Calibration

Tue, August 4 (Week 7)

Camera Signals for 3D Application

Unlike 2D applications, 3D applications require much more than pixels for use of camera signals.

2D applications: take a photo, add a (AR) filter on it, etc.

3D applications: capture the space, render it as a point cloud, etc.

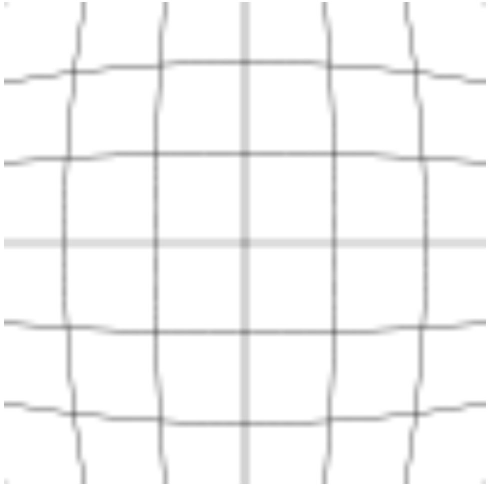
Camera Parameters

Intrinsic parameters: field of view, center pixel, lens distortion

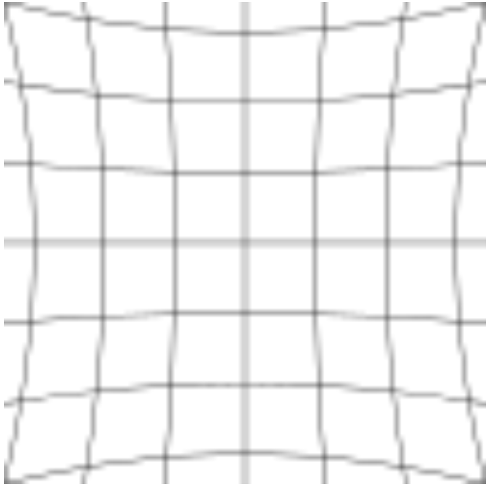
Extrinsic parameters: position, rotation

Note: Intrinsic and extrinsic parameters do not cover everything about the cameras. E.g., focal length, white balance, color temperature

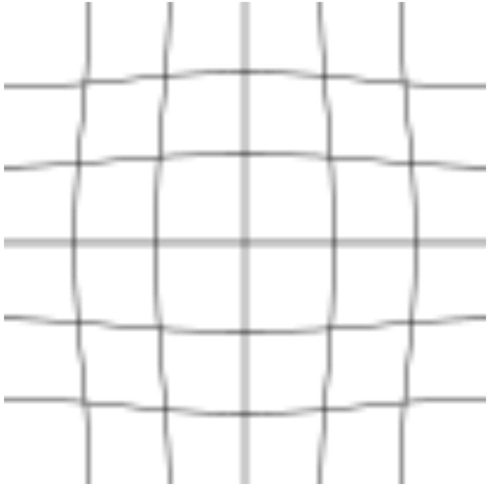
Lens Distortion



Barrel distortion



Pincushion distortion



Mustache distortion
(Mixture of other two)

Calibration

Figuring out intrinsic/extrinsic parameters.

