Camera Control

Screenshot from “World in Conflict”

Pikmin

Camera in Game

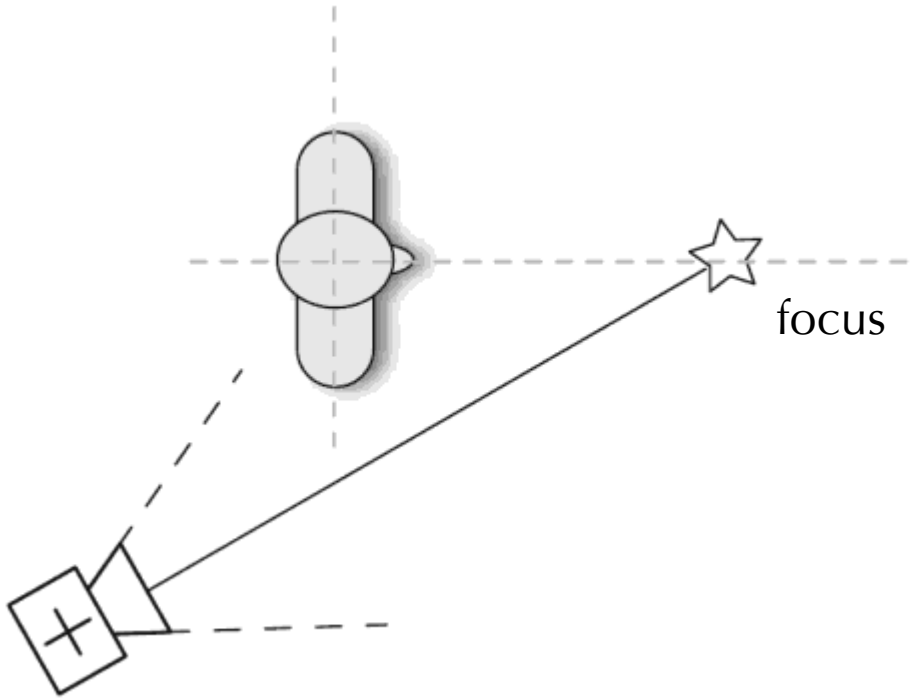
- First person view
  - the player controls the camera

- Third person view
  - Player is busy controlling the character(s)
  - An autonomous camera is usually implemented to track the character(s)

- Second person view??

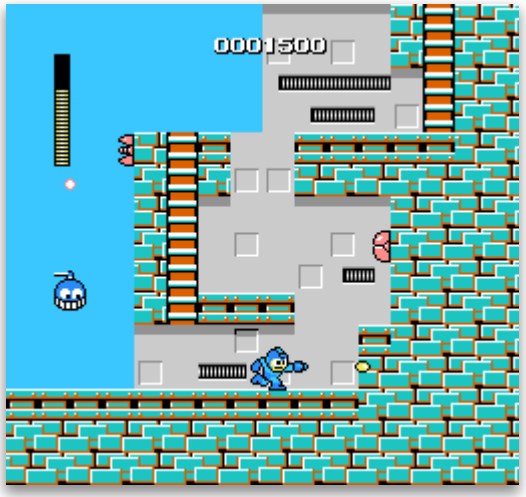
Camera in Game

- 3rd person view



Earlier Approaches

- Bird's-eye view (helicopter view)
  - most 2-d games
  - war games
  - construction games



- Side-scrolling view

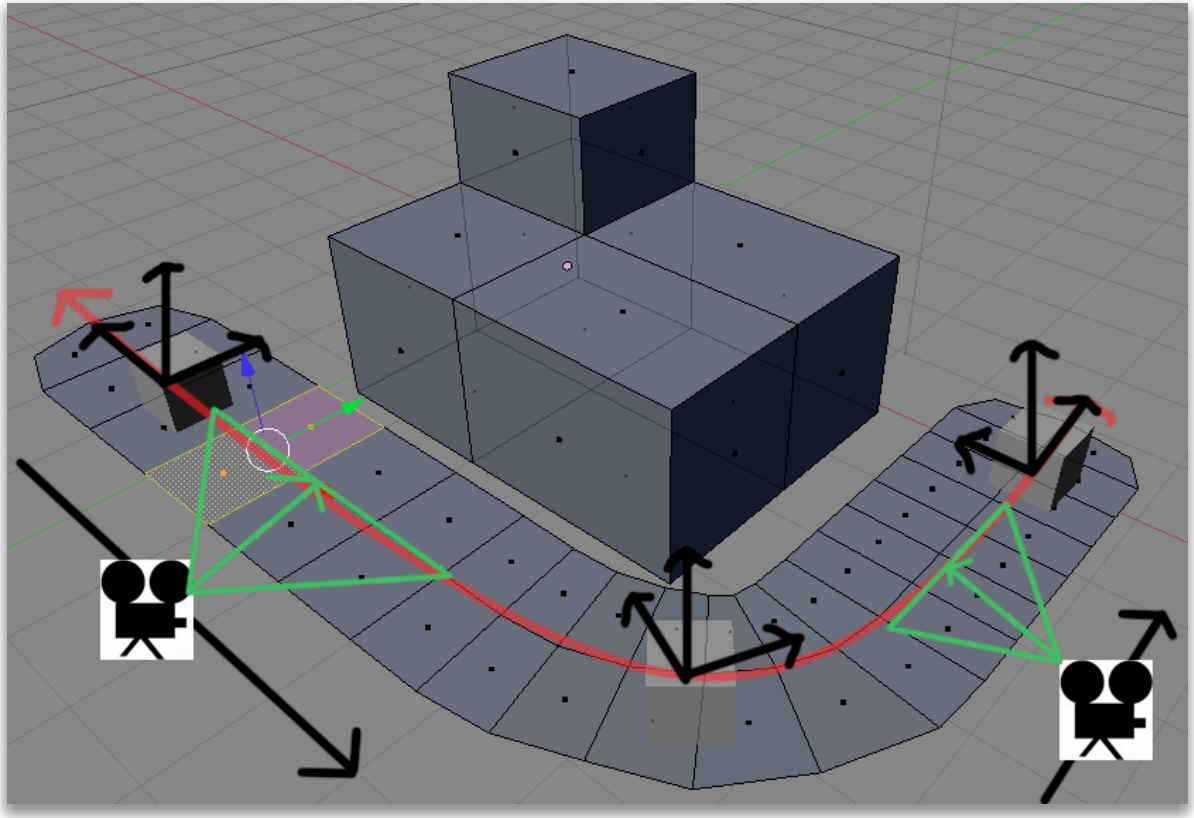
- No camera planning is needed

Earlier Approaches

- Fixed shots

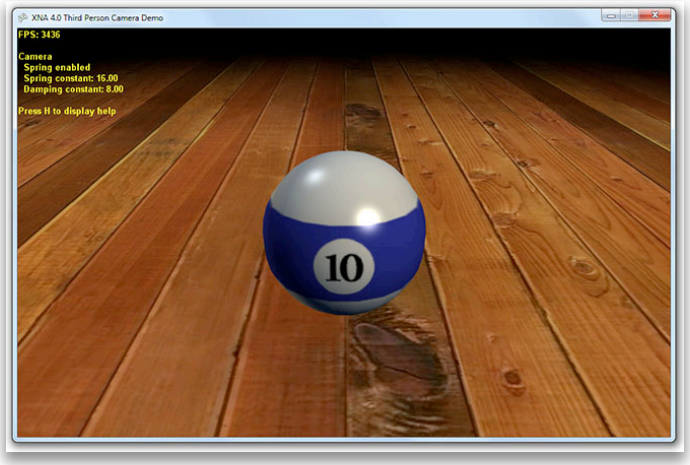
Earlier Approaches

- Scripted to follow a predefined path



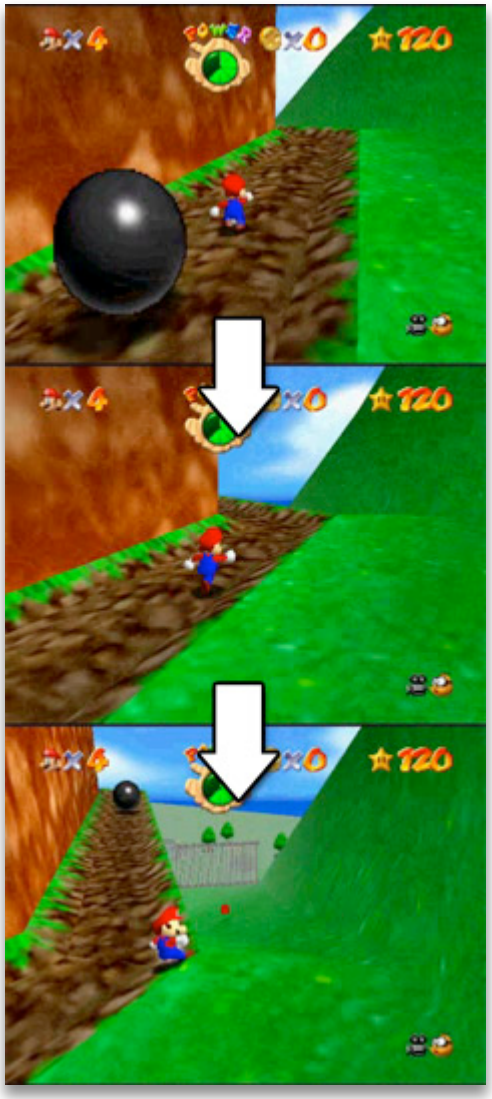
Earlier Approaches

- Tracking using a string damping system
  - the camera and the 3D model are attached to each other by a spring
  - As the user moves the 3D model around the scene the camera is dragged along with it
  - When the user stops moving the 3D model the camera slowly moves back to its resting position behind the 3D model.

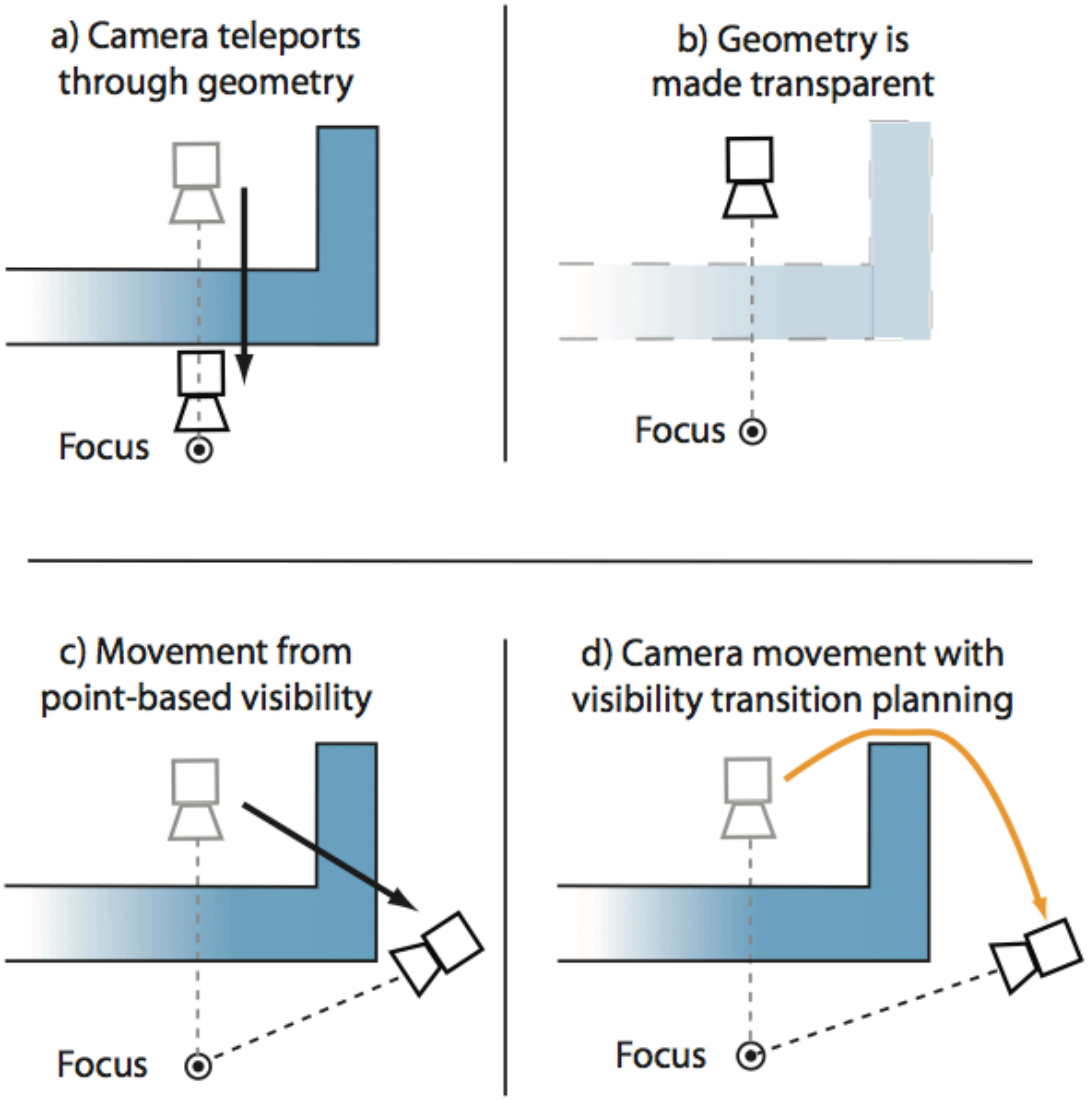


Earlier Approaches

- Camera AI
  - anticipate/predict motion
  - occlusion from scene objects
- However, camera can still be very frustrating
- Other tricks
  - make occlusion transparent
  - jump through walls

