Radiometry and Lights

Computer Vision I
CSE 252A
Lecture 5-Part I

Announcements

- Assignment 1 Posted to the web page: Due 1/27/04
- Read Chapter 4 of Forsyth & Ponce

Last lecture in a nutshell

Some points about SO(n)

- $SO(n) = \{ R \in \Re^{n \times n} : R^T R = I, \det(R) = 1 \}$
  - SO(2): rotation matrices in plane $\Re^2$
  - SO(3): rotation matrices in 3-space $\Re^3$
- Forms a Group under matrix product operation:
  - Identity
  - Inverse
  - Associative
  - Closure
- Closed (finite intersection of closed sets)
- Bounded $R_{i,j} \in [-1, +1]$
- Does not form a vector space.
- Manifold of dimension n(n-1)/2
  - Dim(SO(2)) = 1
  - Dim(SO(3)) = 3

SO(3)

- Parameterizations of SO(3)
- 3-D manifold, so between 3 parameters and 2n+1 parameters (Whitney's Embedding Thm.)
  - Roll-Pitch-Yaw
  - Euler Angles
  - Axis Angle (Rodrigues formula)
  - Cayley's formula
  - Matrix Exponential
  - Quaternions (four parameters + one constraint)

Camera parameters

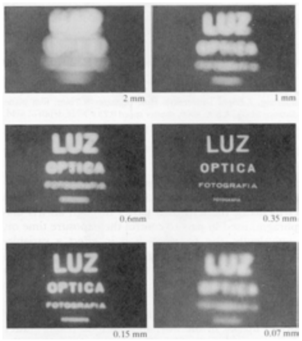
- Issue
  - camera may not be at the origin, looking down the z-axis
    - extrinsic parameters
  - one unit in camera coordinates may not be the same as one unit in world coordinates
    - intrinsic parameters - focal length, principal point, aspect ratio, angle between axes, etc.

$$\begin{pmatrix} U \\ V \\ W \end{pmatrix} = \begin{pmatrix} \text{Transformation} \\ \text{representing} \\ \text{intrinsic parameters} \end{pmatrix} \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{pmatrix} \begin{pmatrix} \text{Transformation} \\ \text{representing} \\ \text{extrinsic parameters} \end{pmatrix} \begin{pmatrix} X \\ Y \\ Z \\ T \end{pmatrix}$$

3 x 3 4 x 4

Pinhole Camera Images with Variable Aperture

2 mm



1mm

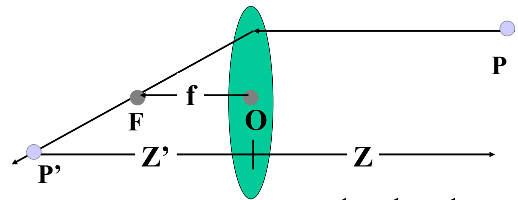
.6 mm

.35 mm

.15 mm

.07 mm

Thin Lens: Image of Point

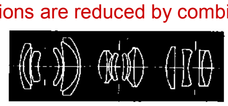


$$\frac{1}{z'} - \frac{1}{z} = \frac{1}{f}$$

Geometrical aberrations

- spherical aberration
- astigmatism
- distortion
- coma

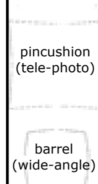
aberrations are reduced by combining lenses



Compound lenses

Distortion

magnification/focal length different for different angles of inclination

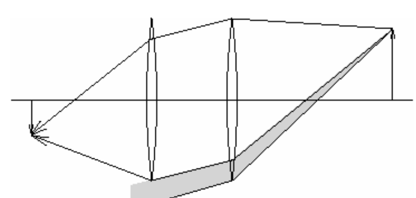


Can be corrected! (if parameters are know)

Chromatic aberration

(great for prisms, bad for lenses)

Vignetting



- Only part of the light reaches the sensor
- Periphery of the image is dimmer
- Problem in practice


Summary of Projection

Perspective Projection	$x' = f\frac{x}{z}$ $y' = f\frac{y}{z}$	*x,y*: World coordinates *x',y'*: Image coordinates *f*: pinhole-to-retina distance
Weak-Perspective Projection (Affine)	$x' = -mx$ $y' = -my$ $\quad m = -\frac{f}{z}$	*x,y*: World coordinates *x',y'*: Image coordinates *m*: magnification
Orthographic Projection (Affine)	$x' = x$ $y' = y$	*x,y*: World coordinates *x',y'*: Image coordinates
Common distortion model	$x'' = \frac{1}{\lambda}x'$ $y'' = \frac{1}{\lambda}y'$ $\lambda = 1 + k_1 r^2 + k_2 r^4 + \cdots$	*x',y'*: Ideal image coordinates *x'',y''*: Actual image coordinates