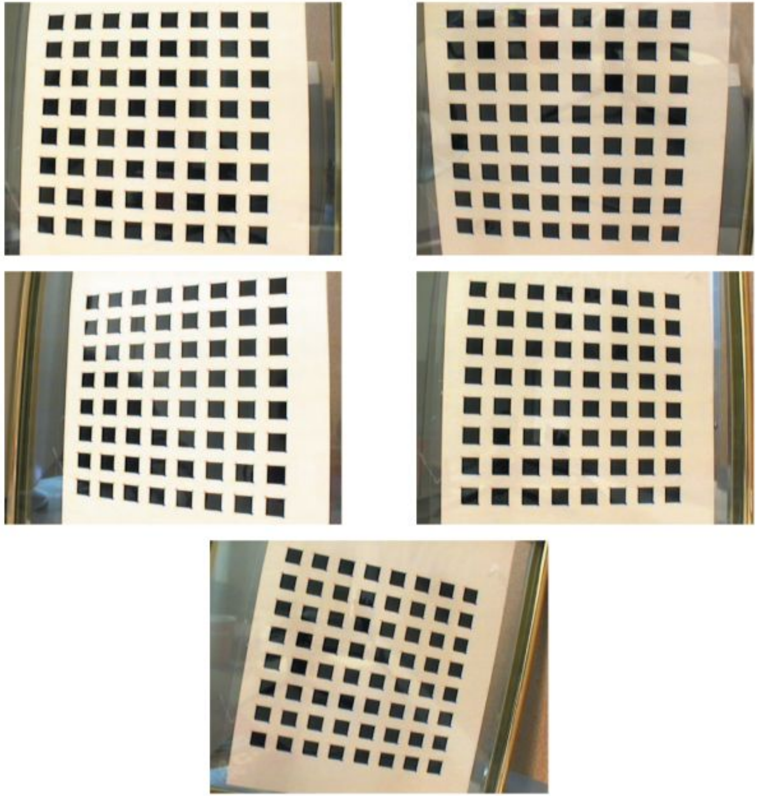
Usually, by taking photos of objects with known size and pattern, and comparing how they look like in the captured pixels.

Opposite of 3D computer vision algorithms that figure out how the space looks like from the pixels, while knowing the parameters.

Color Camera Calibration (Zhang, 2000)

Zhang's method using a checkerboard:

Printing out a checkerboard pattern with a known size and obtain intrinsic parameters using pictures of the checkerboard.



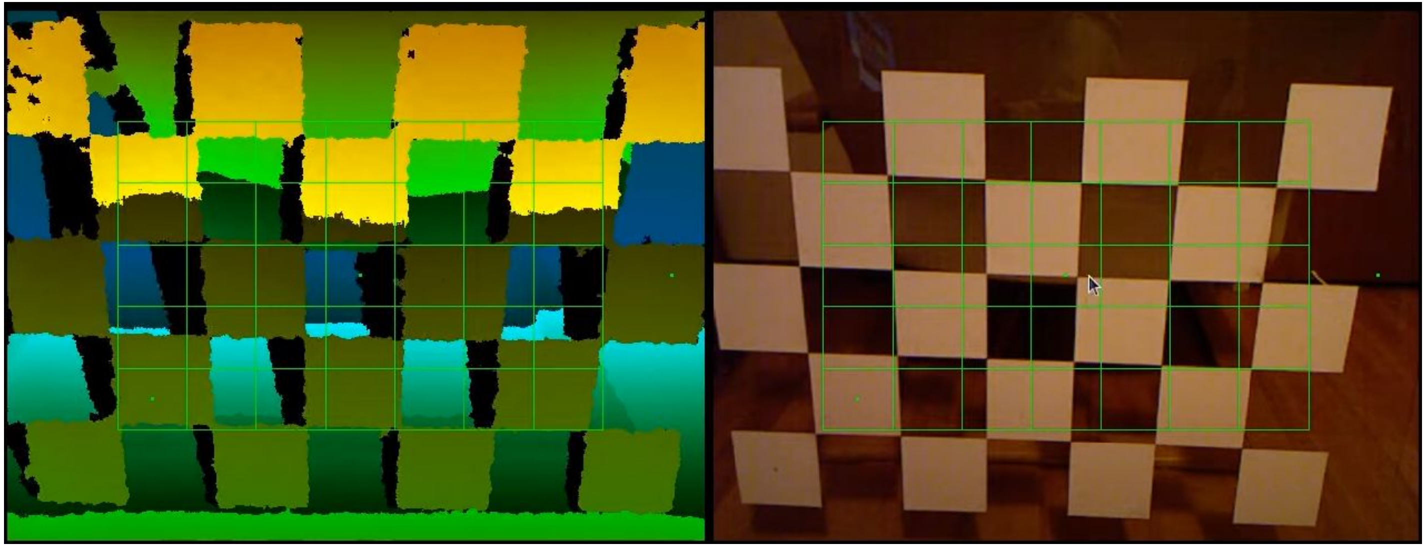
(Similar to how markers can be detected with thick border lines that are easy to find.)

Color Camera Calibration (Zhang, 2000)

Finds distortion parameters at the same time.

