Algorithms and techniques for virtual camera control

Session 2: Basic Knowledge

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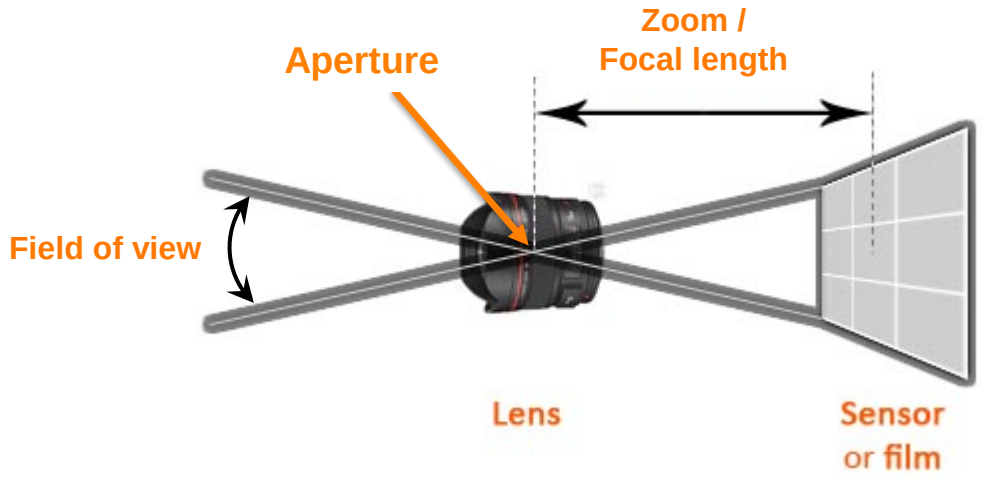
MAY 9, 2016

How to represent real cameras ?

- Camera's aim: capture images

- Intrinsic camera parameters
  - Lens type, sensor size
  - Aperture, zoom / focal length

➢ **Optical considerations** (lens)
  - Brings image distortion
  - And depth of field



Simplified optical system

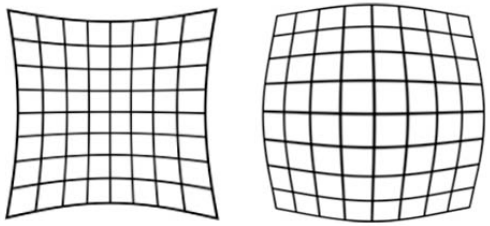
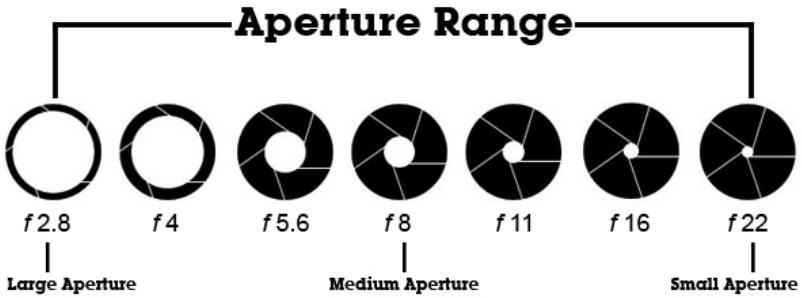


Image distortion

Depth of field



How to represent real cameras ?

- A large amount of camera types
  - Shape + volume + mass
- Operator / mechanical system
  - Position / orient the camera
- **Physical considerations**
  - Shape (comprising the operator / system)
  - Volumes and masses

