

1. `compute_fundamental()`
  - a. Given data1 and data2, we find the normalizing matrices for each set of data.
  - b. Using the normalizing matrices, normalize the points in data1 and data2.
  - c. Using corresponding pairs in normalized data1 and data2, we construct the constraint matrix A and perform SVD on A, getting the solution of F as the last row of Vh.
  - d. Construct the initial F matrix from the solution.
  - e. Enforce the singularity constraint on the initial F, to get the final estimate F matrix.
  - f. Normalized the F matrix by making  $f_{33} = 1$ .
2. `compute_essential()`
  - a. Given data1, data2 and K matrix, normalize data1 and data2 using  $K^{-1}$ .
  - b. Using corresponding pairs in normalized data1 and data2, we construct the constraint matrix A and perform SVD on A, getting the solution of E as the last row of Vh.
  - c. Construct the initial E matrix from the solution.
  - d. Enforce the singularity constraint on E, to get the final estimated E matrix.
3. `decompose_e()`
  - a. Given E, perform SVD on E.
  - b. Construct matrix t from the 3<sup>rd</sup> column of U from SVD(E) by
    - i. `t = e_u[:, 2].reshape((3, 1))`
  - c. Construct matrices r1 and r2 from SVD(E) and matrix W by
    - i. `r1 = np.matmul(np.matmul(e_u, W), e_vh)`  
`r2 = np.matmul(np.matmul(e_u, np.transpose(W)), e_vh)`
  - d. Check for determinant of r1 and r2
    - i. If determinant is  $< 0$ , invert the sign of each r1 and r2.
  - e. Construct the 4 possible P primes.
  - f. For each possible P primes
    - i. Find the 3D intersection point between corresponding points.
    - ii. Check the depth of the intersection point from both pose P and P prime
    - iii. If both depths are positive, means intersection point is in front of both poses
    - iv. Repeat above till all corresponding points are checked and return the P primes with the most intersection points that are in front of both.
4. `pnp_algo()`
  - a. Given points2d, homogenize the points.
  - b. For each point given, get the depths by
    - i. Picking 2 more points from the remaining 9 points to form a set of 3 points.
    - ii. Calculate the distance-squared between each 3d point in the set.
    - iii. Calculate the cos-theta angle between each 2d point in the set.
    - iv. Add the extracted coefficients from equation to constraints.
    - v. Repeat above till all other points combination are used, forming a  $36 \times 5$  matrix A
    - vi. Perform SVD(A) and the solution is the last column of Vh ( $t_0, t_1, t_2, t_3, t_4$ ).
    - vii. Calculate  $x = \text{average}(t_1/t_0, t_2/t_1, t_3/t_2, t_4/t_3)$
    - viii. Final depth of the chosen point is  $\sqrt{x}$
    - ix. Repeat b for every point given, getting a list of depth for each point (X).
  - c. Reconstruct the 3D points using `reconstruct_3d()`
  - d. Calculate r and t using `icp()`