

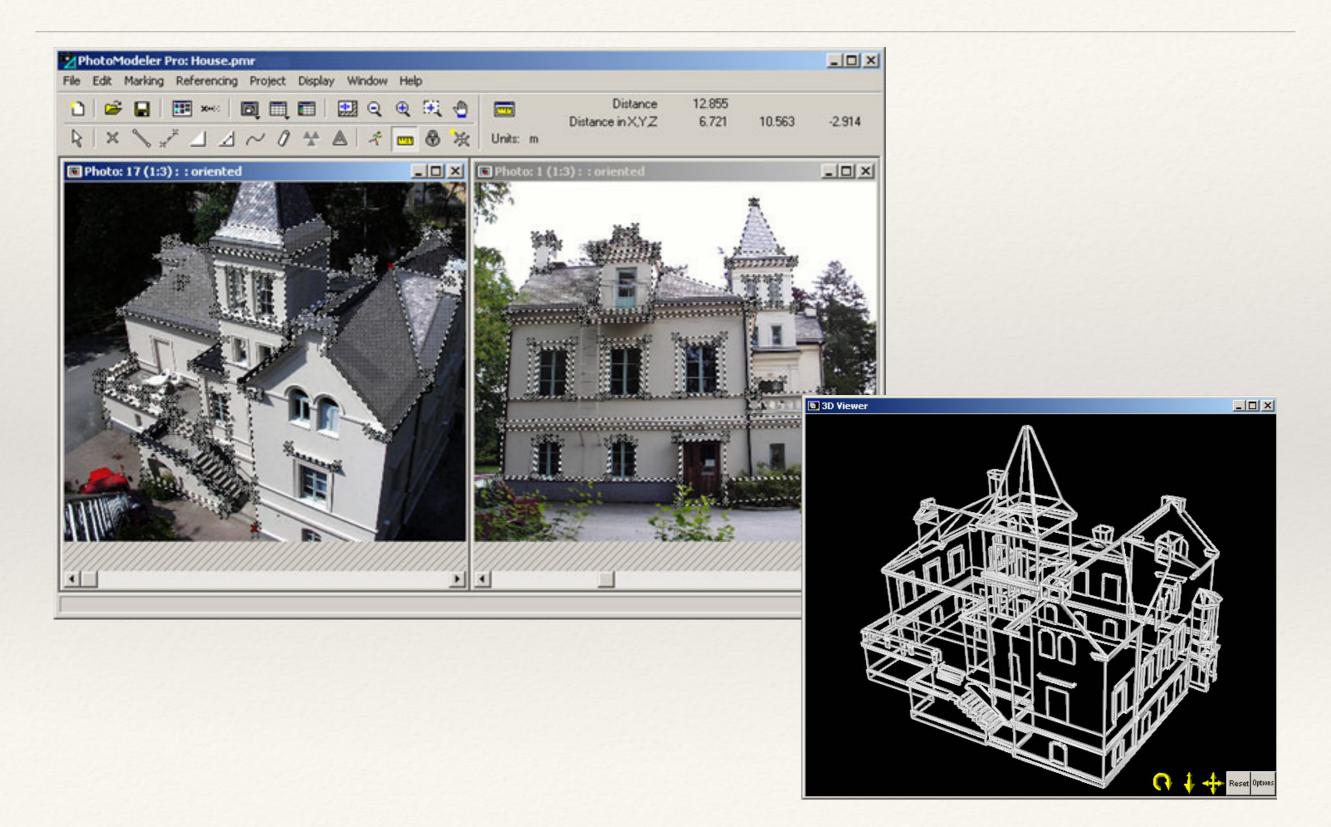
COMP3204/COMP6223: Computer Vision

Towards 3D vision

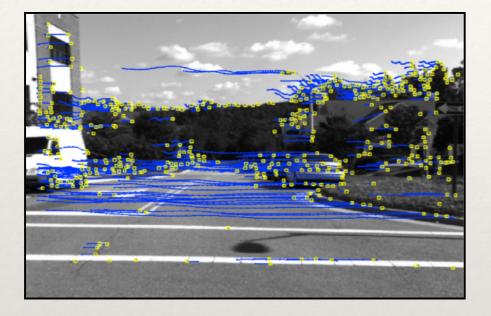
Jonathon Hare jsh2@ecs.soton.ac.uk

Applications

Architecture



Urban Planning







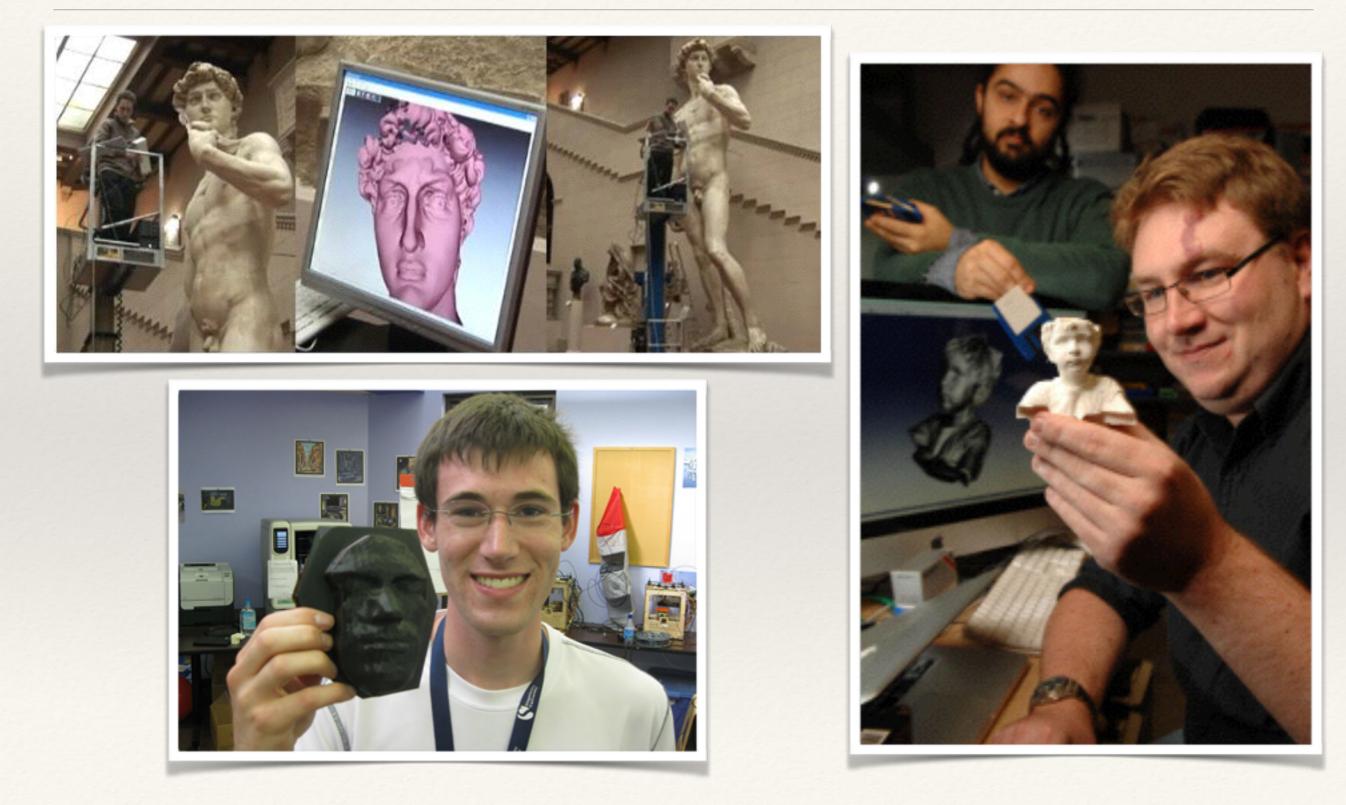