Depth Camera Calibration

Depth camera is a special type of an IR camera with a paired IR source. Therefore, it can be calibrated as an IR camera with the same checkerboard method, but with a checkerboard for IR (e.g., semi-transparent).



Trade-off between Cost and Quality of a Lens

Mobile cameras need to be cheap: <$200.

Depth cameras also are in the price range of <$500.

Good lenses are easily above those price ranges.

By good means more accurate shapes reducing unintentional distortion.

One solution: use cheap lenses with good a calibration method--which is free!

RGBD Cameras

There is no single device that measures both color and depth at the same time. There are devices with both of them called RGBD cameras.

RGBD Cameras

Two intrinsics sets of parameters

: One for color and one for depth.

One extrinsic set of parameters

: Position and rotation between the cameras.

Since both cameras are inside one device, all parameters including the extrinsic parameters can be measured during production!

RGBD Cameras

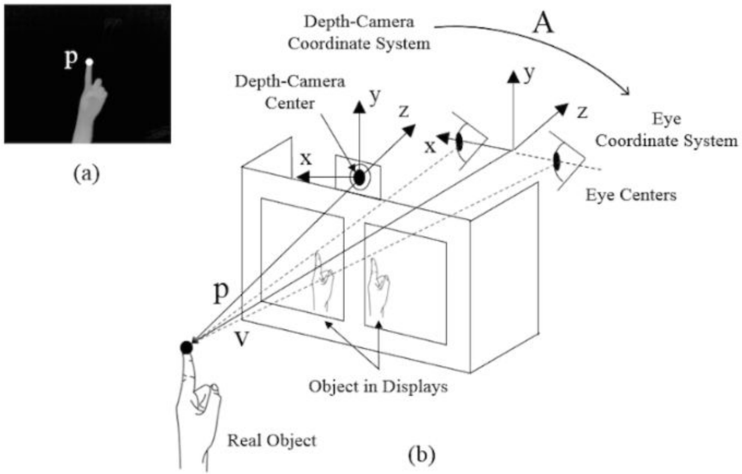
Color Image + Depth Map + Parameters:

RGBD Image (or a colored point cloud)

AR Headsets

Another system to measure its position and rotation:

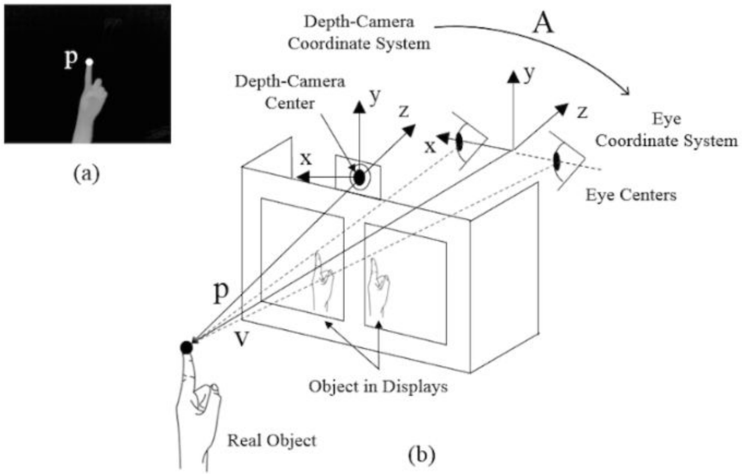
AR headset displays (notice that anything 3D requires something TRS)



AR Headsets

For a headset with displays and a depth camera:

Where should a virtual object get rendered to match a real object measured by the depth camera at a specific position?



SPAAM (Tuceryan et al., 2002)

The classic of calibration (registration) method: measures both intrinsic and extrinsic parameters at the same time.

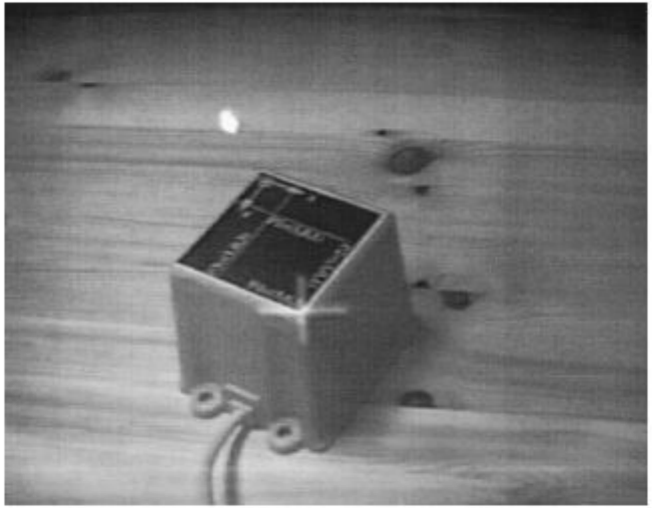


Figure 4. *The calibration procedure requires the user to align a cursor as shown here with a fixed point in the world.*

