Week 3 Summary

Does a **Homography** Have an Inverse?

- According to Wikipedia: Every Homography has an inverse mapping, although this is the more general mathematical definition rather than specifically in the field of computer vision.
- The paper that OpenCV bases its algorithm on (Zhang, 2000 [1]) actually never uses the Homography inverse in its determination of camera parameters.
- Instead, Zhang forms a set of linear constraints on the nine entries (3x3) in the $\boldsymbol{B} = \boldsymbol{A}^{-\boldsymbol{T}}\boldsymbol{A}^{-\boldsymbol{1}}$ matrix. Matrix $\boldsymbol{B}$ is also known as the *image of the absolute conic* (IAC) in projective geometry, an object commonly used in camera calibration, e.g. Hartley & Zisserman, 2004, Section 7.5. By finding this IAC you can determine camera calibration matrix **A** by decomposition.

Statistical **Uncertainty** of Camera Parameters

- A large number of images of calibration patterns is analysed and their 2D image points recorded along with the estimated 3D positions.
- 627 images taken with my phone camera were used for one analysis, and 178 images taken with my camera in another.
- A code was written to randomly select 20 images from the analysed sample images and then OpenCV computed the camera calibration matrix. The individual parameters are then extracted from the matrix. The distortion parameters for the lens were also recorded.
- This is then repeated very many times (up to 30,000 times) so that the uncertainties in each camera parameter (and distortion coefficient) can be estimated.
- A histogram of data can be produced, along with the standard error.

- Things of note:
    - Histograms appear initially to be normally distributed, but superimposing a gaussian curve on top of the data suggests that it may not be?
    - The maximum uncertainty quoted in any parameter (focal length in y) corresponds to a real-world uncertainty of ± 0.7 mm.
    - The optical centres (C_x, C_y) have uncertainties as low as 0.13 pixels, determined from 10,000 combinations of 20 images out of a bank of 627.
    - Of the images taken from the phone camera, the distribution in the optimised focal lengths parameters (OpenCV will find a new camera matrix based upon a free scaling parameter) are very non-uniformly distributed. This is not the same for the other bank of 178 images.

- Now need to determine:
  a) Can I use these for uncertainties in parameters?
  b) Are these acceptable uncertainties for the 3D reconstruction?

[1] **Z. Zhang, "A Flexible New Technique for Camera Calibration", IEEE Transactions on Pattern Analysis and Machine Intelligence, December 2000, Vol 22: pp. 1330-1334**