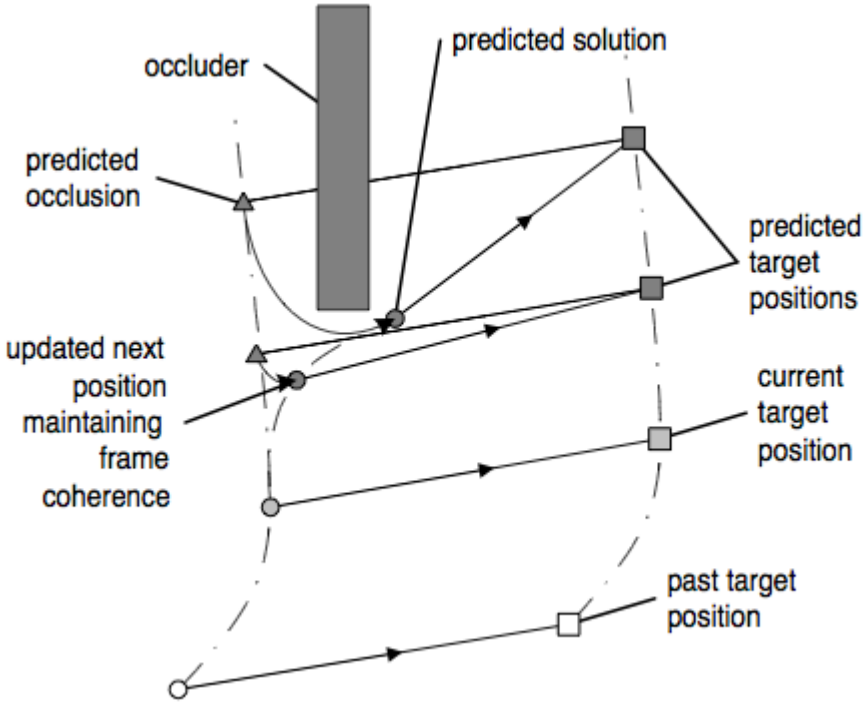


Earlier Approaches



Earlier Approaches

- Camera AI



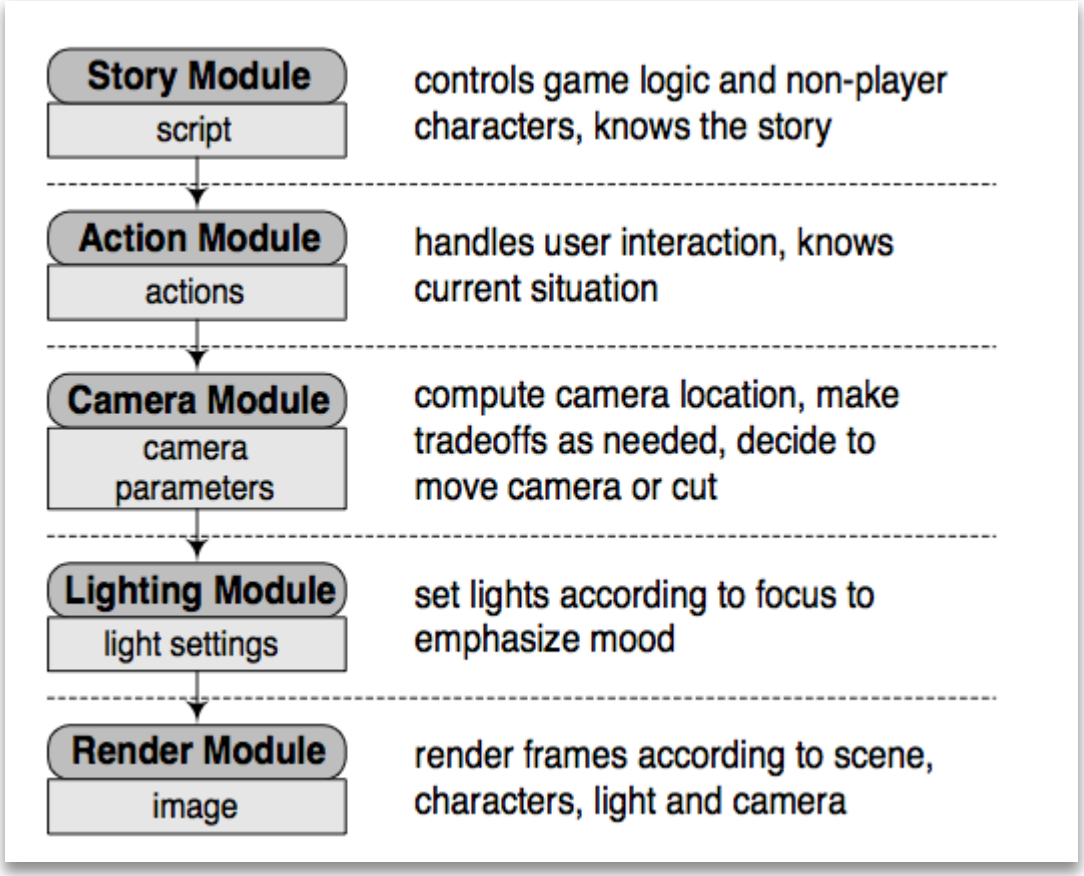
Earlier Approaches

- Interactive camera
  - allows user to change the camera view
  - may put too much burden on the player, e.g., Super Mario Sunshine

> **GameStop**: Needless to say, you spend most of your time in Super Mario Sunshine controlling Mario. But you'll also have to spend time controlling the game's camera. **Actually, much of the game's difficulty comes from having to keep the camera in check while performing Mario's otherwise simple tasks**.

