

BM40A0902 3D Computer Vision
Exercise 2
Images and imaging.

1. Intrinsic calibration (1 point).

Consider a camera with the optical center (the principal point) $(o_x, o_y) = (320, 240)$, the effective size of the pixel $(s_x, s_y) = (10\mu m, 10\mu m)$, $\mu m = 10^{-6}m$, and the focal length $f = 16mm$.

Find the pixel coordinates p of the projection of point ${}^C P = (1, 0, 8)$ (the camera coordinates given in meters).

You can neglect the effect of optical distortions.

2. Calibrated projection and weak perspective camera (2 points).

Download `task2.mat` file and load it. The python template contains the code for loading `.mat` file. The file contains 3 variables:

- `points` - 3×19600 matrix containing 19600 3D points ${}^W P_i$ in the world frame coordinates.
- `colors` - 3×19600 matrix containing RGB colors for each point.
- `wTc` - 4×4 matrix defining frame ${}^W T_C$, where W is the world frame and C is the camera frame.

It is also known that the optical center (the principal point) is $(o_x, o_y) = (70, 70)$, the effective size of the pixel $(s_x, s_y) = (10\mu m, 10\mu m)$, $\mu m = 10^{-6}m$, and the focal length $f = 16mm$. Assume that there are no optical distortions.

You can also find functions `plot_color` and `plot_color_projection` for plotting of colored points in 3D space and the projection plane respectively in the given materials. In Python, those functions use PyVista library for its ability to efficiently plot large numbers of 3D points. The `plot_frame` function is provided for PyVista as well.

Complete the following subtasks:

- (a) Use `plot_color` to plot given colored points in the world frame. Plot camera frame using `plot_frame` in world coordinates on the same figure.
- (b) Construct 3×4 projection matrix M taking into account both the intrinsic and the extrinsic camera parameters. Use matrix M to find image plane projections of the points given in `task2.mat` file.
- (c) On a separate figure, plot projected points using function `plot_color_projection`. What do you see on the plot?
- (d) Calculate point projection using weak-perspective camera (using the same camera parameters as before). Remember that the mean of Z coordinate should be taken in camera frame coordinates!

- (e) On a separate figure, plot newly projected points using function `plot_color_projection`. What do you see on the plot now? When can you use weak-perspective camera? Is it suitable for this particular case?

3. Projective points (1 point).

Consider a simple camera frame projection matrix (the intrinsic parameters)

$$M = \begin{pmatrix} -f & 0 & 0 & 0 \\ 0 & -f & 0 & 0 \\ 0 & 0 & 1 & 0 \end{pmatrix}.$$

Compute the projection of the (homogeneous) point $(X, Y, Z, W) = (1, 0, 1, 0)$ in terms of f .

Note that this point has no single corresponding point in the Euclidean space. Is its projection still somehow meaningful? Which Euclidean points project to the same location?