# HW 05 – REPORT


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학번: 202055501

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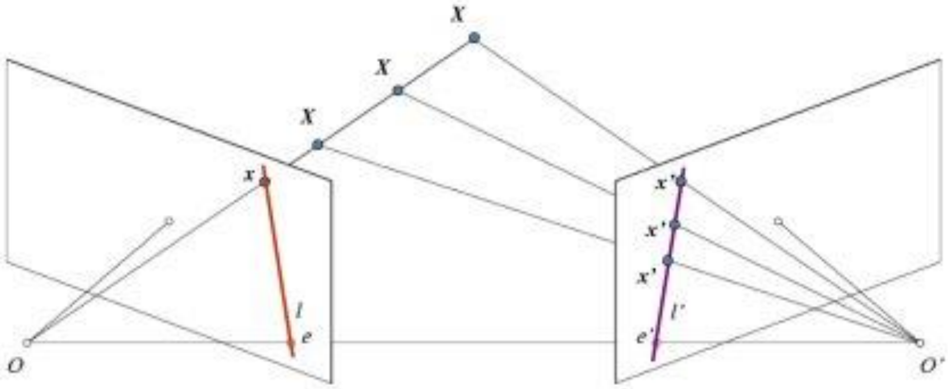
# 1. Introduction

## 1.1 Stereo

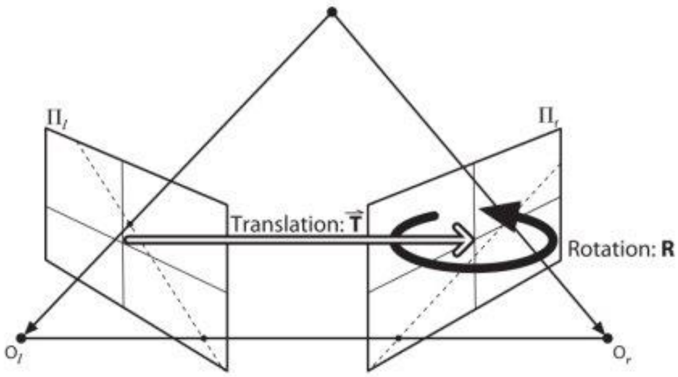



## 1.2 Epipolar geometry

- *every point on the line OX projects to the same x point on the image plane. If we consider the right image also, different x points on the line OX projects to different x' points in right plane*. Using these two images, we can triangulate the correct 3D point.
- *The projection of the different points on OX form a line on right plane: line l'- l it epiline corresponding to the point x; In order to find the 3D point x, we should along this epiline. This is called Epipolar Constraint. Similarly, all points will have its corresponding epilines in the other image. The plane XOO' is called Epipolar Plane.*
- O and O′ are the camera centers. The projection of O′ on the left image is at point, e - epipole. Epipole is the intersection point between the image plane and the line going through the camera center. (e′ is the epipole of the left camera.) (In case, you are not able to locate the epipole in the image, it is because it is outside the image (which means, one camera doesn't see the other)).
- All the epilines pass through its epipoles; to find the location of epipole, we find their intersection point of different epilines

### 1.2.3 Fundamental Matrix (F) and Essential Matrix (E).

Essential Matrix contains the information about translation and rotation, which describe the location of the second camera relative to the first in global coordinates. Fundamental Matrix F maps a point in one image to an epiline in the other image.




# 2. Body

## 2.1 Fundamental matrix estimation:

The fundamental matrix $F$ is defined by $x'TFx$ =0 for any pair of matches $x$ and $x'$ in two images. Let $x$ =($u$, $v$,1)$^T$ and $x'$=($u'$, $v'$,1)$^T$.

$F$ = [[$f$11 $f$12 $f$13][$f$21 $f$22 $f$23][$f$31 $f$32 $f$33]]$^T$ each match gives a linear equation:

$uu'f$11 +$vu'f$12 +$u'f$13 +$uv'f$21 +$vv'f$22 +$v'f$23 +$uf$31 +$vf$32 +$f$33 = 0

$$\begin{bmatrix} u_1u_1' & v_1u_1' & u_1' & u_1v_1' & v_1v_1' & v_1' & u_1 & v_1 & 1 \\ u_2u_2' & v_2u_2' & u_2' & u_2v_2' & v_2v_2' & v_2' & u_2 & v_2 & 1 \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ u_nu_n' & v_nu_n' & u_n' & u_nv_n' & v_nv_n' & v_n' & u_n & v_n & 1 \end{bmatrix} \begin{bmatrix} f_{11} \\ f_{12} \\ f_{13} \\ f_{21} \\ f_{22} \\ f_{23} \\ f_{31} \\ f_{32} \\ f_{33} \end{bmatrix} = 0$$

Therefore, for all corresponding points, it can be generalized as follows.