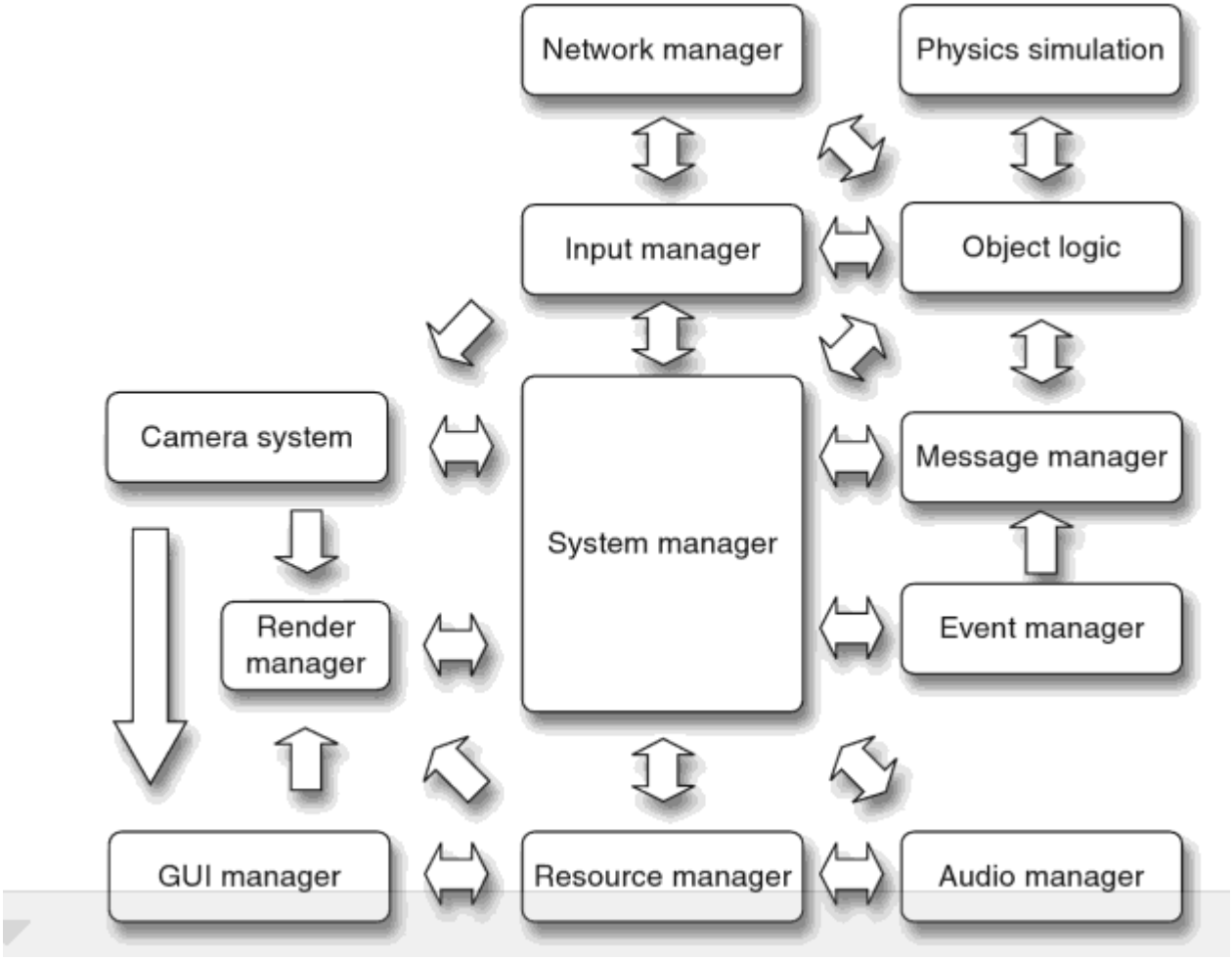
High-level Camera System

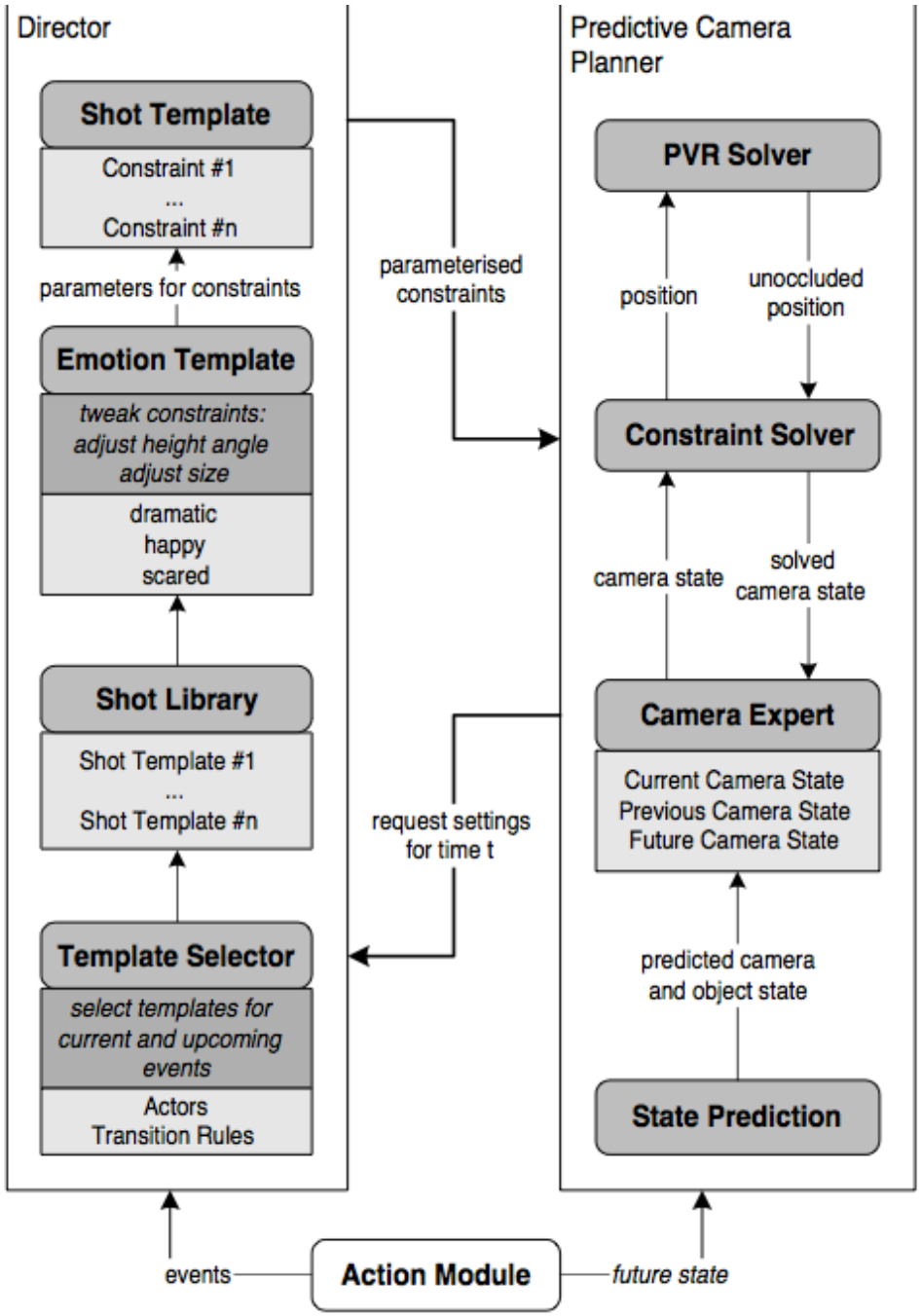
- Game pipeline



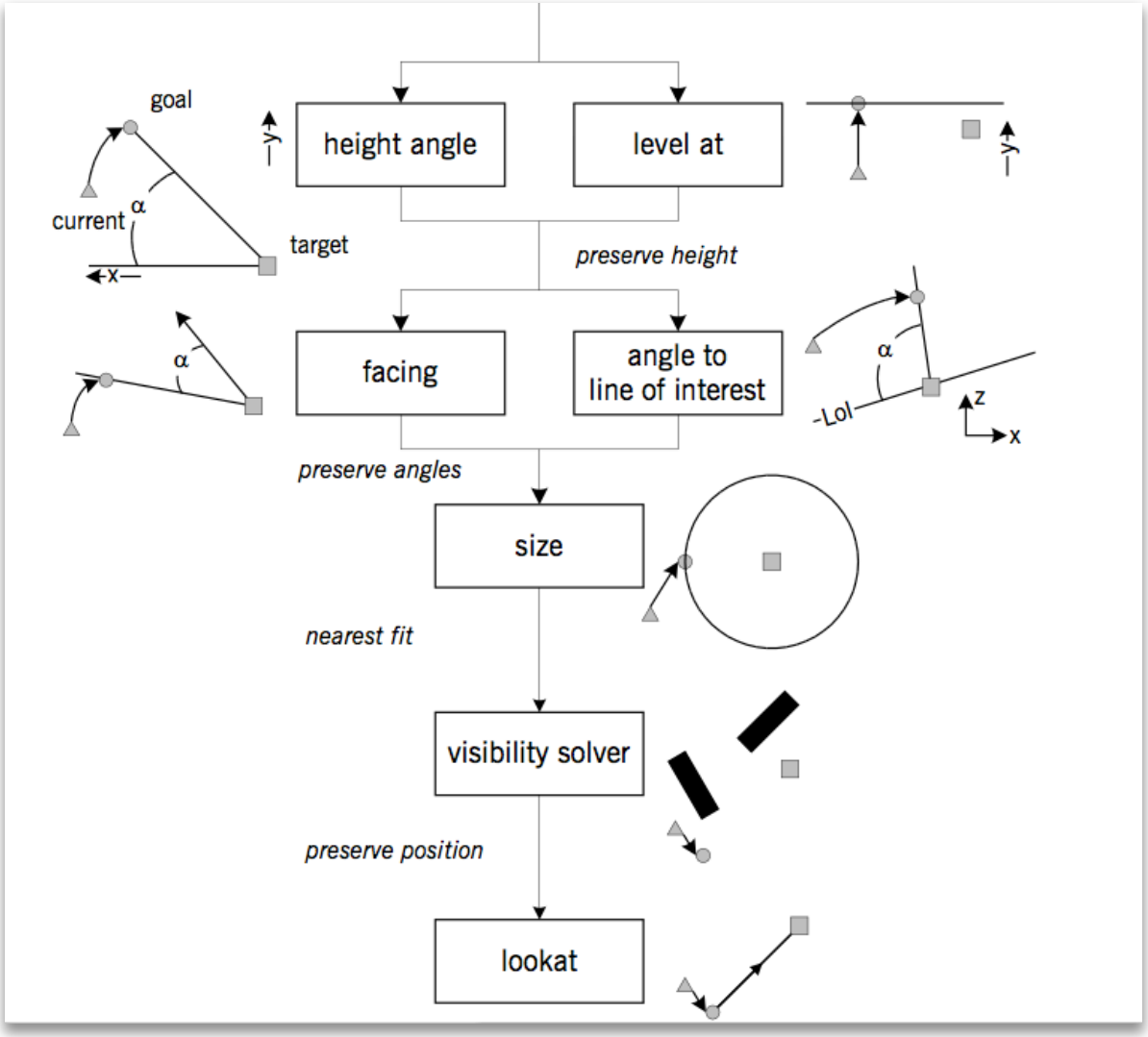
High-level Camera System

- another example




Director
Shot Template
Constraint #1
...
Constraint #n
parameters for constraints
Emotion Template
tweak constraints:
adjust height angle
adjust size
dramatic
happy
scared
Shot Library
Shot Template #1
...
Shot Template #n
Template Selector
select templates for
current and upcoming
events
Actors
Transition Rules
parameterised
constraints
request settings
for time t
Predictive Camera
Planner
PVR Solver
position
unoccluded
position
Constraint Solver
camera state
solved
camera state
Camera Expert
Current Camera State
Previous Camera State
Future Camera State
predicted camera
and object state
State Prediction
events
Action Module
future state

Constraints

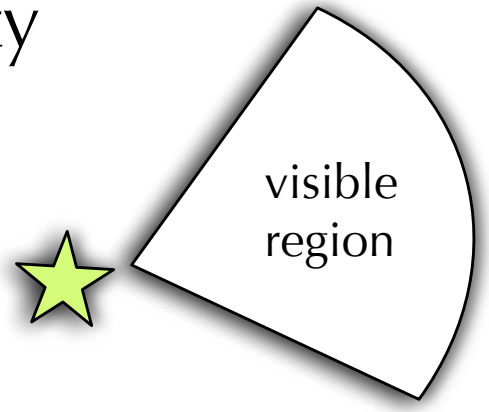


Camera Tracking in Game

- **Objective**

  Formulate motion strategy for mobile **camera** to track a **target** with **unknown trajectory** through a complex, but known environment

- **Constraints**
  - bounded velocity (both camera and target)
  - limited camera visibility
    - viewing angle
    - viewing range

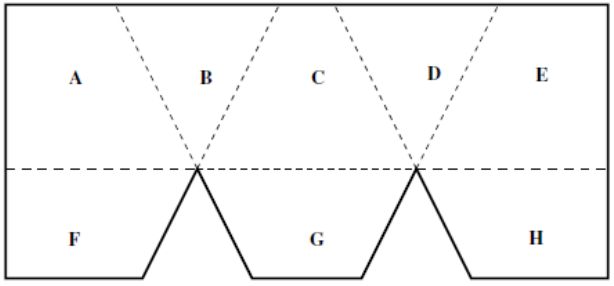


Camera Tracking in Game

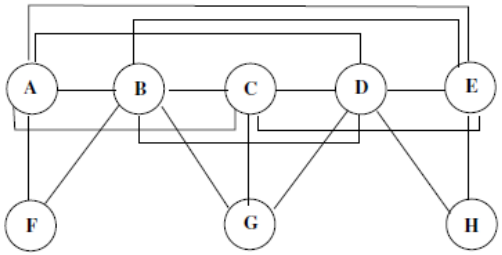
- **Characteristics of a Good Camera**
  - real-time tracking
  - maintain visibility of the targets as long as possible
  - predict and proactively cover occlusion risks
  - smooth motion
  - maintain the size of the target
  - provide good camera emotion (?)
  - use cinematography
- Many methods proposed in robotics and in computer graphics

Recent Work: Bad News

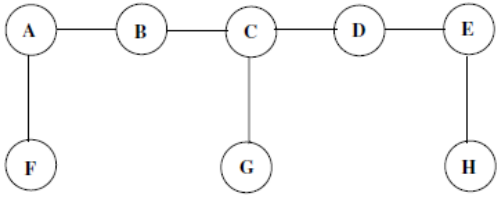
- *A complexity result for the pursuit-evasion game of maintaining visibility of a moving evader*
  - Murrieta-Cid, Paul Monroy, Seth Hutchinson, Jean-Paul Laumond
  - Defines the notion of Strong Mutual Visibility
  - The problem of deciding whether strong mutual visibility can be maintained for a given space is NP-complete



