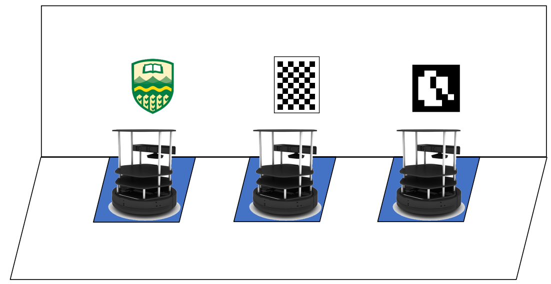
House Keeping Matters

- Homework assignment #3 to be posted later today, and on October 28 due time, I'll post (partial) solution.
- Proposal of the course project due Wednesday October 23 (was Monday October 21)
- Midterm will be on Wednesday October 30 (was October 28)
- Proposal presentation October 28 (was October 30), 10-15 minutes per group
- Doodle sign up for consultation slots on the course project (by group) this Friday PM

Pose with Perspective-n-Point (PnP)



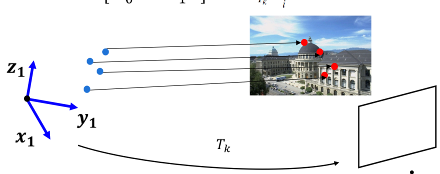
Definition: Given the (1)model of an object (geometry), (2) its projection on the image and (3) camera intrinsics, determine the object pose with respect to camera.

3D-to-2D
Motion from 3D Structure and Image Correspondences

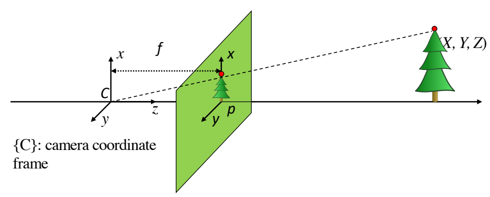
Motion estimation		
2D-2D	3D-3D	3D-2D

- f_{k-1} is specified in 3D and f_k in 2D
- This problem is known as *camera resection* or PnP (perspective from *n* points)
- The minimal-case solution involves 3 correspondences (PnP).
- The solution is found by determining the transformation that minimizes the reprojection error

$$T_k = \begin{bmatrix} R_{k,k-1} & t_{k,k-1} \\ 0 & 1 \end{bmatrix} = \arg\min_{T_k} \sum_i \|p_k^i - \hat{p}_{k-1}^i\|^2$$



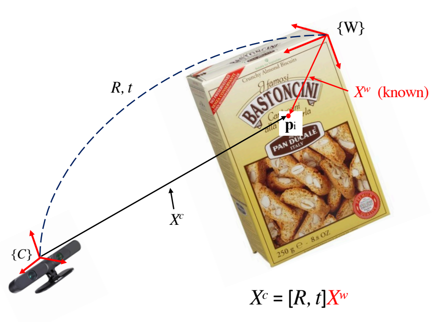
Camera model: frontal model



$$(x, y) = \left(f\frac{X}{Z}, f\frac{Y}{Z}\right)$$

1. For a calibrated camera, f is known.
2. Given an image point u = (x, y), the length (cu) = $\sqrt{x^2 + y^2 + f^2}$ can be calculated.

Perspective-n-Point (PnP)



$X^c = [R, t]X^w$

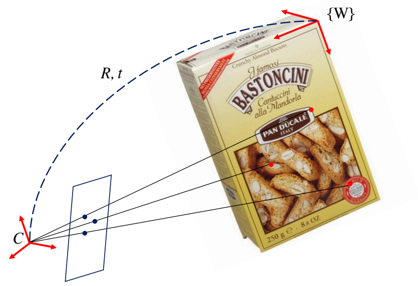
Perspective-3-Point (P3P)

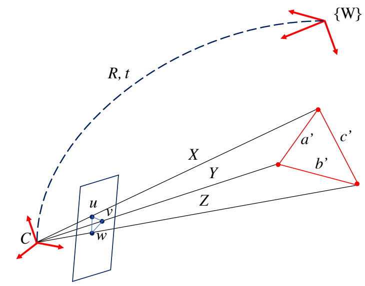
Definition:

Given the model of an object (geometry) and its projection on the image, determine the object pose with respect to the camera.

Two Steps:
1. Determine 3 object points in the camera coordinate frame, X^c.
2. Solve for the extrinsics/pose $\{R, t\}$ with $X^c = [R, t]X^w$.

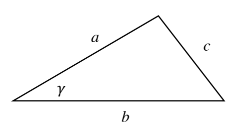
Note that X^w are known.



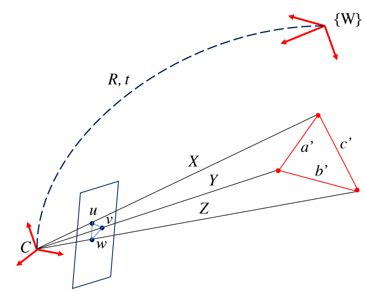


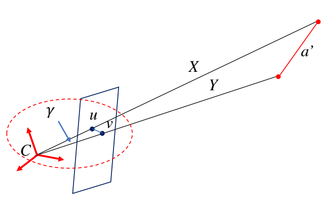
Perspective-n-Point (PnP)

Only need "law of cosines"



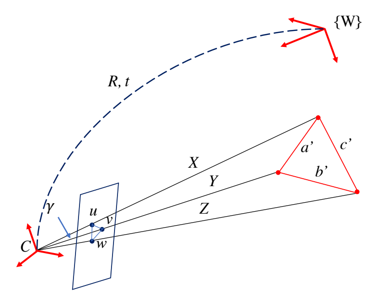
$$a^2+b^2 - c^2 - ab2\cos\gamma = 0$$





$$(Cu)^2+(Cv)^2 - (uv)^2 - (Cu)(Cv)2\cos\gamma = 0$$

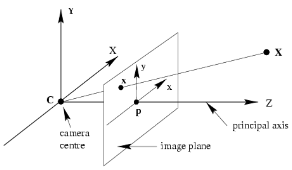
$$X^2+Y^2 - a'^2 - XY2\cos\gamma = 0$$

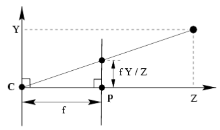


$$\begin{cases} Y^2+Z^2 - YZp - b'^2 = 0 \\ Z^2+X^2 - XZq - c'^2 = 0 \\ X^2+Y^2 - XYr - a'^2 = 0 \end{cases}$$

$$p = 2\cos\alpha, q = 2\cos\beta, r = 2\cos\gamma$$

Given lengths X, Y and Z, obtain vectors X^c, Y^c, and Z^c by polar to Cartesian coordinate conversion





Perspective-n-Point (PnP)

Definition:

Given the model of an object (geometry) and its projection on the image, determine the object pose.

Solution:

1. Identify three distinct points on the object: X^w, Y^w, and Z^w
2. Solve for X, Y, and Z to obtain three X^c Y^c, and Z^c
3. We have three equations of the form, $X^c = [R, t]X^w$, or nine (linear) constraints on $[R, t]$ of 6 DOF, to obtain our solution.

For further details, refer to:

https://www.learnopencv.com/head-pose-estimation-using-opencv-and-dlib/