And you can find $F$ matrix instead of solving $Af$ = 0, we seek $f$ to minimize $|Af|$, least eigenvector for $ATA$.

- Construct the constrain matrix A
- Solve the homogeneous linear system using SVD: *np.linalg.svd(A) function that computes the Singular Value Decomposition of 2D array in the form: F = UΣV$^T$.*
- enforce the rank 2 constrain on F:

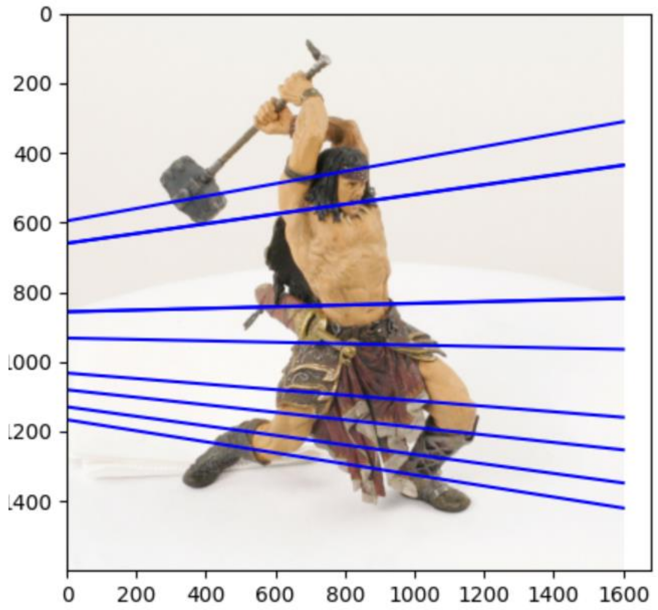
## 2.2 compute epipoles

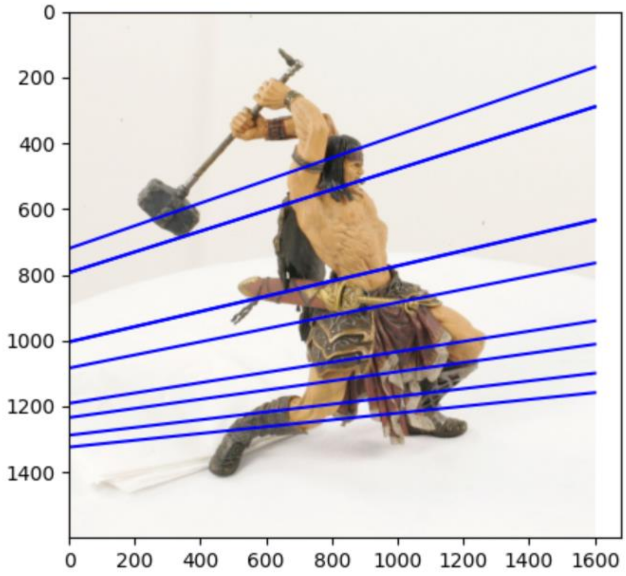
- Computes the epipoles of the two images, using the fundamental matrix and normalizes the coordinates.