Polygon and region decomposition



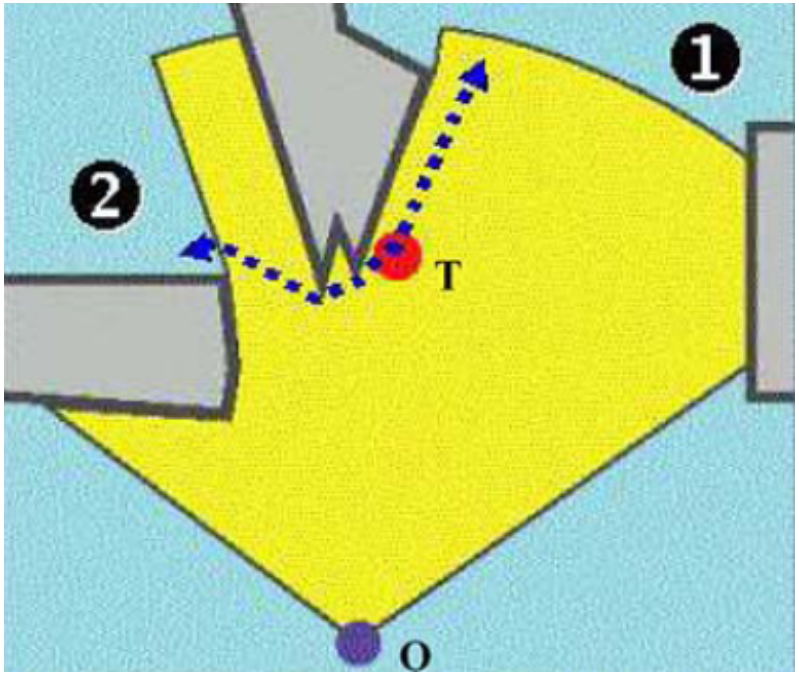
Mutual Visibility Regions Graph



Accessibility Graph

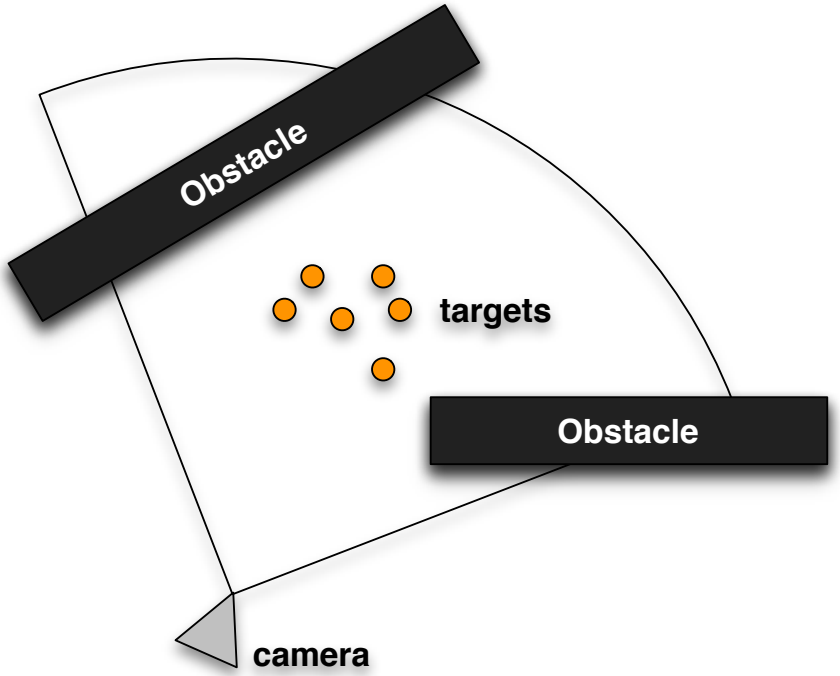
Recent Work

- *A Sampling-Based Motion Planning Approach to Maintain Visibility of Unpredictable Targets* [Murieta-Cid, Tovar, Hutchinson AuRo 2005]
  - Uses idea of *shortest distance to escape (SDE)*
  - Sample paths to maximize SDE



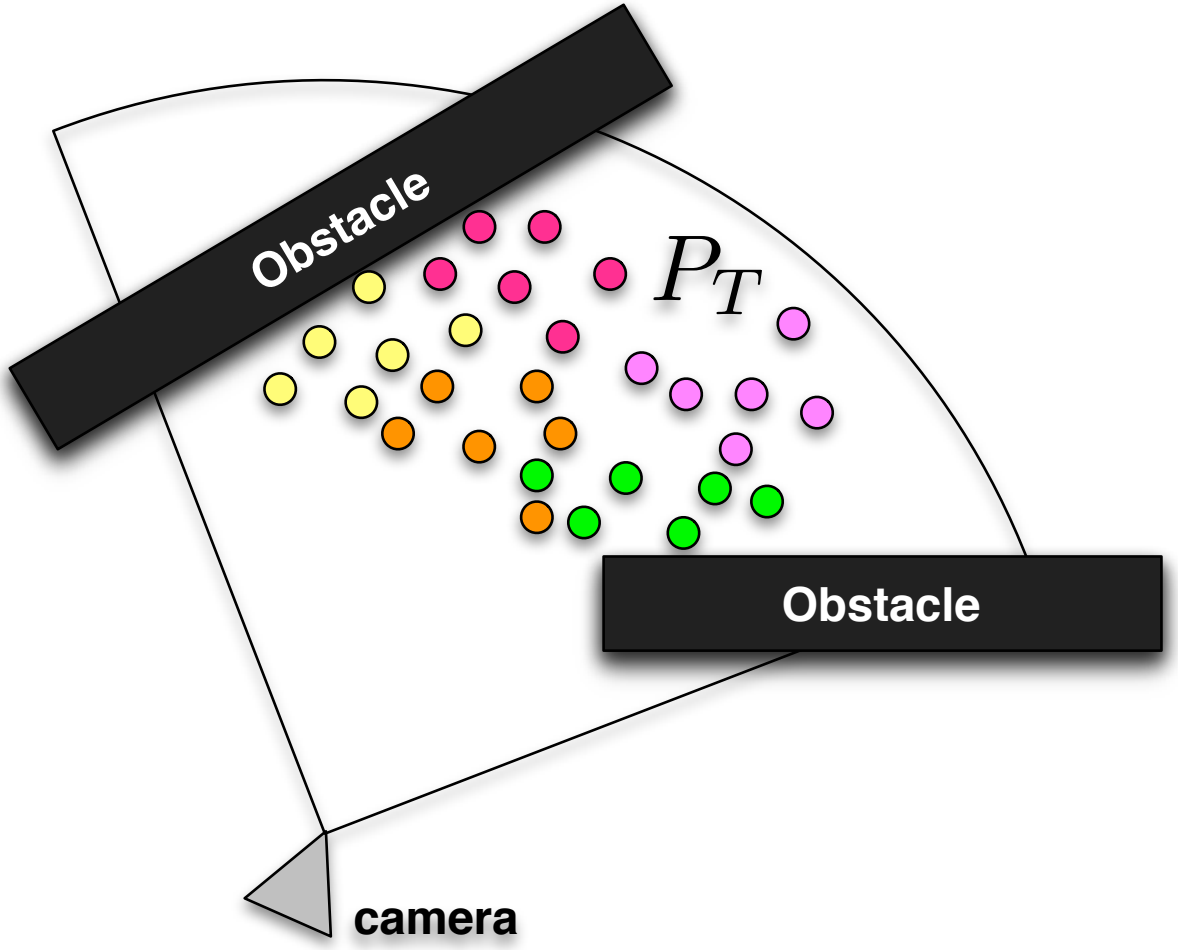
Recent Work

- **IO Camera**
  - Based on Becker et. al., *An Intelligent Observer* (1997)
  - Sample possible target and camera locations
  - Find the camera location that can see most targets