Virtual Tourism

Photosynth [®]	
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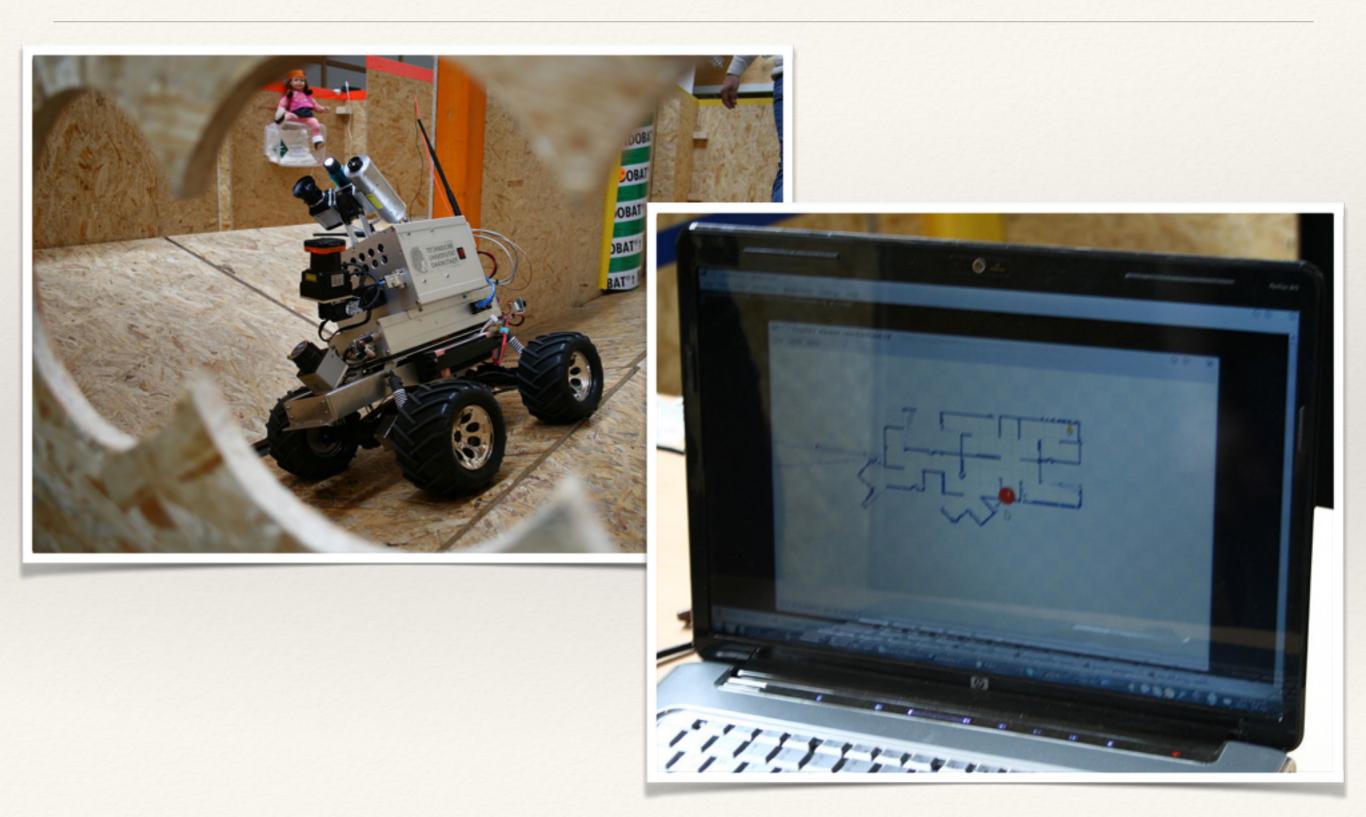
Clothing & body measurement

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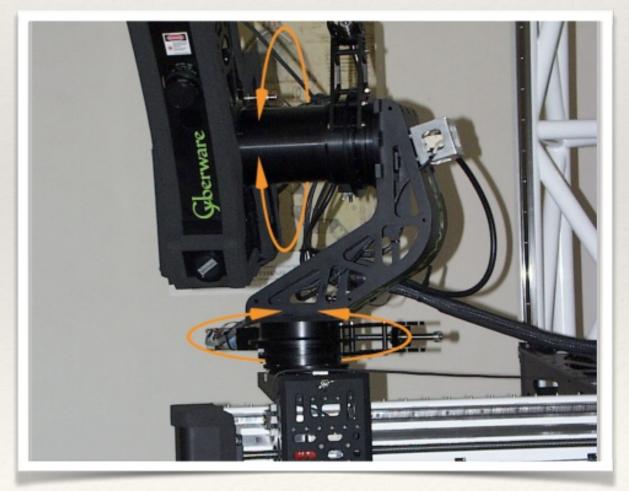
SLAM