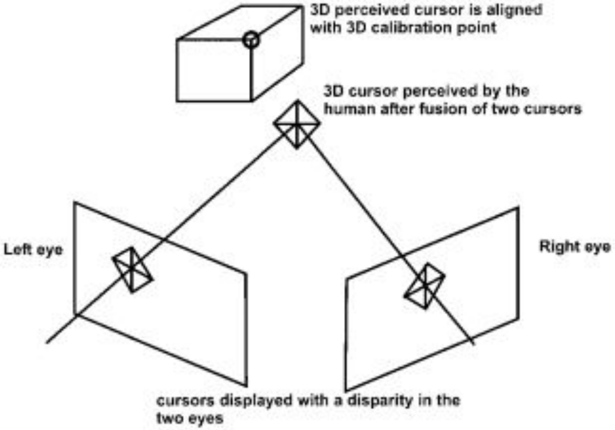
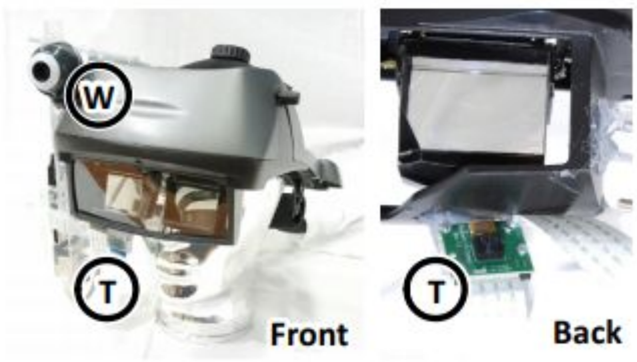


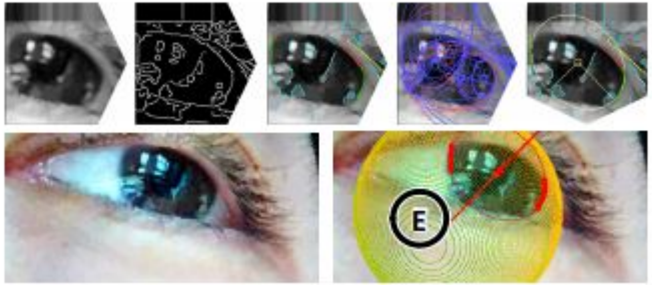
Figure 6. *The data collection by the user for calibrating the display is performed by the user moving his head until the perceived crosshair in 3D is colocated with the 3D calibration point.*

AR Headset (INDICA; Itoh & Klinker, 2014)

Pushing to the limit, the only parameter that cannot be premeasured are the eye positions (which is a superset of IPD).

Using eye trackers to detect eye positions.

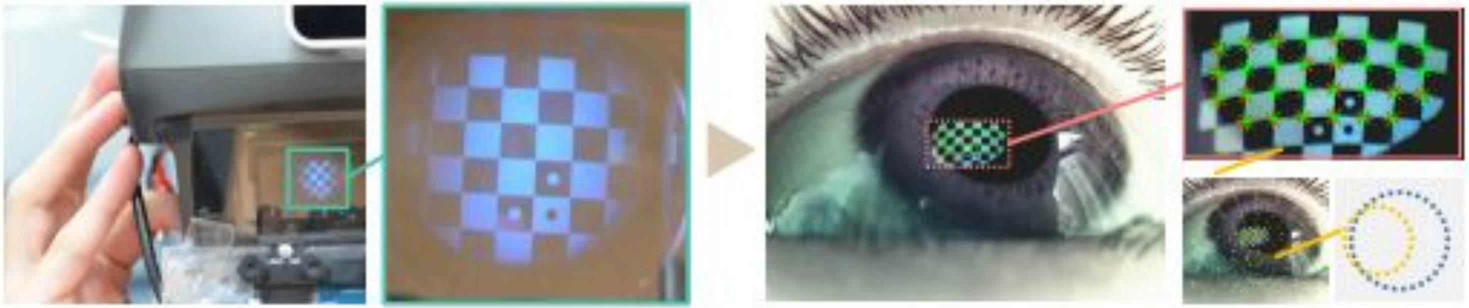




AR Headsets (Plopski, 2015)