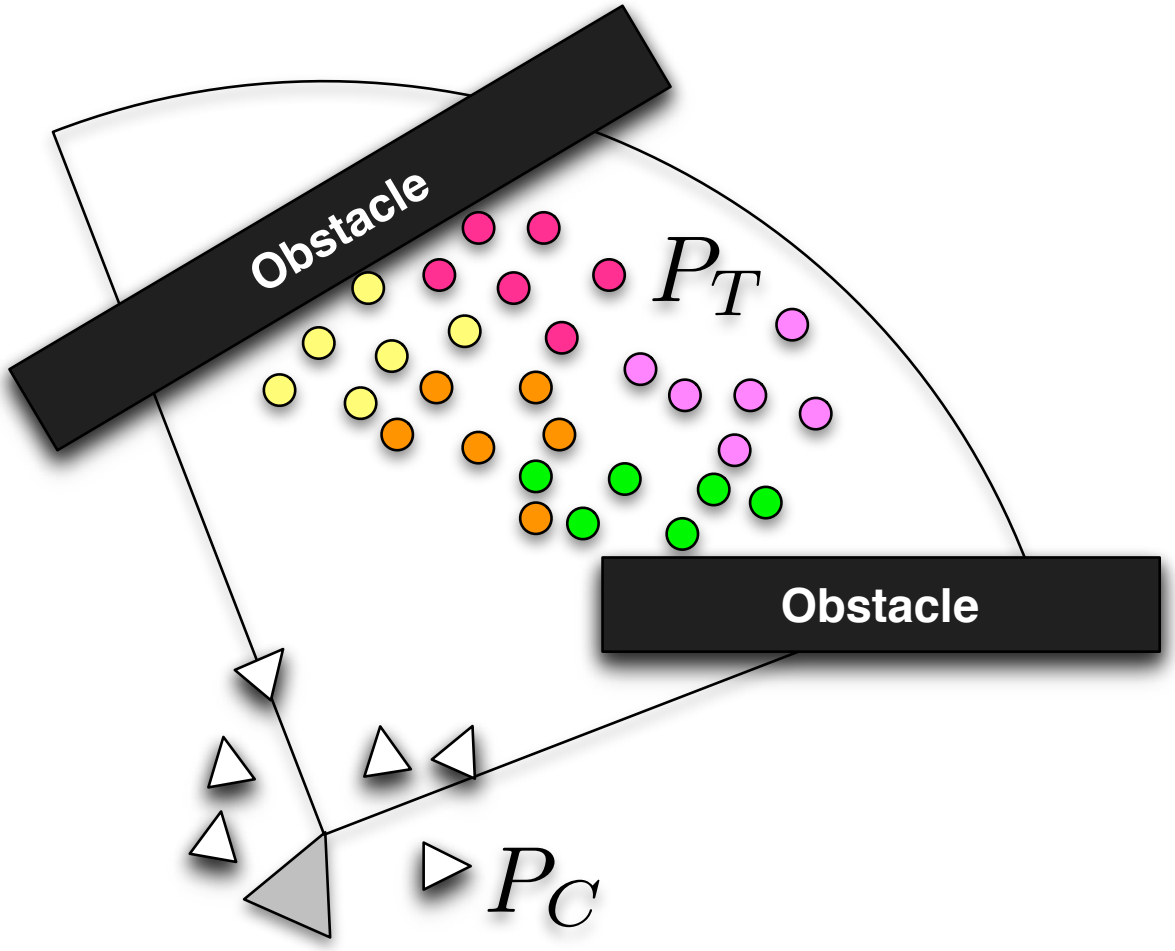
IO Camera

- sample around the targets



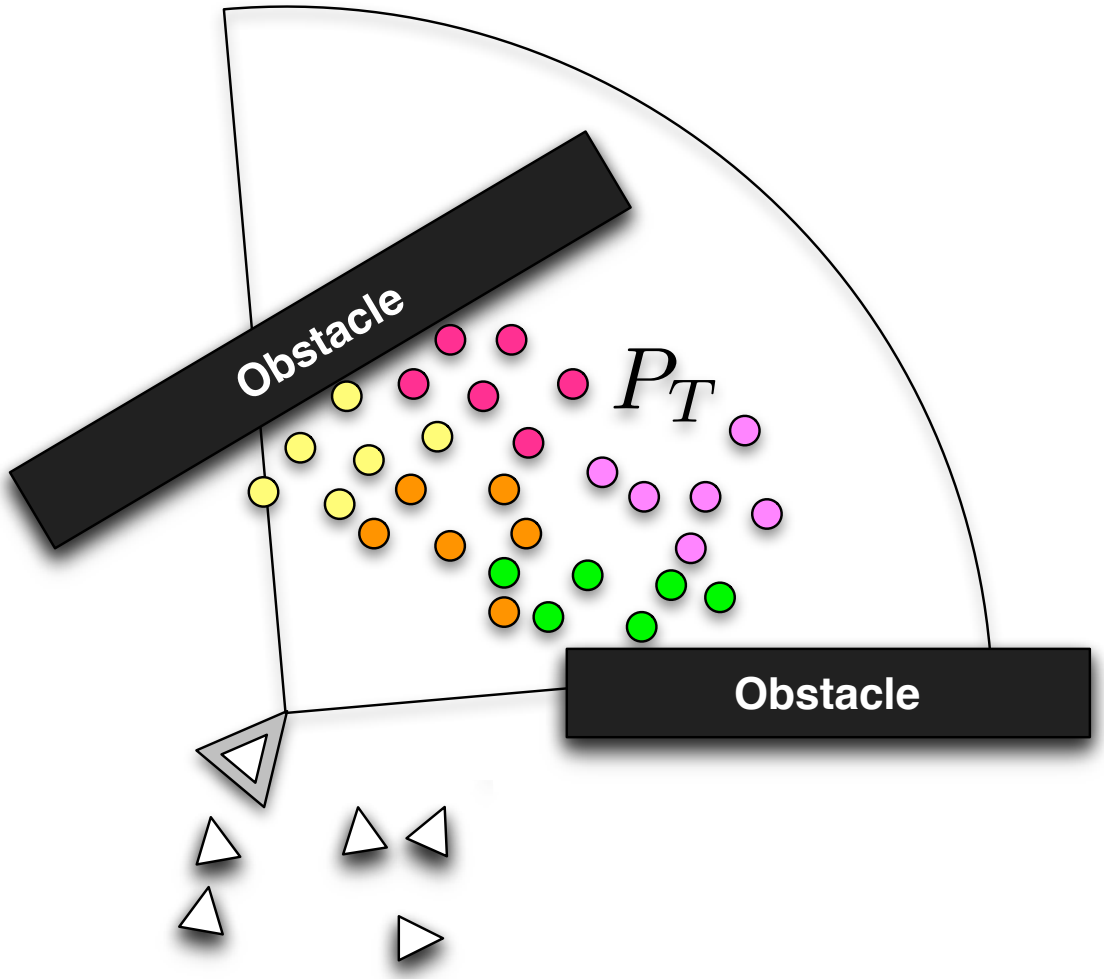
IO Camera

- sample around the camera



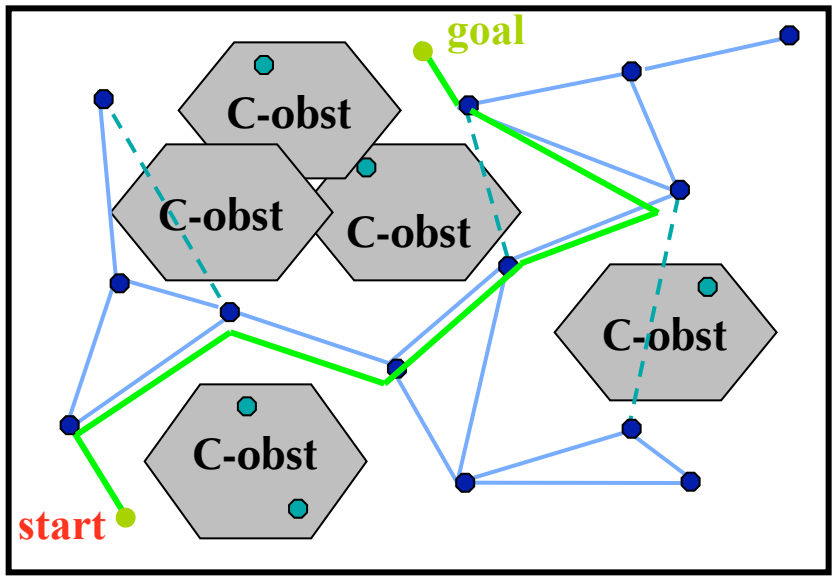
IO Camera

- move to the best position



Motion Planning

C-space



Roadmap Construction (Pre-processing)

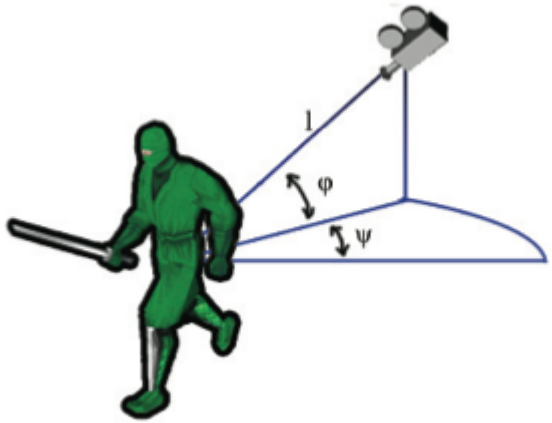
1. Randomly generate robot configurations (nodes)
   - discard nodes that are invalid
2. Connect pairs of nodes to form **roadmap**
   - simple, deterministic *local planner* (e.g., straightline)
   - discard paths that are invalid

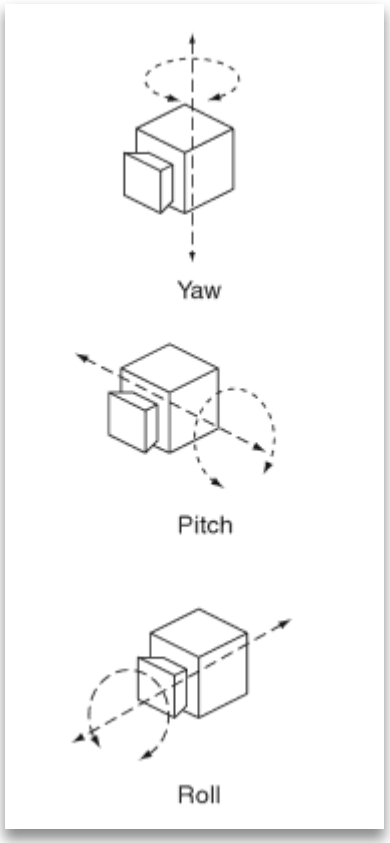
Query processing

1. Connect *start* and *goal* to roadmap
2. Find path in roadmap between *start* and *goal*
   - regenerate plans for edges in roadmap

Recent Work

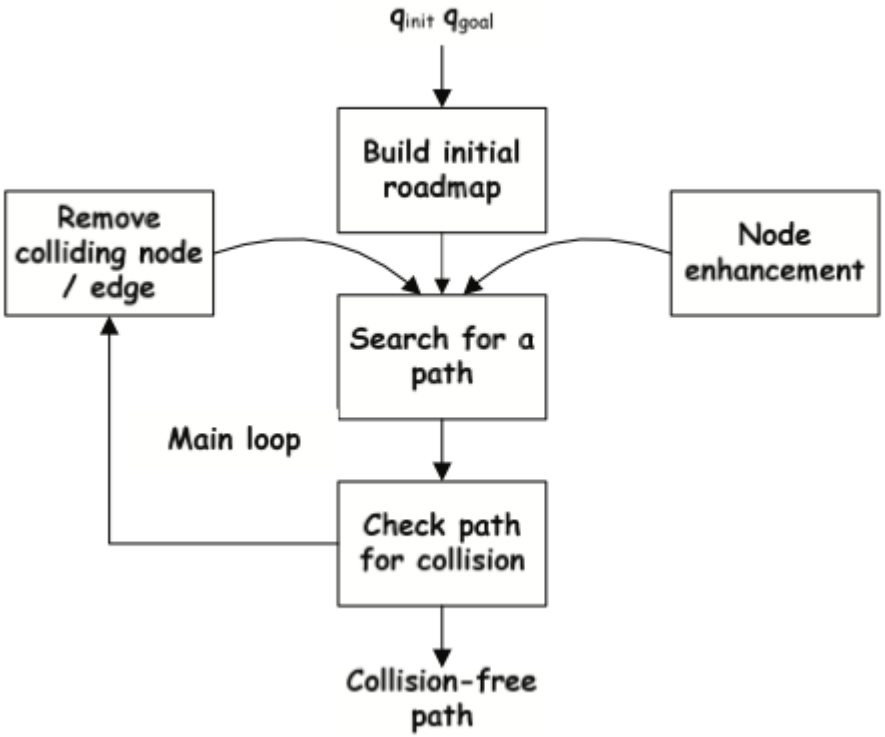
- Camera Configuration
  - two rotational angles
  - distance to the character





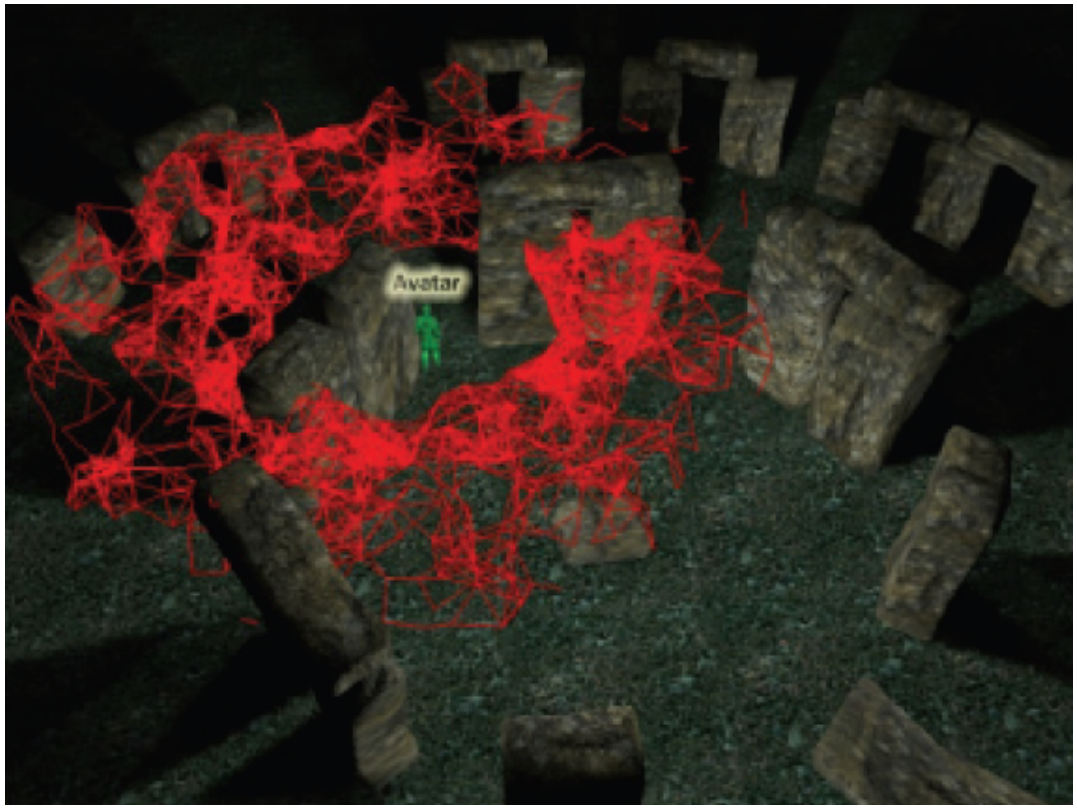
Recent Work

- Camera Planning



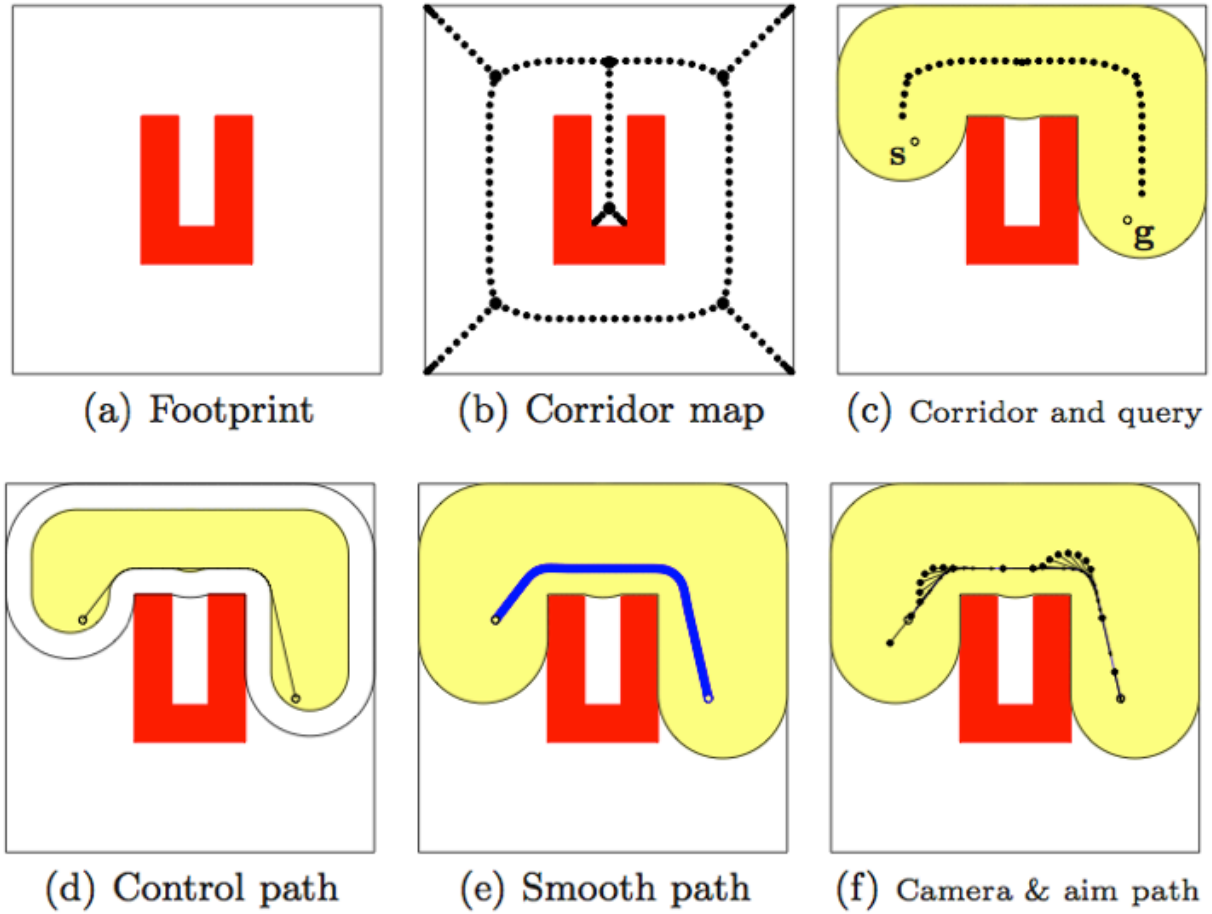
Recent Work

- *Real-Time Camera Planning for Navigation in Virtual Environments* [Li and Cheng Smart Graphics 2009]
  - Uses Lazy PRM, updated in real time