Arri
Arriflex
435

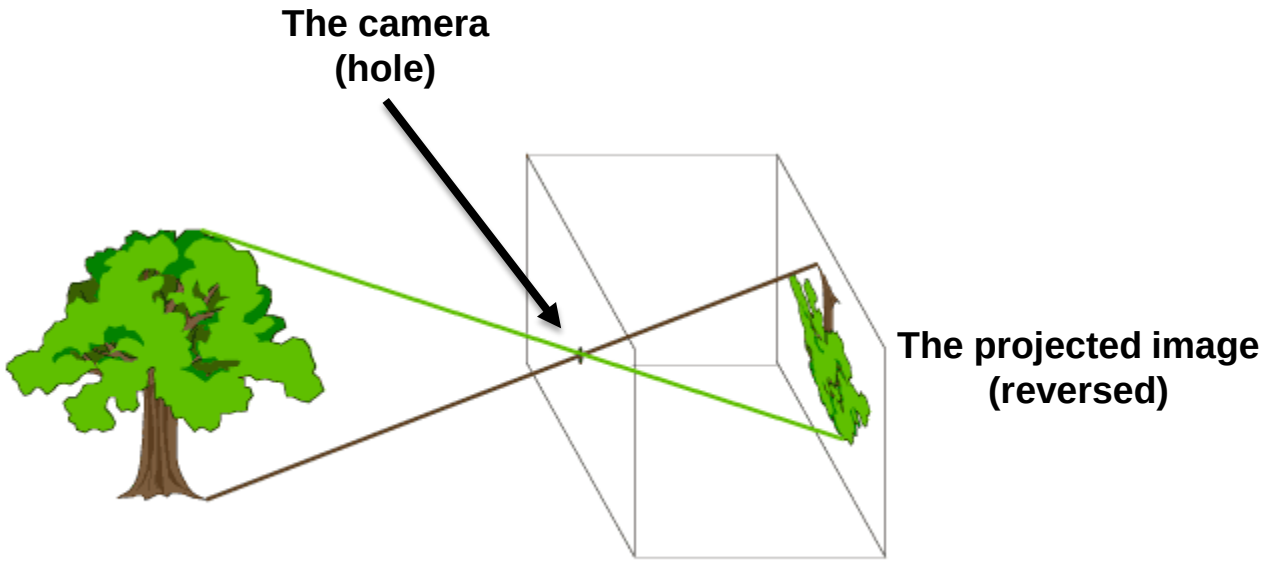
Aaton
Penelope

Steadycam

Camera mounted on
a mobile crane

Model of a virtual camera

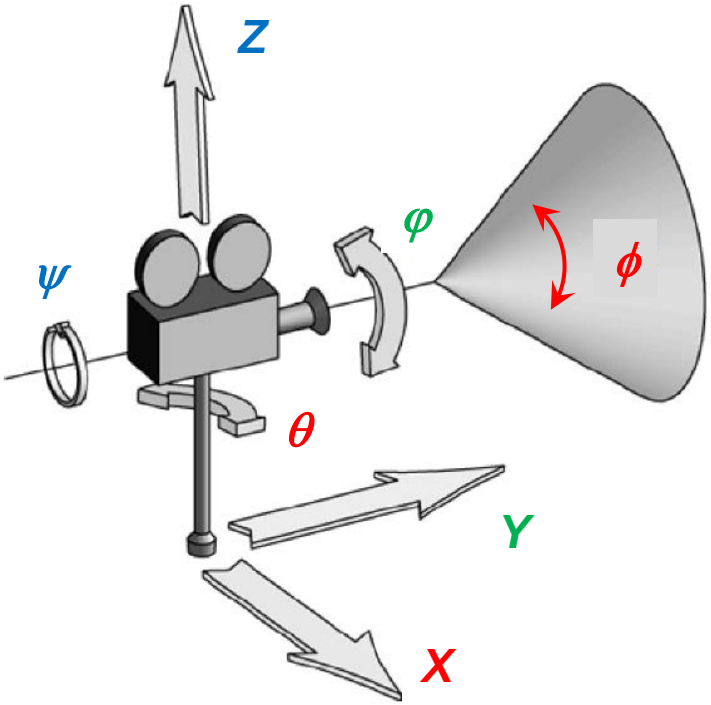
- **« Ideal » camera model (pinhole)**
  - No operator (free camera)
  - No mass, no volume (single point)
  - No image distortion (ideal screen projection)

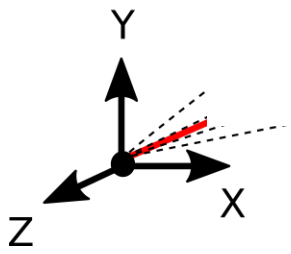


Pinhole camera model

Model of a virtual camera

- **7D camera configuration** c
  - 3D world **position** : X, Y, Z
  - 3D world **orientation** (pan, tilt, roll)
    - 3 Euler angles : θ *(pan)*, φ *(tilt)*, ψ *(roll)*
    - Or a quaternion
    - Or a look-at direction ($\psi = 0$)
  - 1D **zoom**
    - Field of view angle : ϕ
  - **Aspect Ratio** (fixed)
    - Image width / Image height (e.g. 3:2, 4:3, 16:9)