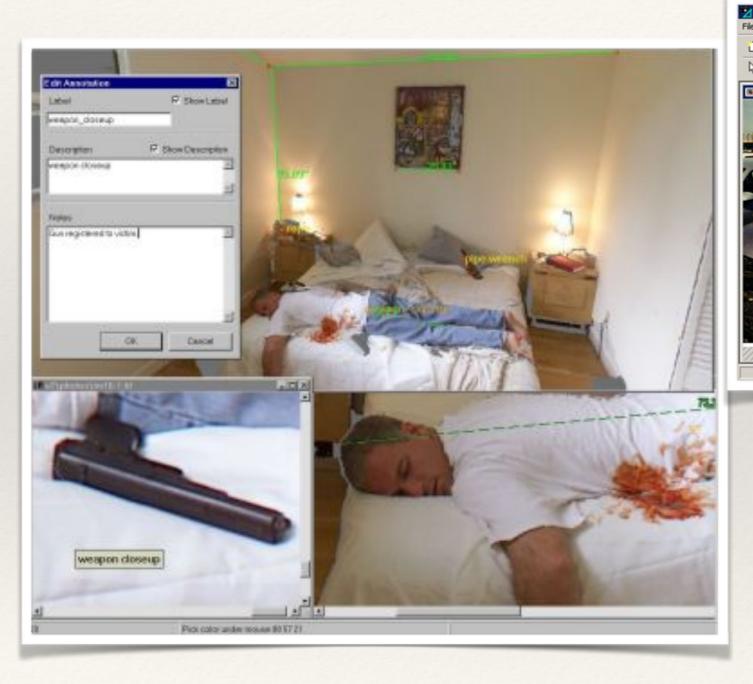
Cultural Heritage

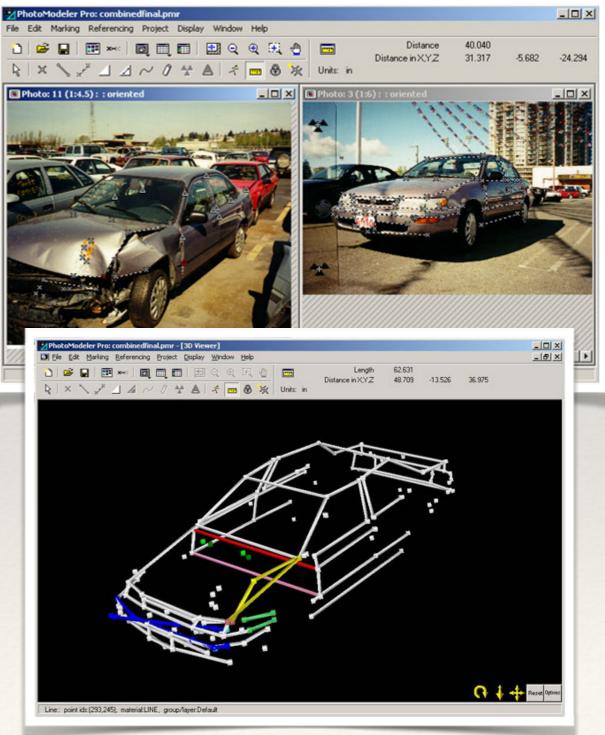






Forensics



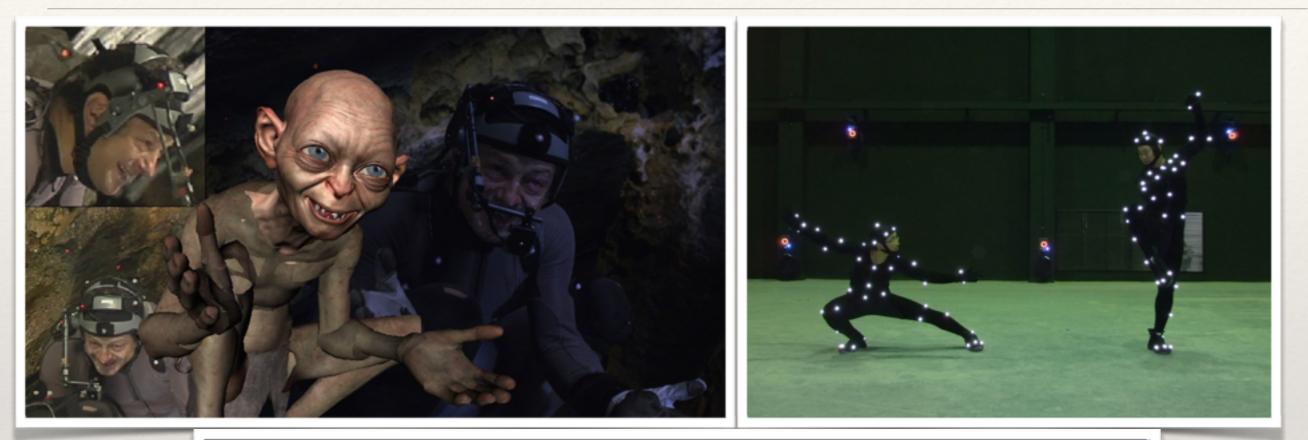


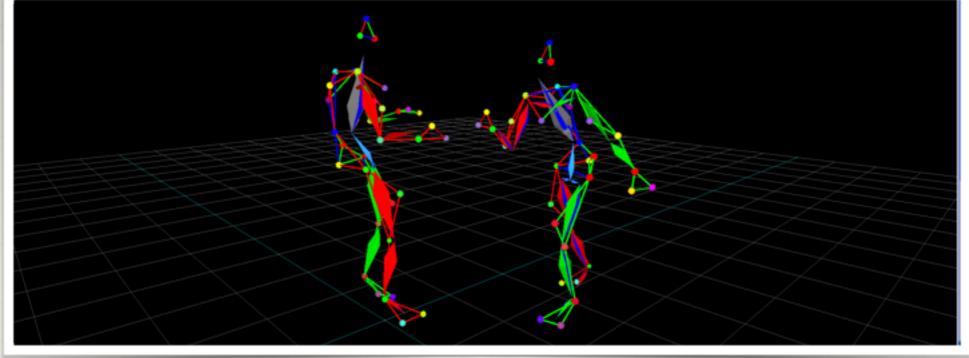
Surveillance



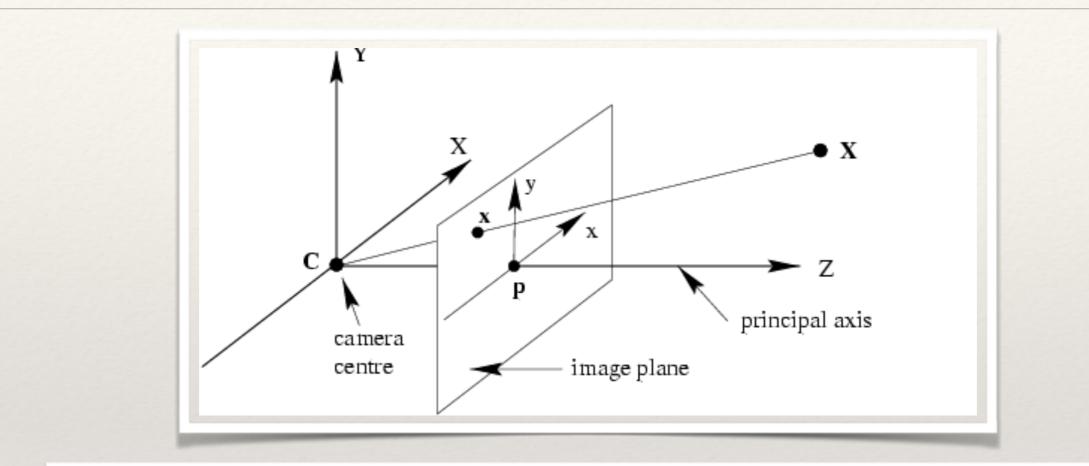


Motion Capture (Films & Games)