Recent Work

- *Camera Planning in Virtual Environments Using the Corridor Map Method* [Roland Geraerts MIG 2009]



(a) Footprint (b) Corridor map (c) Corridor and query

(d) Control path (e) Smooth path (f) Camera & aim path

Recent Work

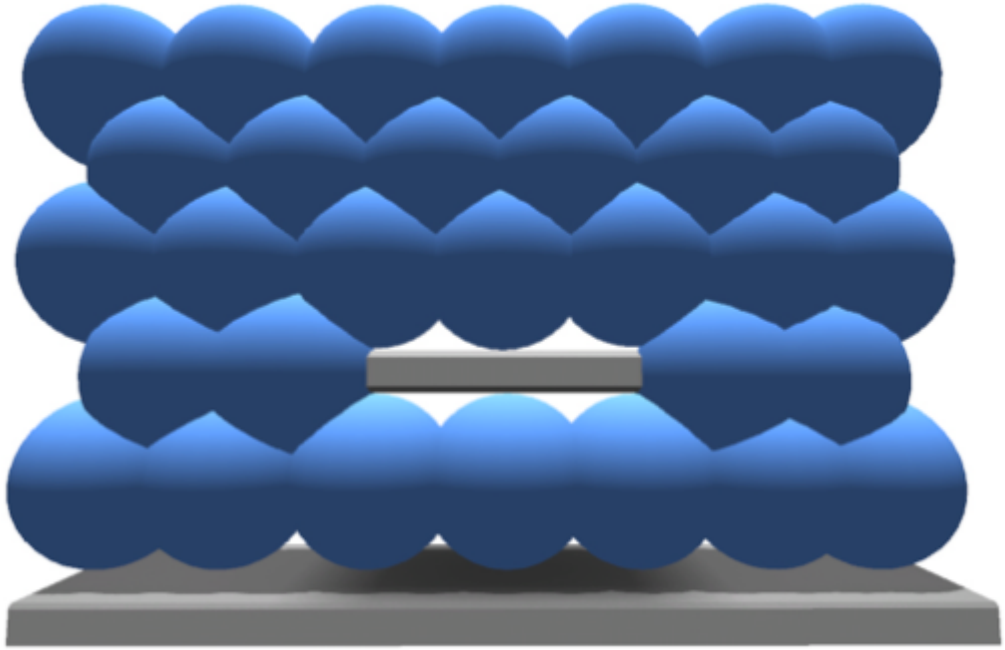
- *Camera Planning in Virtual Environments Using the Corridor Map Method*
  [Roland Geraerts MIG 2009]

Recent Work

- *Visibility transition planning for dynamic camera control* [Oskam et. al SCA 2009]
  - Sample visibility between spherical regions
  - Use visibility graph to plan “visibility-aware” paths

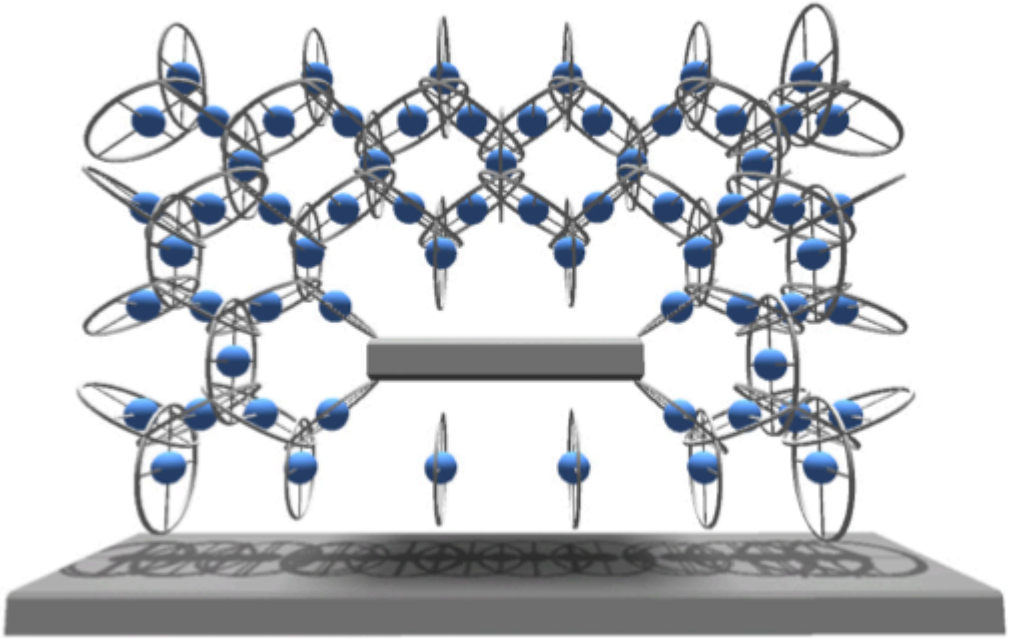
Visibility-aware Roadmap

- Free space sampled with spheres



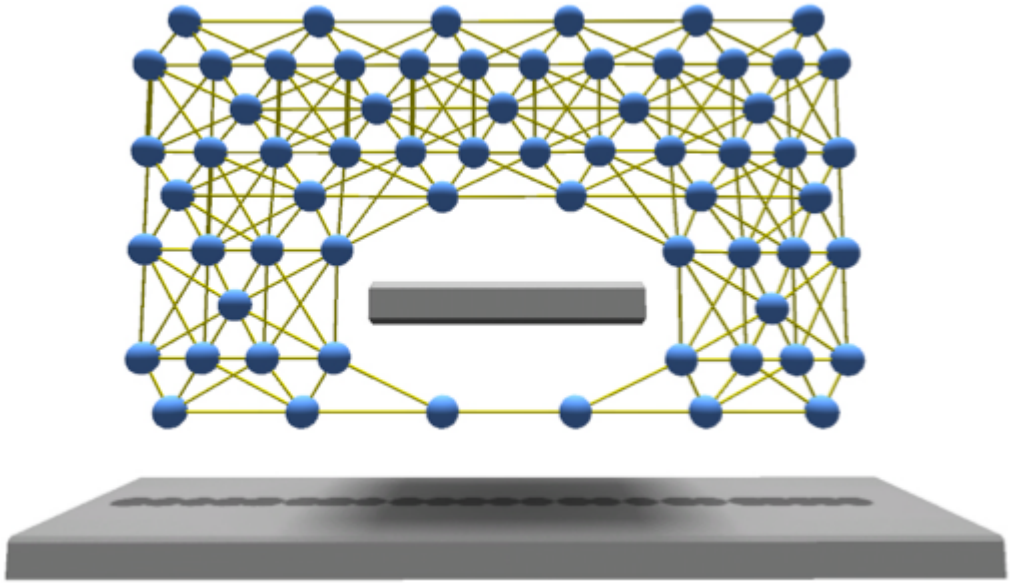
Visibility-aware Roadmap

- Compute portal regions for overlapping spheres



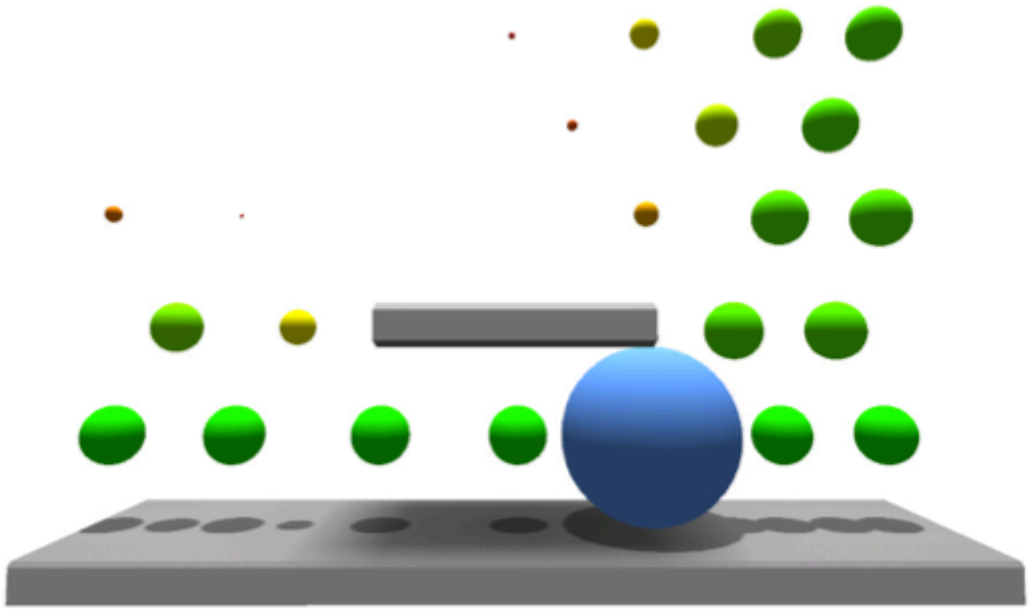
Visibility-aware Roadmap

- Construct roadmap from portals

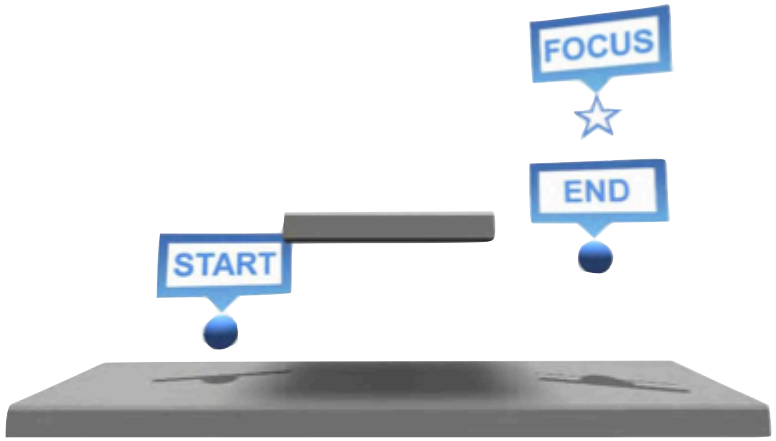


Visibility-aware Roadmap

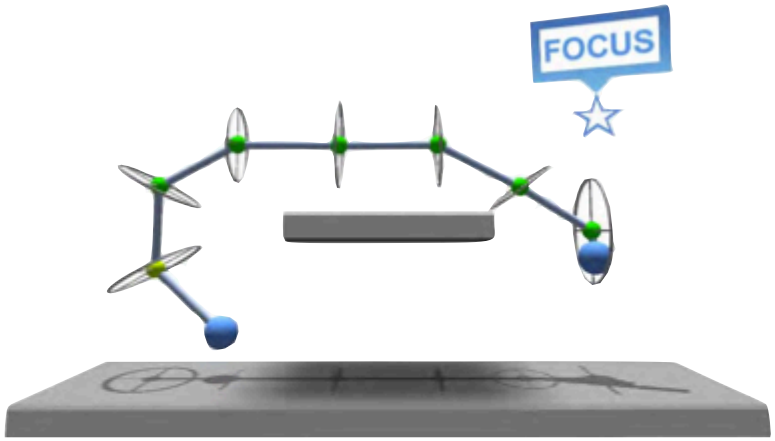
- Compute visibility for each pair of spheres



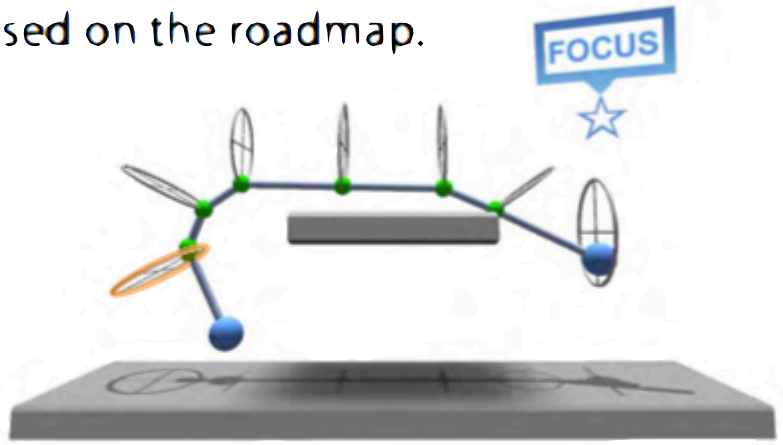
Visibility-aware Roadmap



Compute visibility aware path based on the roadmap.