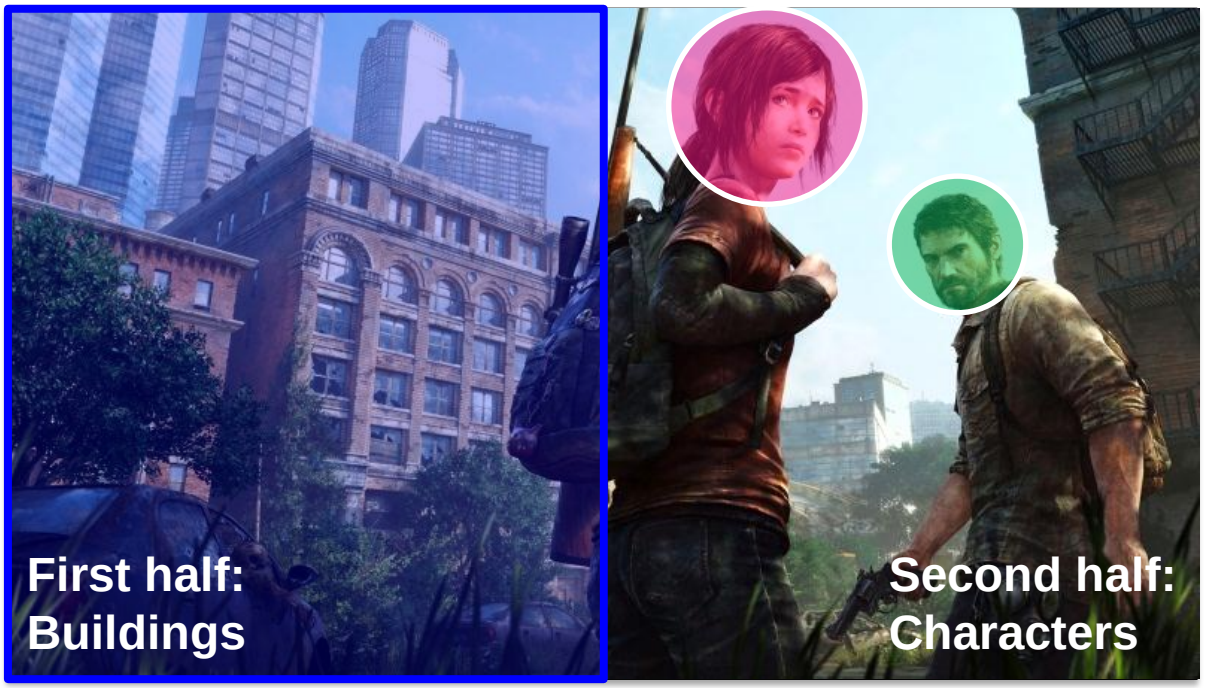


In the world space

In the camera space (perspective projection)

Automated viewpoint computation

Specification of the desired shot:



Specified features F^i

2D space

(Screen)