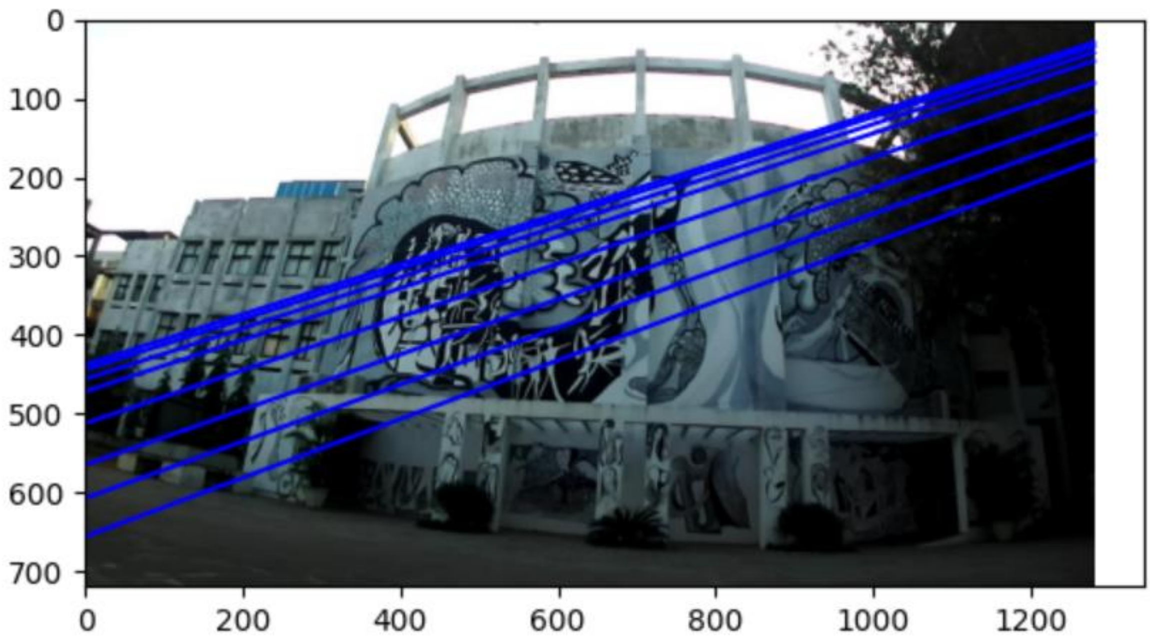
## 2.3 Epipolar lines

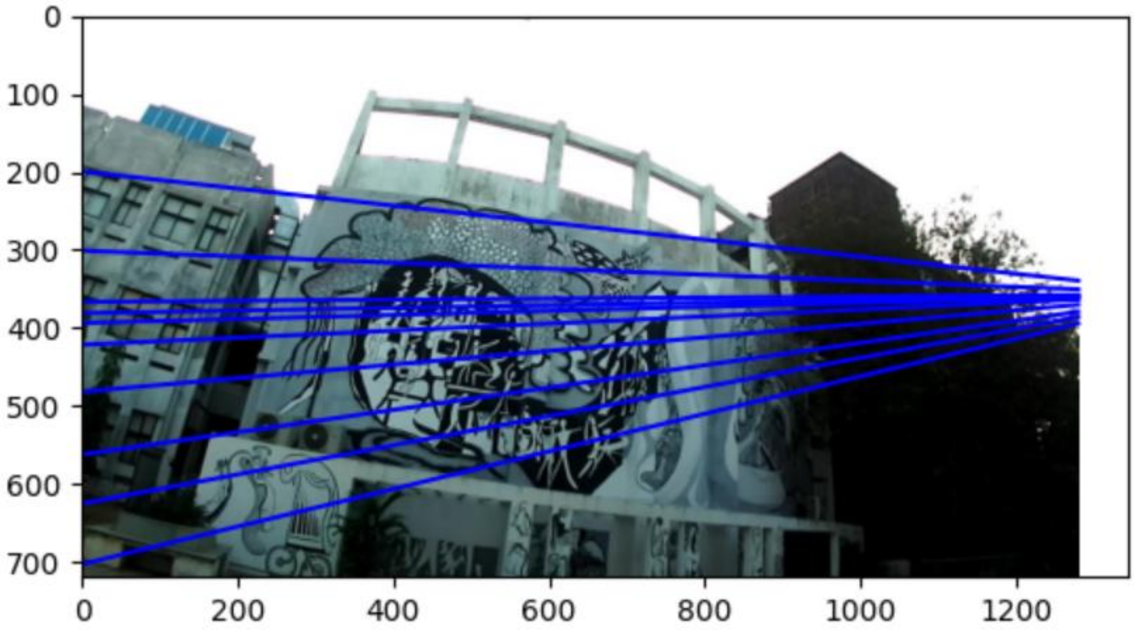
- Draws the Epipolar lines on the images

Output:










## 3. Conclusion

In conclusion, this homework required implementing functions that compute fundamental matrices, epipoles, and drawing epipolar lines for two images. Through this exercise, we gained a deeper understanding of the epipolar geometry and how it relates to stereo vision, as well as the practical skills necessary to implement these concepts in code. Overall, this homework served as an excellent opportunity to apply our knowledge of computer vision and image processing to a real-world problem, and it has helped to improve our skills in this area.