Another method

Using reflections on the corneal to figure out eye positions.



Example: Multi-camera Telepresence Application

If you want to use multiple cameras from different angles for high quality capture of the scene, you need to know where each of the cameras are:

Extrinsic parameters

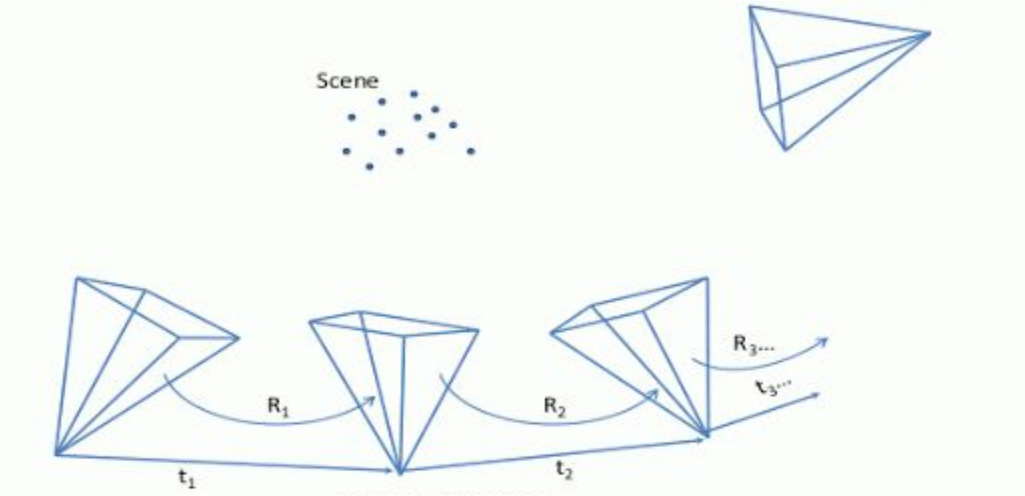
(Notice the similarity to TRS matrices.)

Example: Multi-camera Telepresence Application

Problem description:

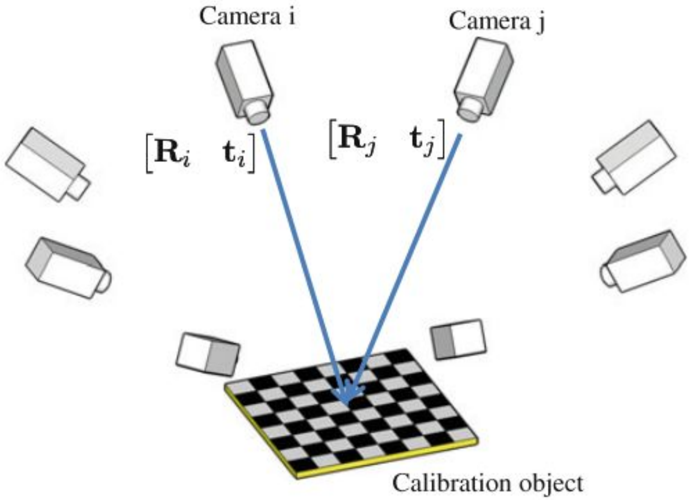
N cameras with their are Intrinsics are known. Find the N-1 extrinsics.

(-1 because extrinsics are all relative so one camera can be the origin.)



Example: Multi-camera Telepresence Application

In an environment with cameras at fixed positions, again the checkerboard method works.



Calibration of Multi-camera Setups, Fig. 1 Calibration of inward-looking cameras

Example: Multi-camera Telepresence Application

Necessary to utilize camera signals from multiple cameras, for example, to run high quality 3D reconstruction.