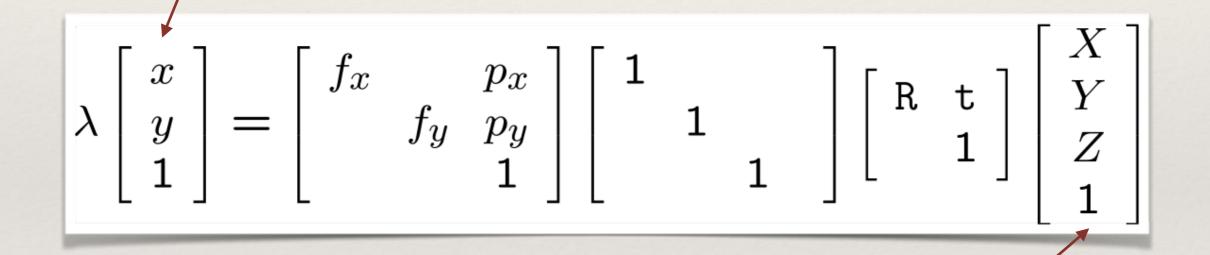






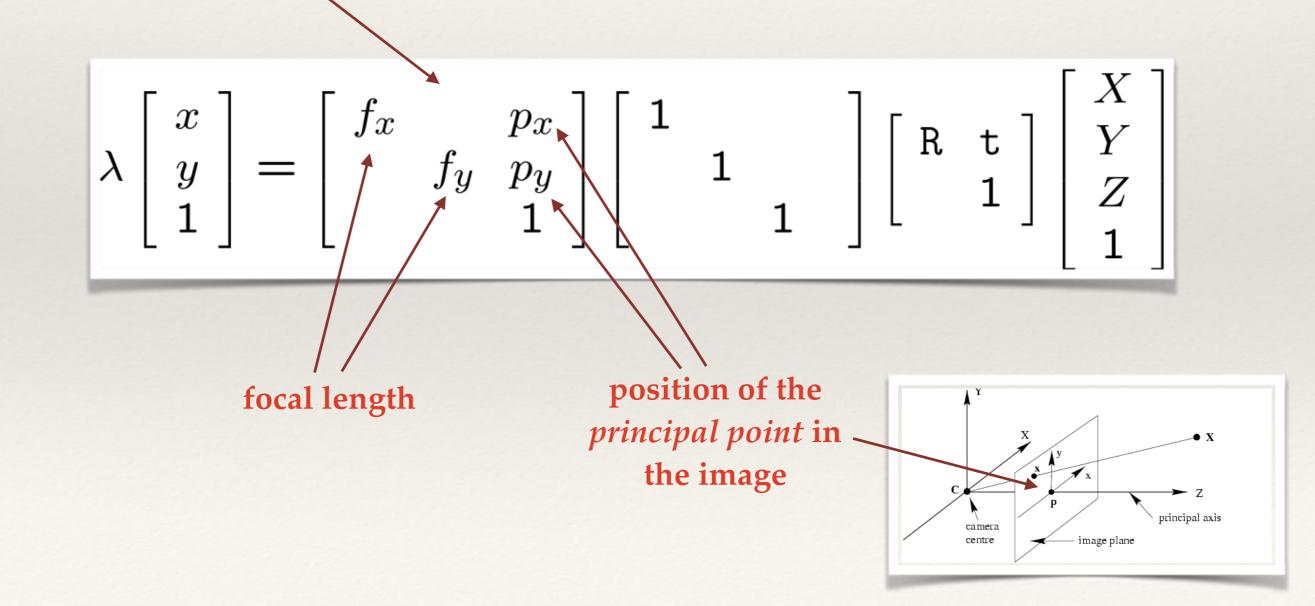
$$\lambda \begin{bmatrix} x \\ y \\ 1 \end{bmatrix} = \begin{bmatrix} f_x & p_x \\ & f_y & p_y \\ & & 1 \end{bmatrix} \begin{bmatrix} 1 & & \\ & 1 & \\ & & 1 \end{bmatrix} \begin{bmatrix} R & t \\ & I \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \\ 1 \end{bmatrix}$$

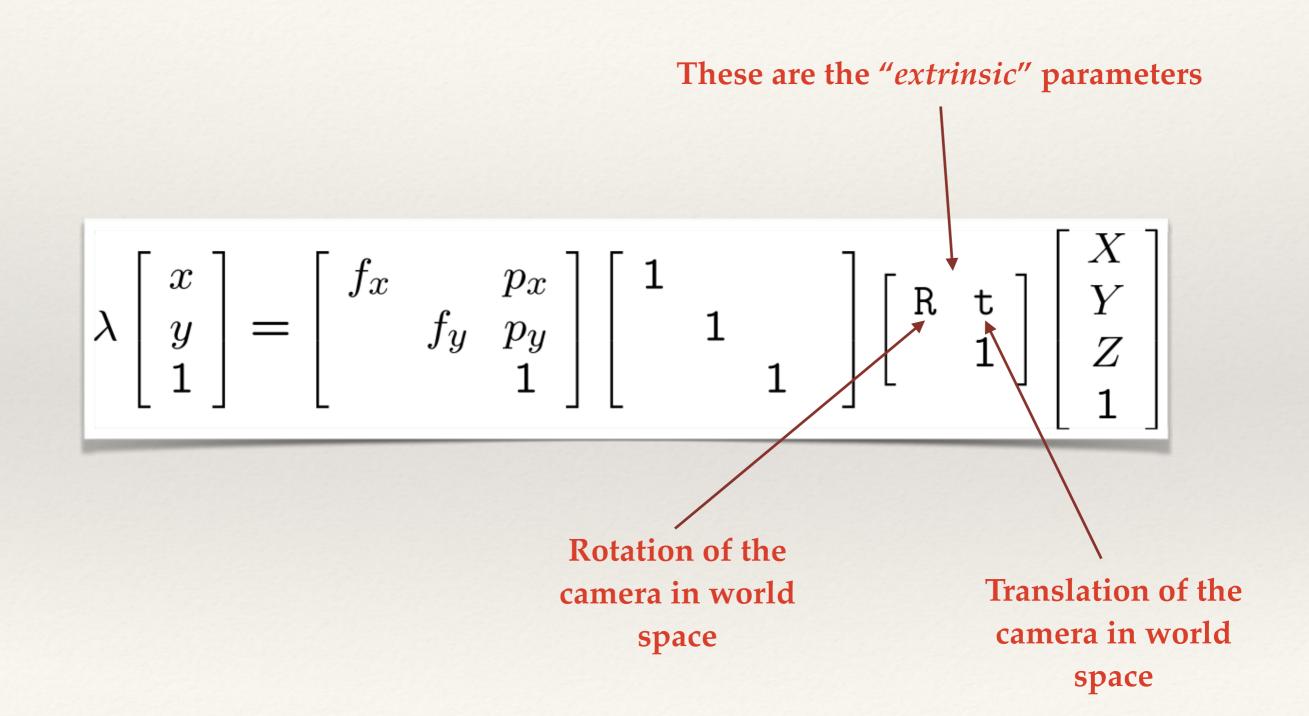




This is a point in the world

These are the *"intrinsic"* parameters





Camera Calibration

$$\lambda \begin{bmatrix} x \\ y \\ 1 \end{bmatrix} = \begin{bmatrix} f_x & p_x \\ f_y & p_y \\ & 1 \end{bmatrix} \begin{bmatrix} 1 & & \\ & 1 & \\ & & 1 \end{bmatrix} \begin{bmatrix} R & t \\ & 1 \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \\ 1 \end{bmatrix}$$

