Assignment 2 (Due: Dec. 20, 2025)
(Send your solutions to TA: 13893138834@163.com)

1. (**Math**) In the augmented Euclidean plane, there is a line $x-3y+4=0$, what is the homogeneous coordinate of the infinity point of this line?

2. (**Math**) On the normalized retinal plane, suppose that $\mathbf{p}_n$ is an ideal point of projection without considering distortion. If distortion is considered, $\mathbf{p}_n=(x, y)^T$ is mapped to $\mathbf{p}_d=(x_d, y_d)^T$ which is also on the normalized retinal plane. Their relationship is,

$$\begin{cases} x_d = x\left(1+k_1r^2+k_2r^4\right)+2\rho_1xy+\rho_2\left(r^2+2x^2\right)+xk_3r^6 \\ y_d = y\left(1+k_1r^2+k_2r^4\right)+2\rho_2xy+\rho_1\left(r^2+2y^2\right)+yk_3r^6 \end{cases}$$

   where $r^2 = x^2 + y^2$

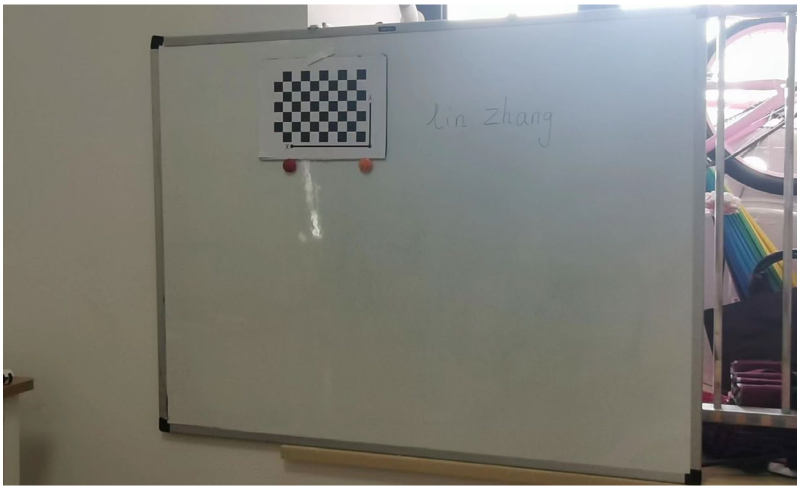
   For performing nonlinear optimization in the pipeline of camera calibration, we need to compute the Jacobian matrix of $\mathbf{p}_d$ w.r.t $\mathbf{p}_n$, i.e.,

$$\frac{d\mathbf{p}_d}{d\mathbf{p}_n^T}$$

   It should be noted that in this question $\mathbf{p}_d$ is the function of $\mathbf{p}_n$ and all the other parameters can be regarded as constants.

3. (**Programming**) Bird's-eye-view generation. The geometric transform between the physical plane and its bird's-eye-view image can be simply described by a **similarity transformation** matrix. Bird's-eye-view is very useful in autonomous industrial inspection, ADAS, etc. In this question, your task is to create the bird's-eye-view image of a physical plane, e.g., the wall of your room. For this purpose, you may need to,
   1) make a calibration board with chessboard patterns;
   2) calibrate your camera (the camera mounted on your laptop or the camera of your mobile phone with fixed focal length) to get its intrinsics;
   3) attach regular patterns (e.g., chessboard patterns) to the wall, determine the 2D coordinate system C_W of the wall, and determine the coordinates $\left\{\mathbf{x}_{Wi}\right\}_{i=1}^{N}$ of the feature points of the regular patterns with respect to C_W;
   4) take the image I_d of the wall with regular patterns;
   5) undistort image I_d with the camera's intrinsics to get the undistorted image I;
   6) For each $\mathbf{x}_{Wi}$, determine its image $\mathbf{x}_{Ii}$ on I;
   7) solve the homography matrix $P_{W\to I}$ between the wall and the image I wall using $\left\{\mathbf{x}_{Wi} \leftrightarrow \mathbf{x}_{Ii}\right\}_{i=1}^{N}$;
   8) generate the final bird's-eye-view image of the wall using the technique introduced in our lecture.

   For submission, you **only** need to submit the following items to TA:
   1) the intrinsic parameters of your camera;
   2) the original image of the wall (or other physical planes) taken by your camera; make sure that your name is painted or attached on the wall (or the plane); (maybe similar to following image I provide to you)
   3) the generated bird's-eye-view image of the wall (or other physical planes).



4. (Programming) I have established a dataset for training models for detecting speed-bumps and persons. This dataset can be downloaded from
https://github.com/csLinZhang/CVBook/tree/main/chapter-15-YOLO/For-yolov4
Using this dataset, please train a speed-bump detection model and test your model on the provided test video (on the course website). For this question, you only need to hand in your video with detected bounding-boxes to the TA. A sample frame of our result video may like the following image.