Construct initial path along overlap regions.



Post-processed path within the overlap regions.

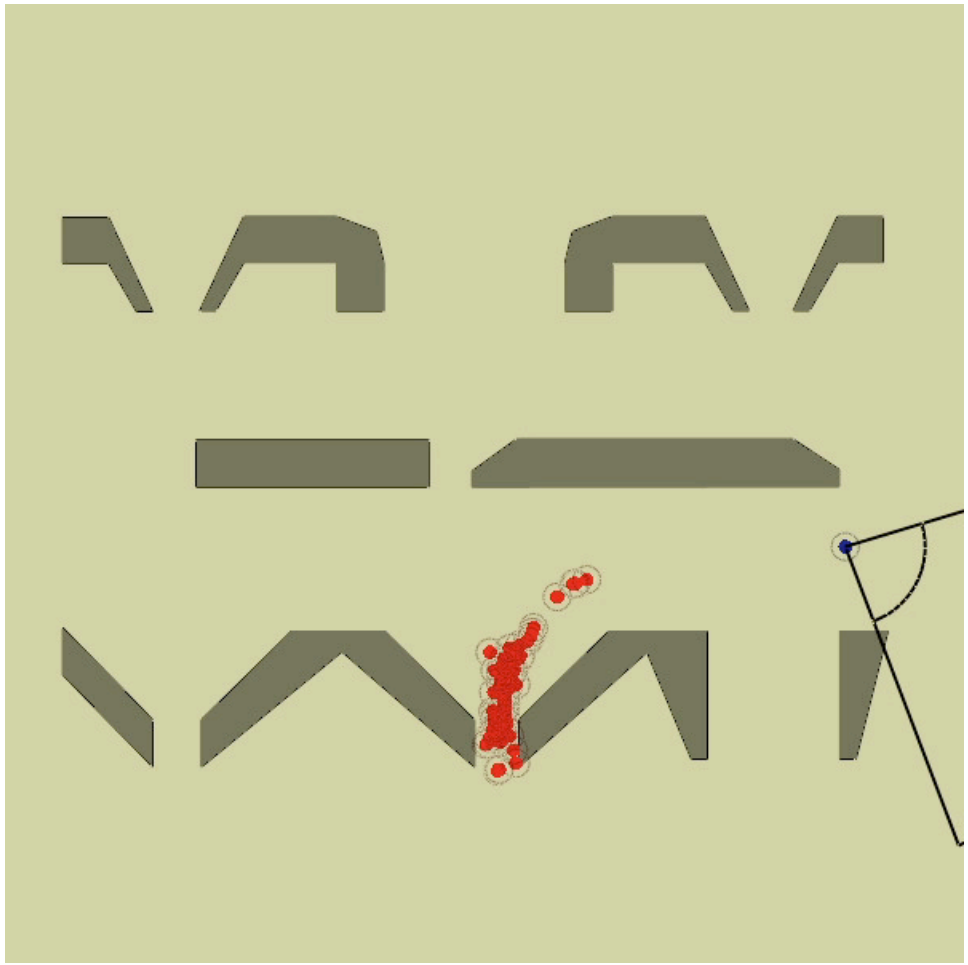
Traverse path with camera, recompute if the focus is moving.

