore \frac{B}{Z} = \frac{x_L' - x_r' - \Delta x}{f}$$

P1) (a) Prob of choosing one inlier = P

prob of choosing s inlier (only contains inlier) = p^s

$\therefore$ prob of one or more outlier = $1 - p^s$

$\therefore$ prob that N loop have one or more outlier = $(1-p^s)^N$

$\therefore$ prob that atleast one set of all inlier = $1 - ((1-p^s))^N$

(b) $p = 0.6$, $s = 4$, Prob of one set inlier = 95%

$\therefore \quad 0.95 \geq 1 - (1 - (0.6)^4)^N$

$\therefore \quad (0.8704)^N \geq 0.05$

$\therefore \quad N \geq \dfrac{\log(0.05)}{\log(0.8704)}$

$\therefore \quad N \geq 21.5627$

$\therefore \quad N \geq 22$ loops

$\therefore$ Minimum N is 22

ECE 5554 Computer Vision Homework 4

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Problem 6:
I used different feature detection and matching techniques other than the SIFT and Brute Force method which was used in Problem 5. Following are the descriptors I used.

1. Original SIFT with Brute Force Matcher: Reference
2. RootSIFT with Brute Force Matcher [1] : Based on SIFT but descriptors are L1 normalized and square-rooted.
3. ORB with Brute Force Matcher [2]
4. FAST with Brute Force Matcher
5. SIFT with FLANN based Matcher [2]
6. SIFT with knn based Brute Force Matcher
7. ORB BEBLID [3]

I tested these on single image “image01.jpg” with parameters as follows:
1. Number of Keypoints: 50
2. RANSAC Iteration Loop (N) = 1000
3. Number of corresponding pairs for RANSAC (s) = 4
4. Threshold distance (threshold) = 5.0
5. Minimum number of inliers (d) = 30% of keypoints = 15

Observations:

OGSIFT	ROOTSIFT	ORB	FAST	SIFTFLANN	SIFTKNN	ORBBEBLID
19	26	6	5	19	19	5
17	26	6	5	20	19	5
21	25	6	5	18	19	5
18	25	7	5	18	19	5
20	25	6	5	16	18	5
19	26	6	5	21	19	4
21	26	6	5	21	19	4
16	26	6	5	20	19	4
15	23	6	5	18	19	4
17	23	6	5	17	18	4

The table shows the maximum number of inliers detected using RANSAC algorithm for 10 runs. The average number of inliers for each method is:

METHOD	AVERAGE INLIERS
OGSIFT	18.3
ROOTSIFT	25.1
ORB	6.1
FAST	5
SIFTFLANN	18.8
SIFTKNN	18.8
ORBBEBLID	4.5

Conclusion:
ROOTSIFT method gives the most number of inliers about 35% more than the second best. There might be some error in the implementation of ORB and FAST descriptors as the number of key points detected using those methods are very low.

Reference:

1. R. Arandjelović and A. Zisserman, "Three things everyone should know to improve object retrieval," 2012 IEEE Conference on Computer Vision and Pattern Recognition, Providence, RI, USA, 2012, pp. 2911-2918, doi: 10.1109/CVPR.2012.6248018.
2. https://docs.opencv.org/4.x/dc/dc3/tutorial_py_matcher.html
3. https://github.com/iago-suarez/BEBLID