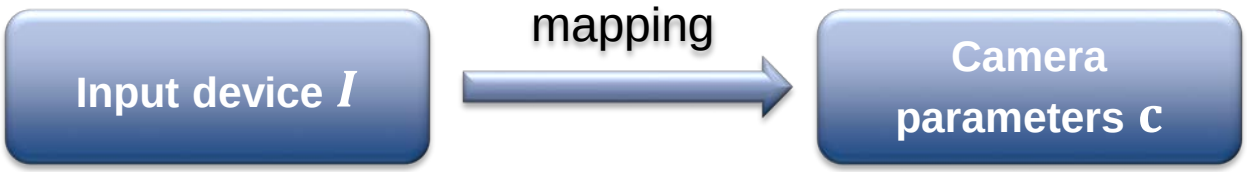
Search

7D Space C

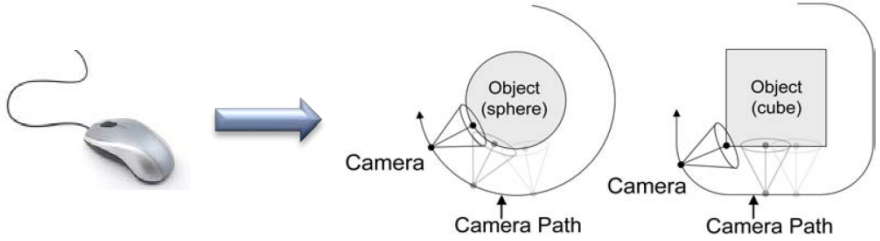
(Camera configurations
Positions X,Y,Z
Orientations θ, φ, ψ,
Field of Views ϕ)

Best 7D camera configuration $c \in C$ satisfing all F^i ?

Interactive viewpoint computation



- **Classical Mouse + Keyboard**
  - Dedicated to object inspection and scene exploration



[Khan et al. 2005]

- **Based on Motion Capture**
  - Mimic real camera work
  - Direct mapping to camera parameters

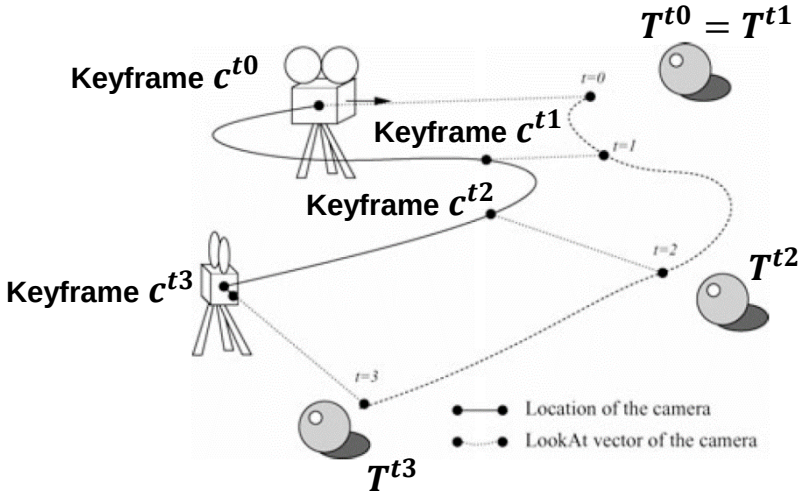
- **Goal: control the shot composition**
  - ➢ Direct / indirect control of image features F^i
  - ➢ Many interaction metaphors

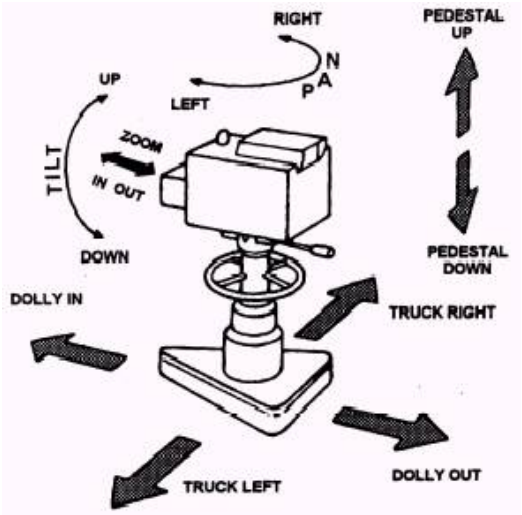
Optitrack

What practical tools to speed-up user tasks ?

Computation of camera paths

- Strongly coupled with camera models
- Classical approach (3D animation)
  - Quaternion trajectories (slerp)
  - Linear / spline-based interpolation
- Traditional motions (cinema)
  - Uses tripods / articulated arms
  - Pan/Tilt
  - Pedestal
  - Dolly, Track
  - Crane / Boom
  - …