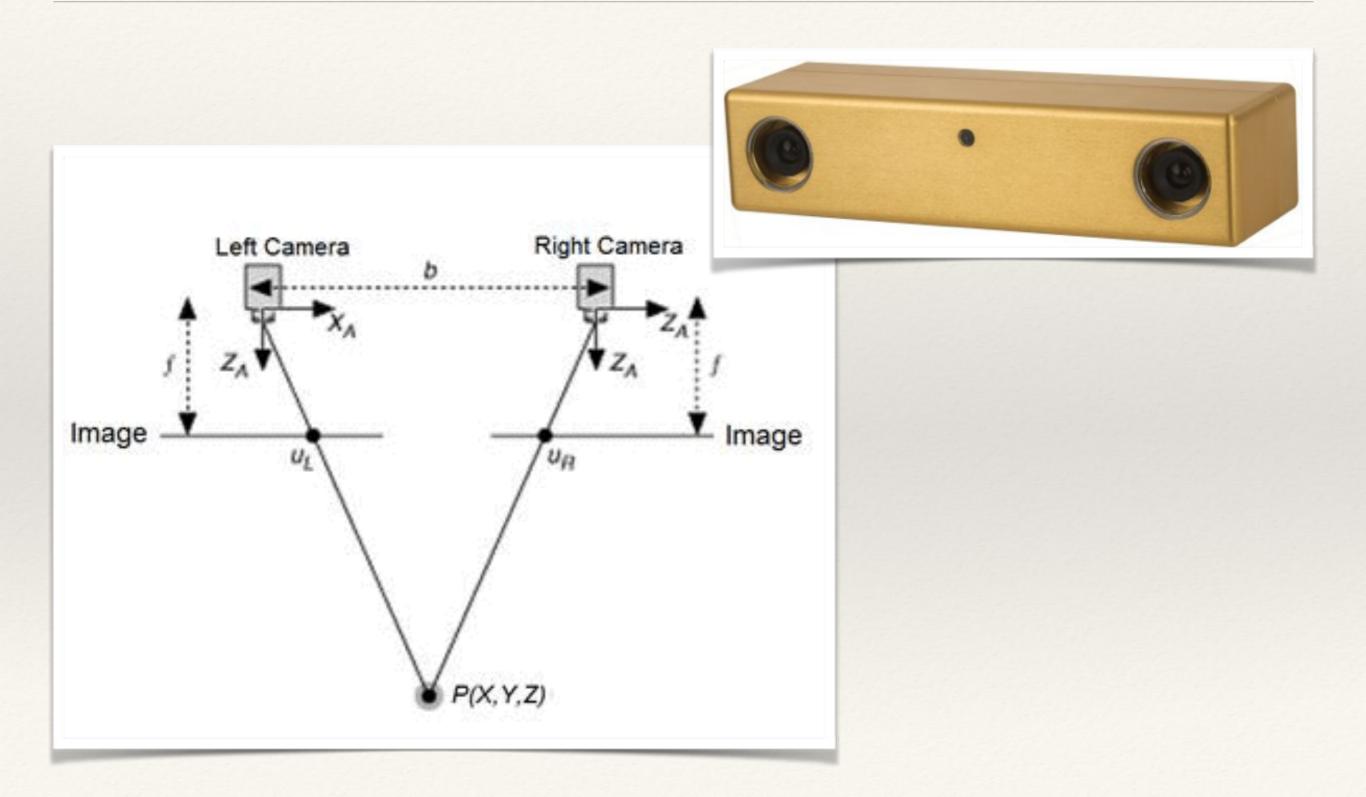
- Camera calibration is the process of estimating the intrinsic parameters of a camera
 - Also deals with learning non-linear radial distortion parameters of real camera lenses
 - Typically determined by solving sets of point correspondences from images of "calibration patterns"