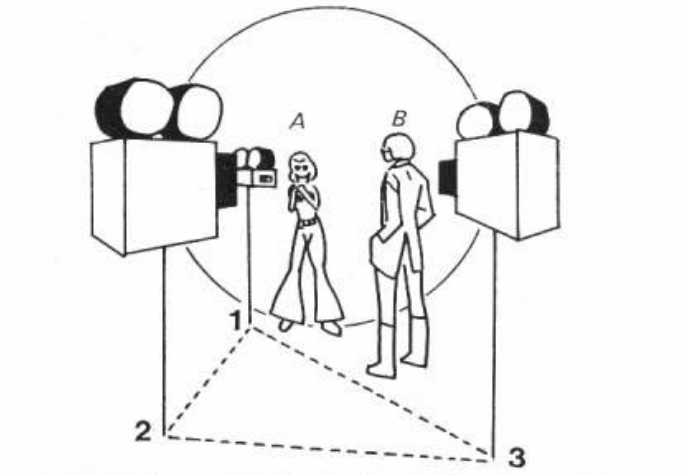
Naturally creates smooth camera motions

Interactive and automated editing

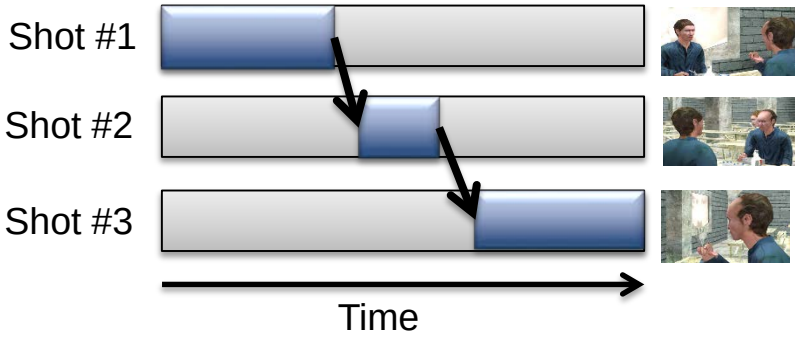
- Shots
- Cuts

- **Where** to cut to ?
  - Best next viewpoint ?
  - Continuity rules, cinema conventions
- **When / Why** to cut ?
  - Best moment to cut ?
  - Pace, occlusions, actions, …

- Traditional editing (cinema)
  - Rely on « cook-books » / empiric rules
  - Shoot rushes + cut + paste



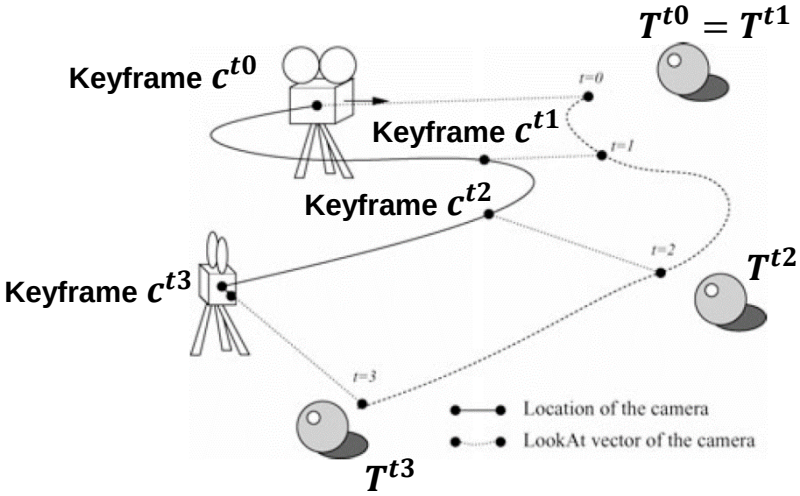
Shooting and editing dialogues
[Arijon 76]



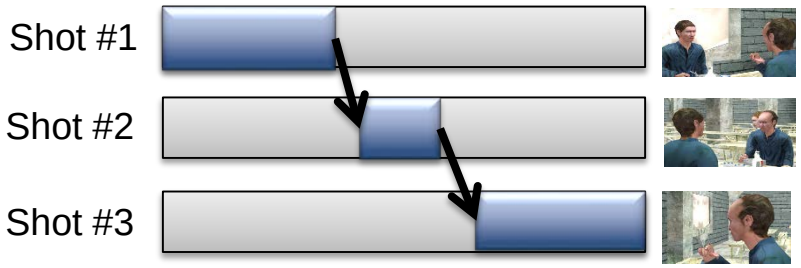
Coming next…

#1 Interactive control

#2 Automated viewpoint computation



#3 Camera path planning



#4 Automated editing