Camera Calibration Demo

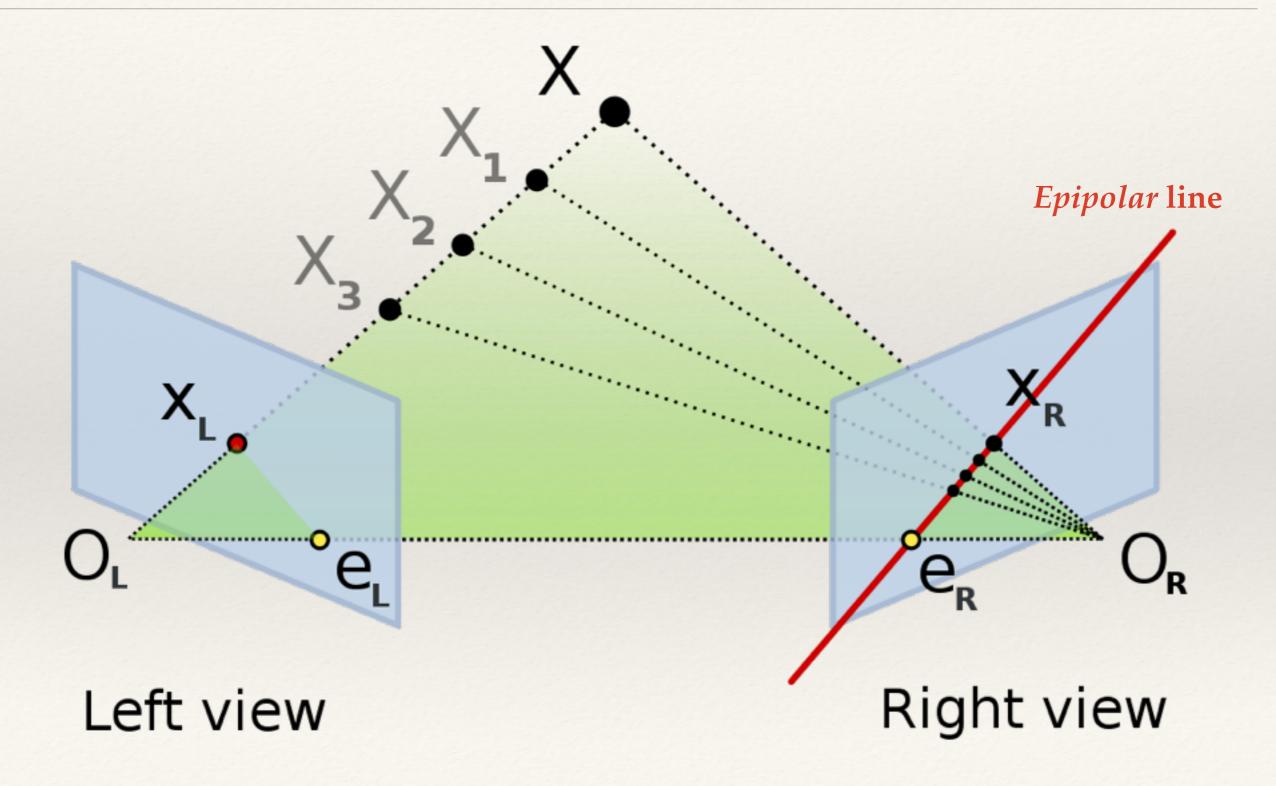
Measuring Depth

Narrow Baseline Stereo

Stereo Camera



Epipolar geometry



Dense narrow-baseline stereo



Warp images to simplify epipolar geometry

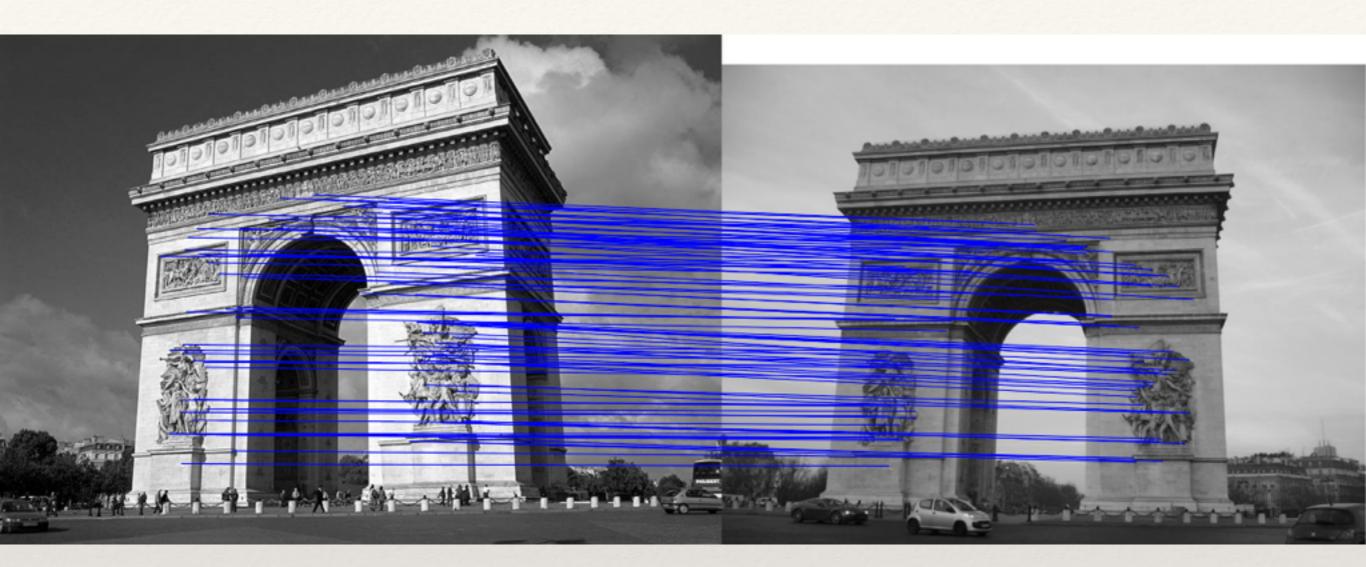


Compute disparity map by matching pixels along the epipolar lines

Wide Baseline Stereo



Multiple images can be used to jointly infer 3D structure, and the camera pose and intrinsics of each camera



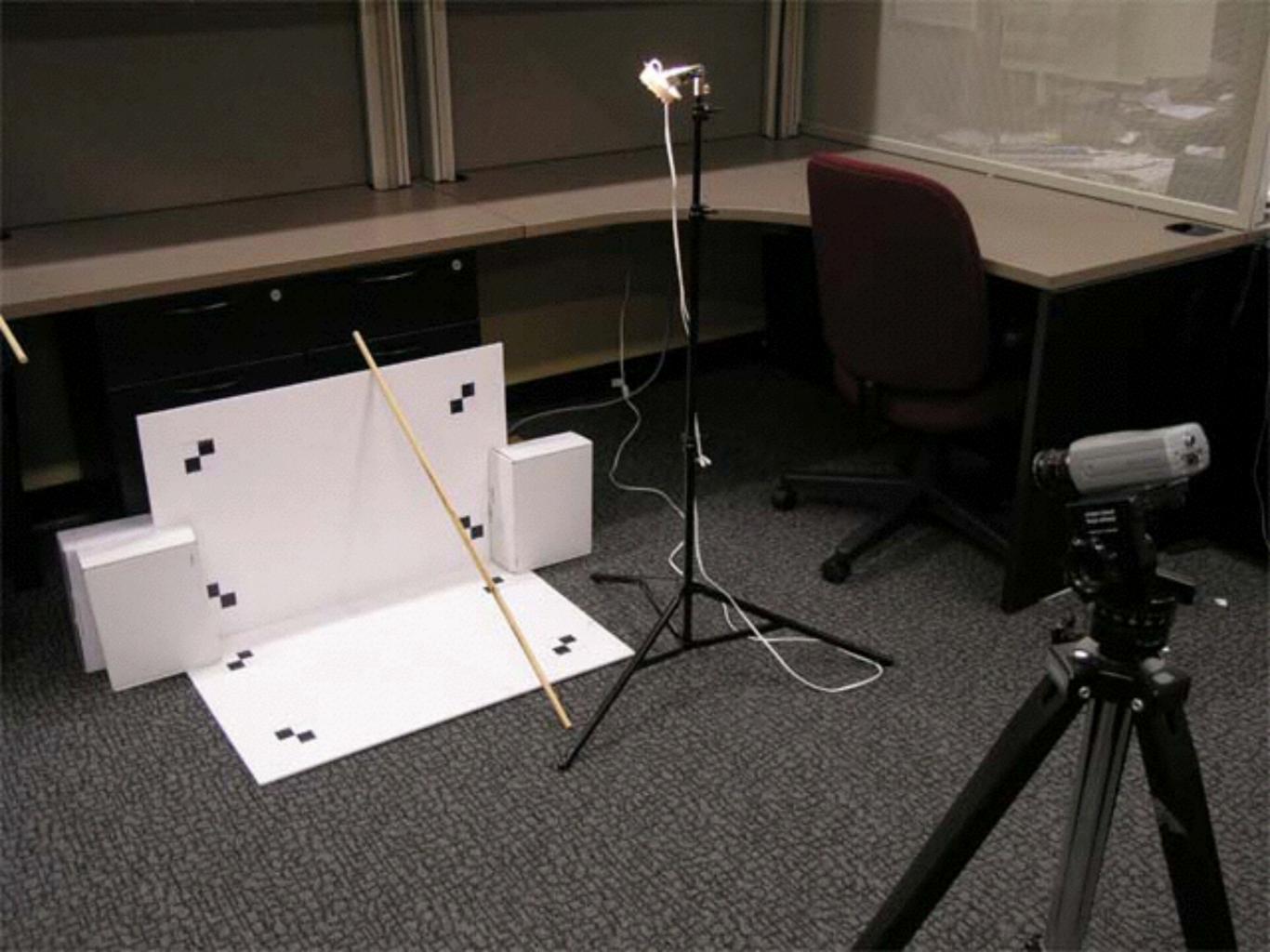
Point matches (i.e. SIFT) are used as the basis for triangulating 3D points from the 2D images

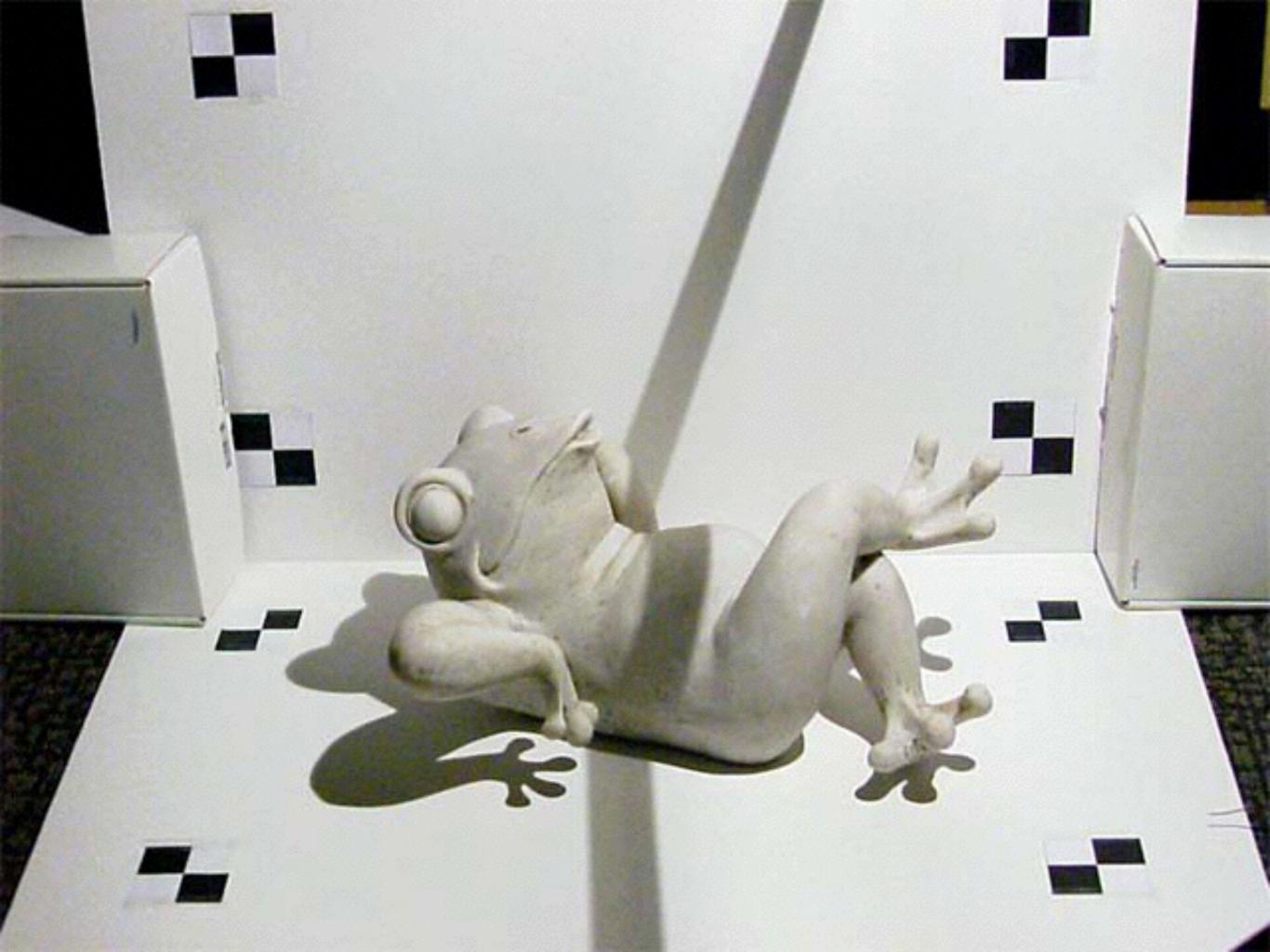
Reconstructing Venice



Monocular Vision

Shadow Scanner







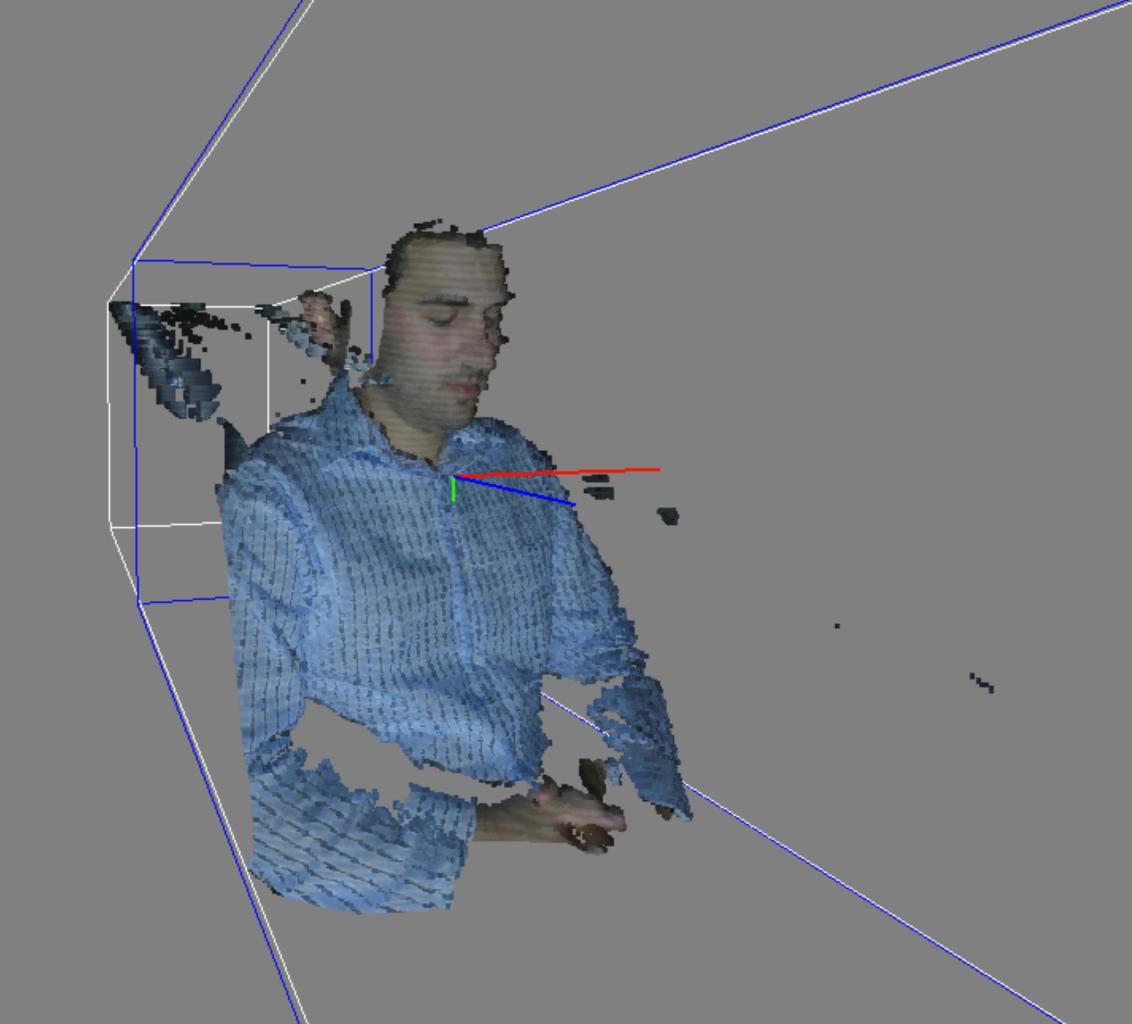
Structured Light Imaging

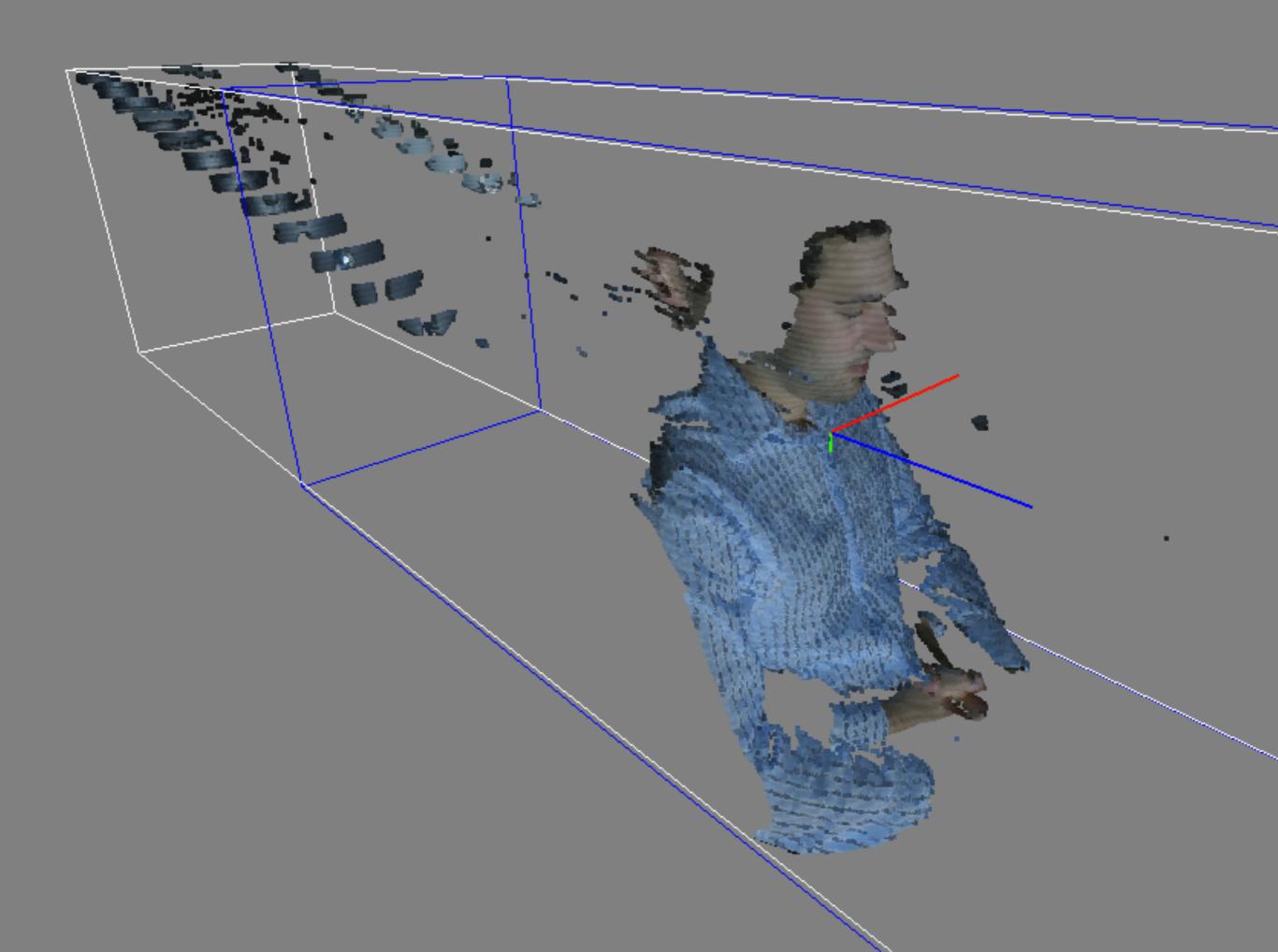
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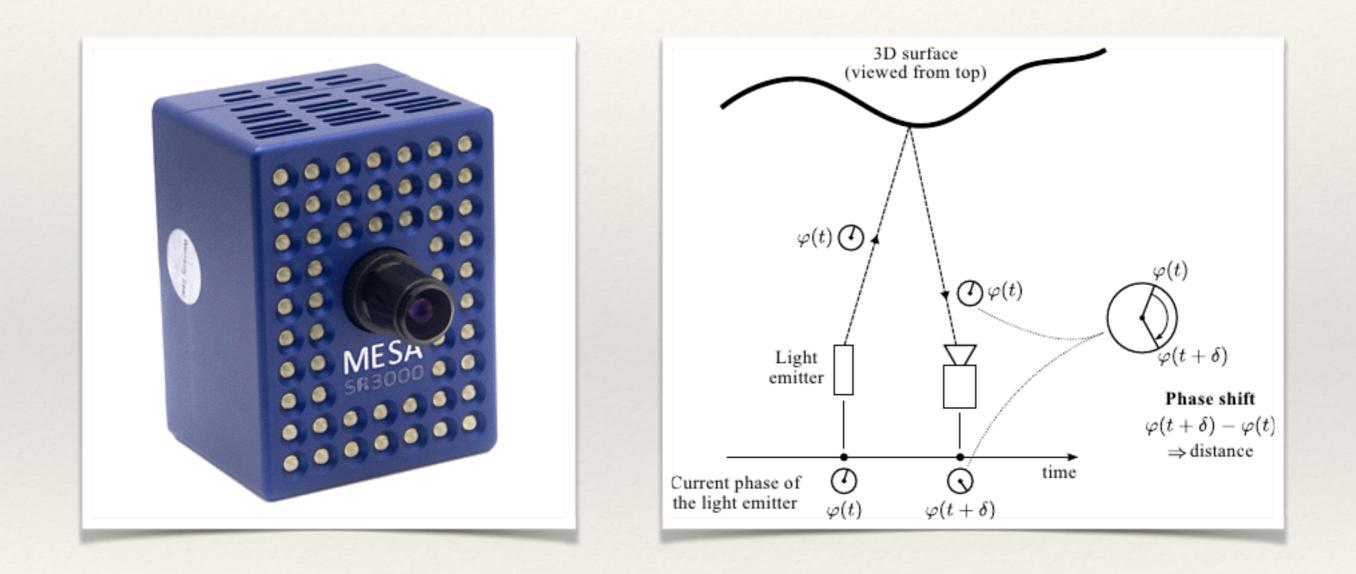
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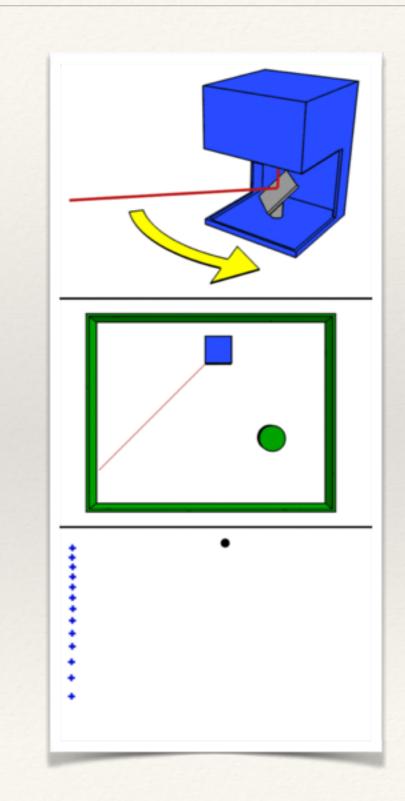
Time of Flight Imaging



Non-visible techniques

LIDAR





PrimeSense (Kinect)

- * Uses coded structured IR light
 - * IR Laser projects a stationary, random pattern of dots
 - Basically shining light through a opaque stencil with holes in it
 - * IR camera records those dots
 - Template matching is used to compare the actual location of the dots from the IR sensor to the known location if the dots were projected on a plane perpendicular to the optical axis at a known distance



Summary

- * 3D computer vision has lots of practical applications
- * Camera models give a mathematical description of how a pixel in a 2D image is related to a point in a 3D scene
 - Camera calibration can be used to find the parameters of a camera
- * Multiple views of a scene can be used to infer depth
- * There are lots of other techniques for capturing depth that only require a single sensor