Visibility-aware Roadmap

Our Work@GMU

- Tracking a group of agents

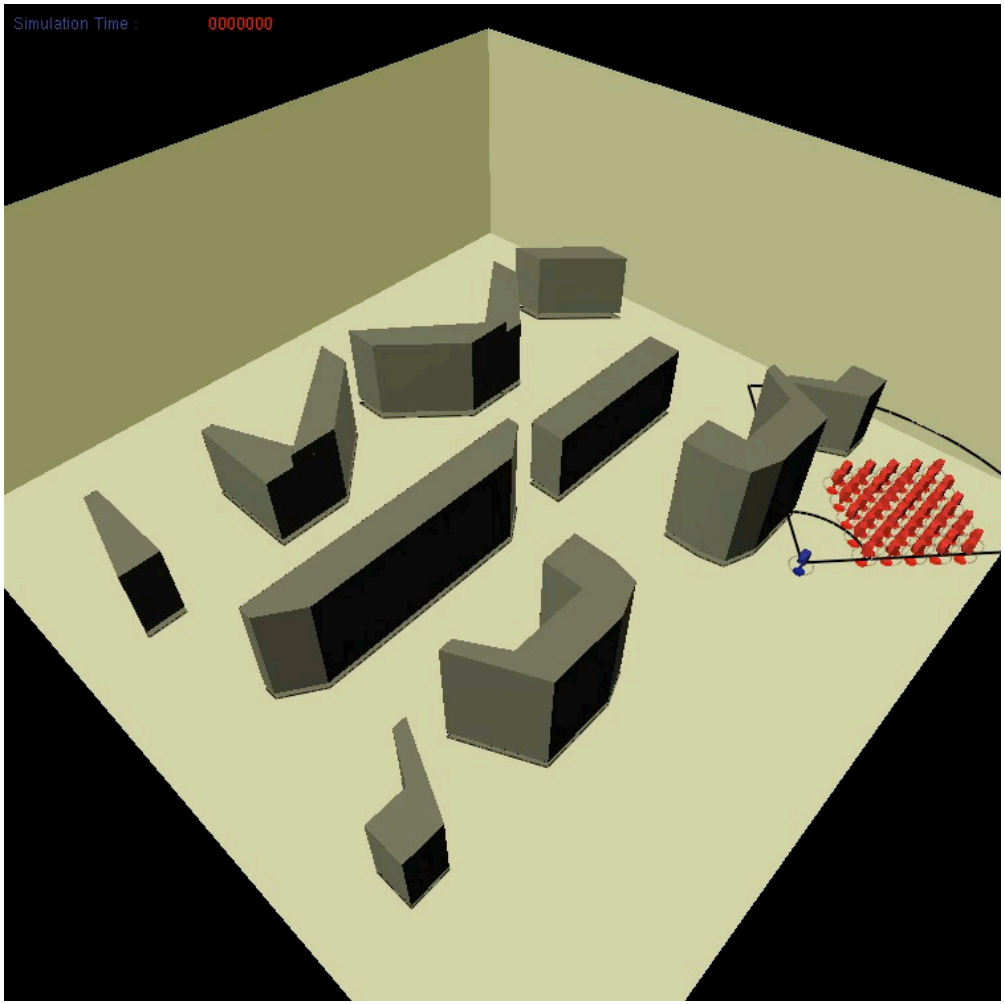
Reactive camera



Our Work@GMU

- Tracking a group of agents

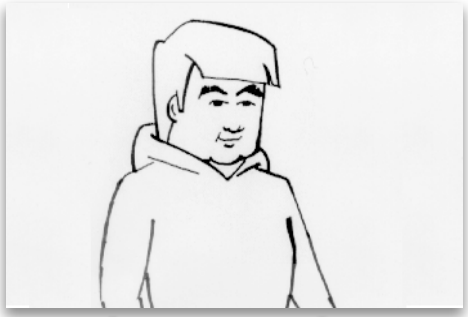
Planned camera



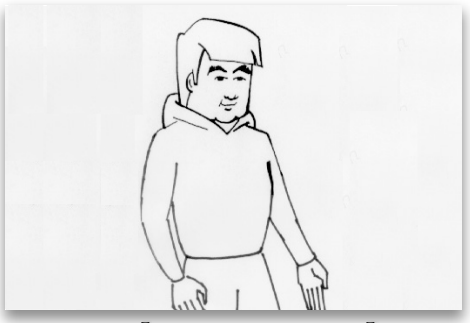
Principles of Cinematography

Camera distance

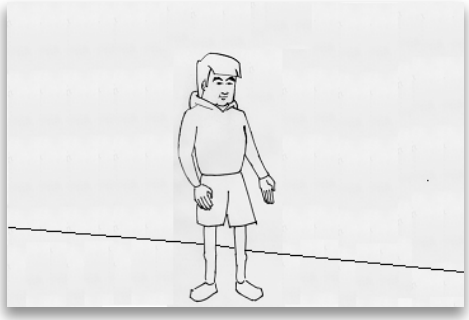
Close up



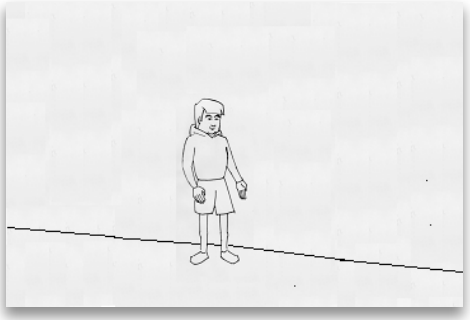
Close shot



Medium shot



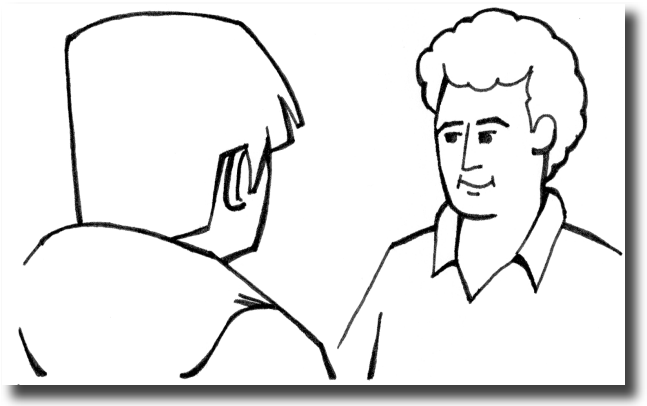
Full shot



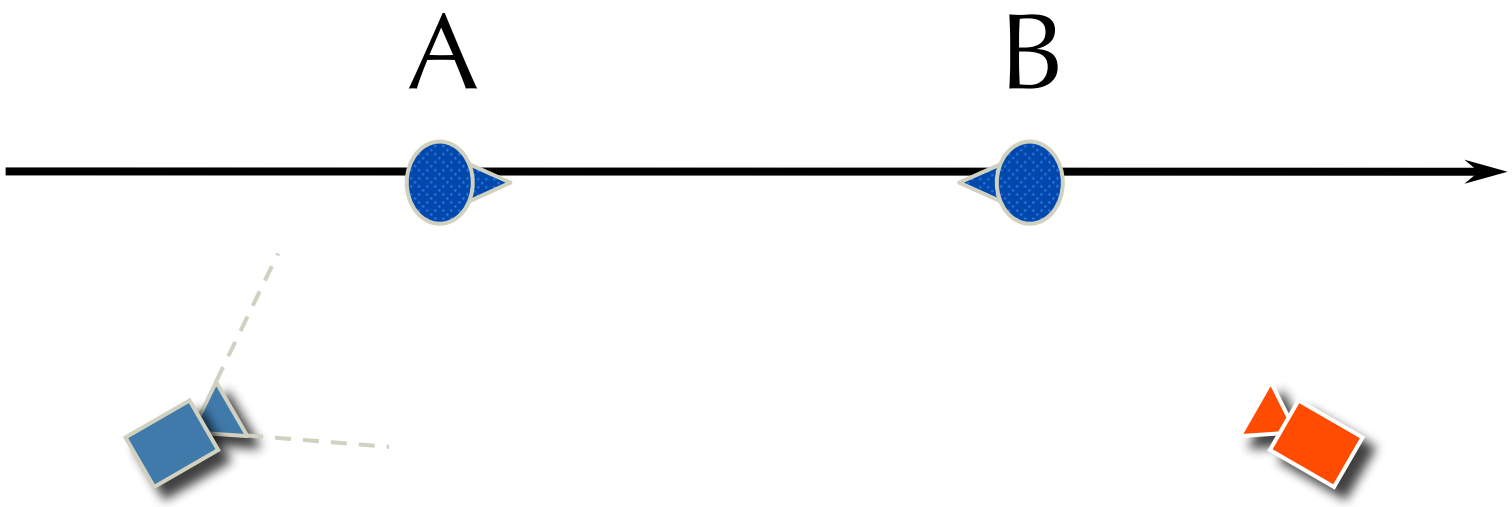
Long shot

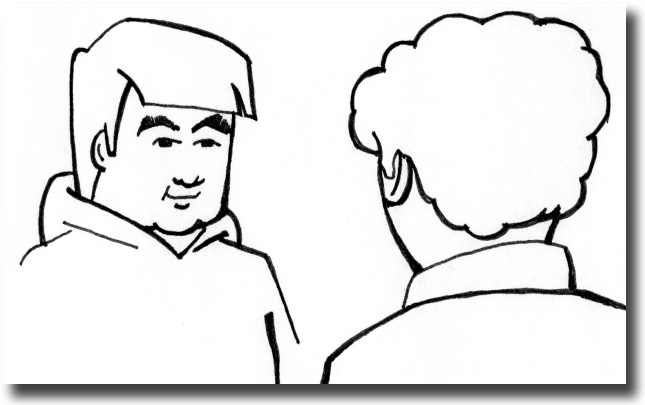
The Line of Interest

External Camera

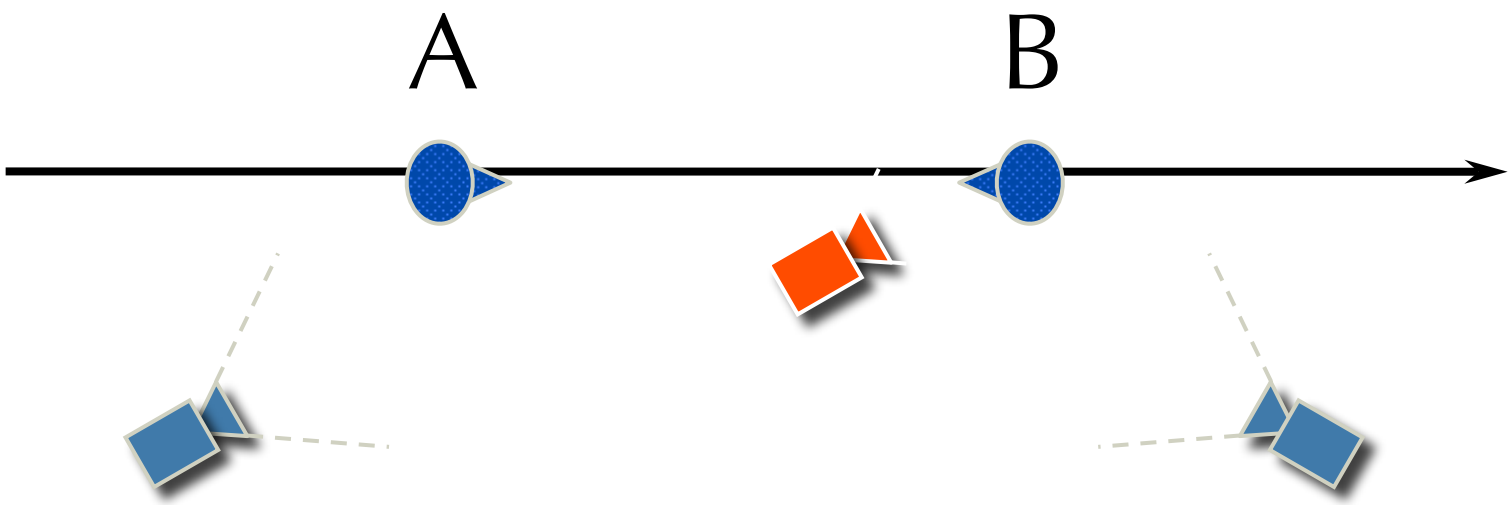


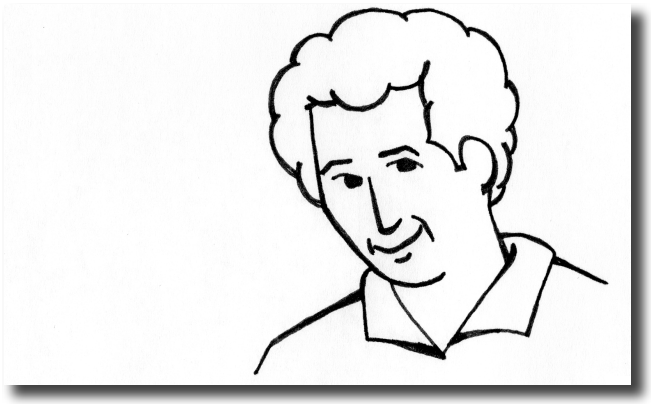
External Camera



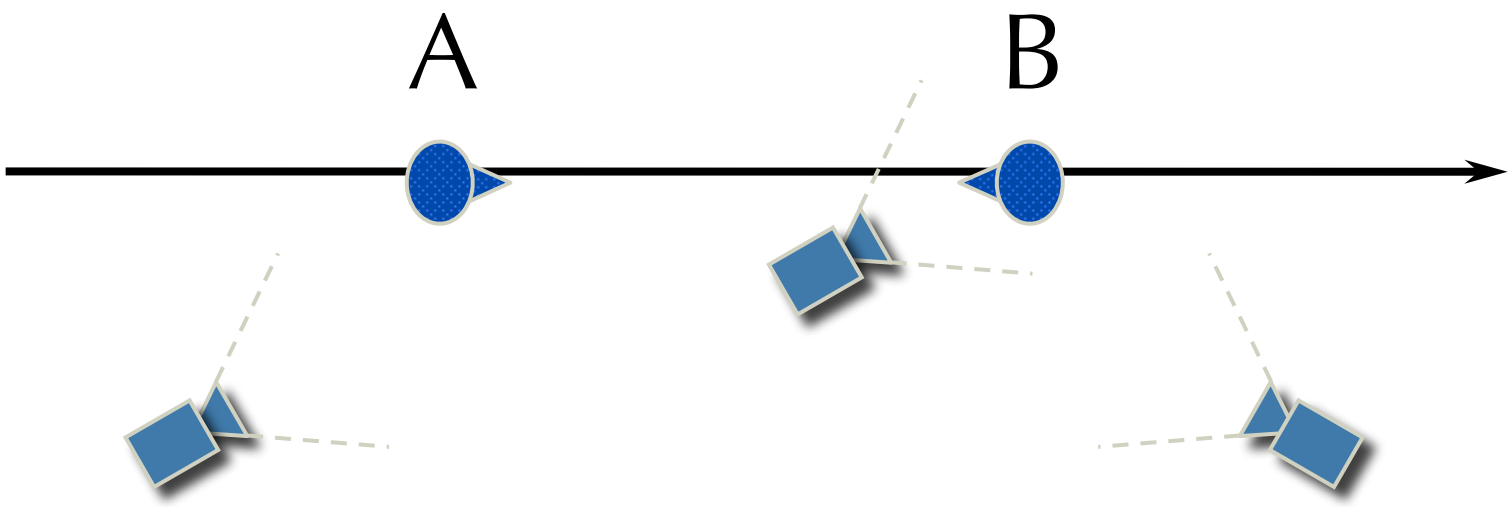


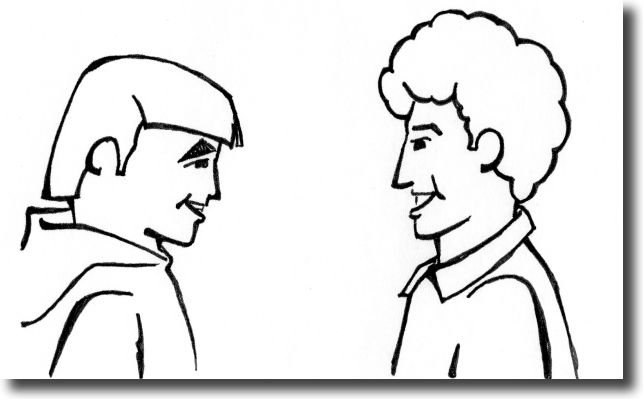
Internal Camera



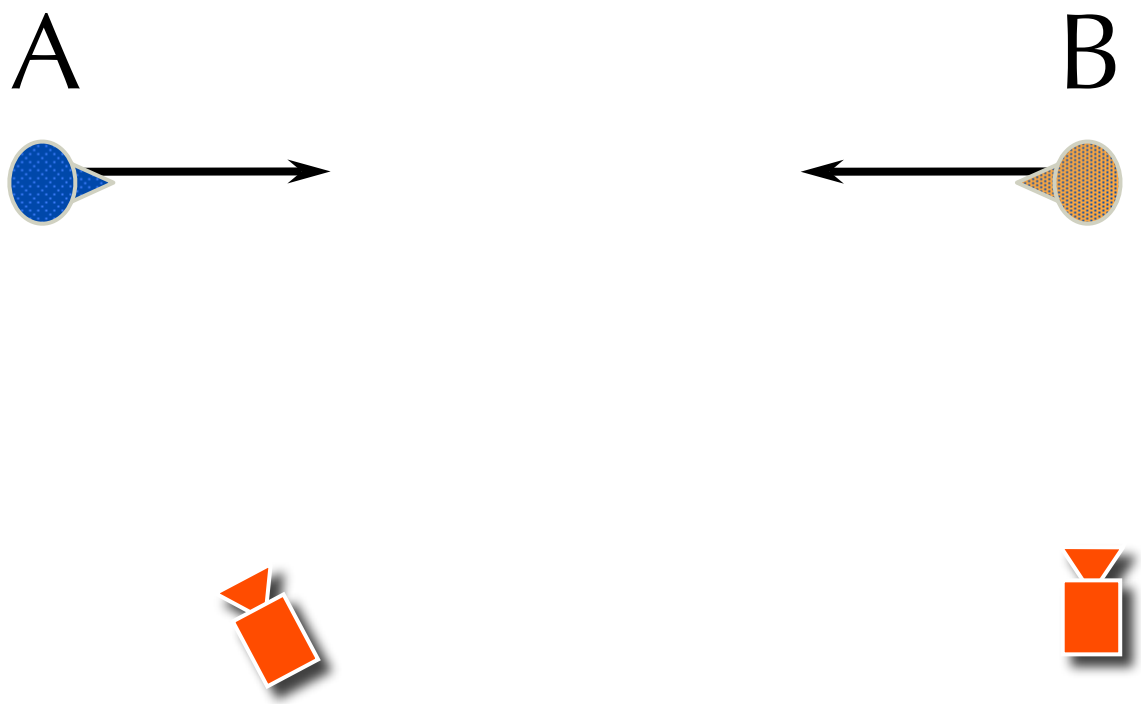


Apex camera





Moving cameras

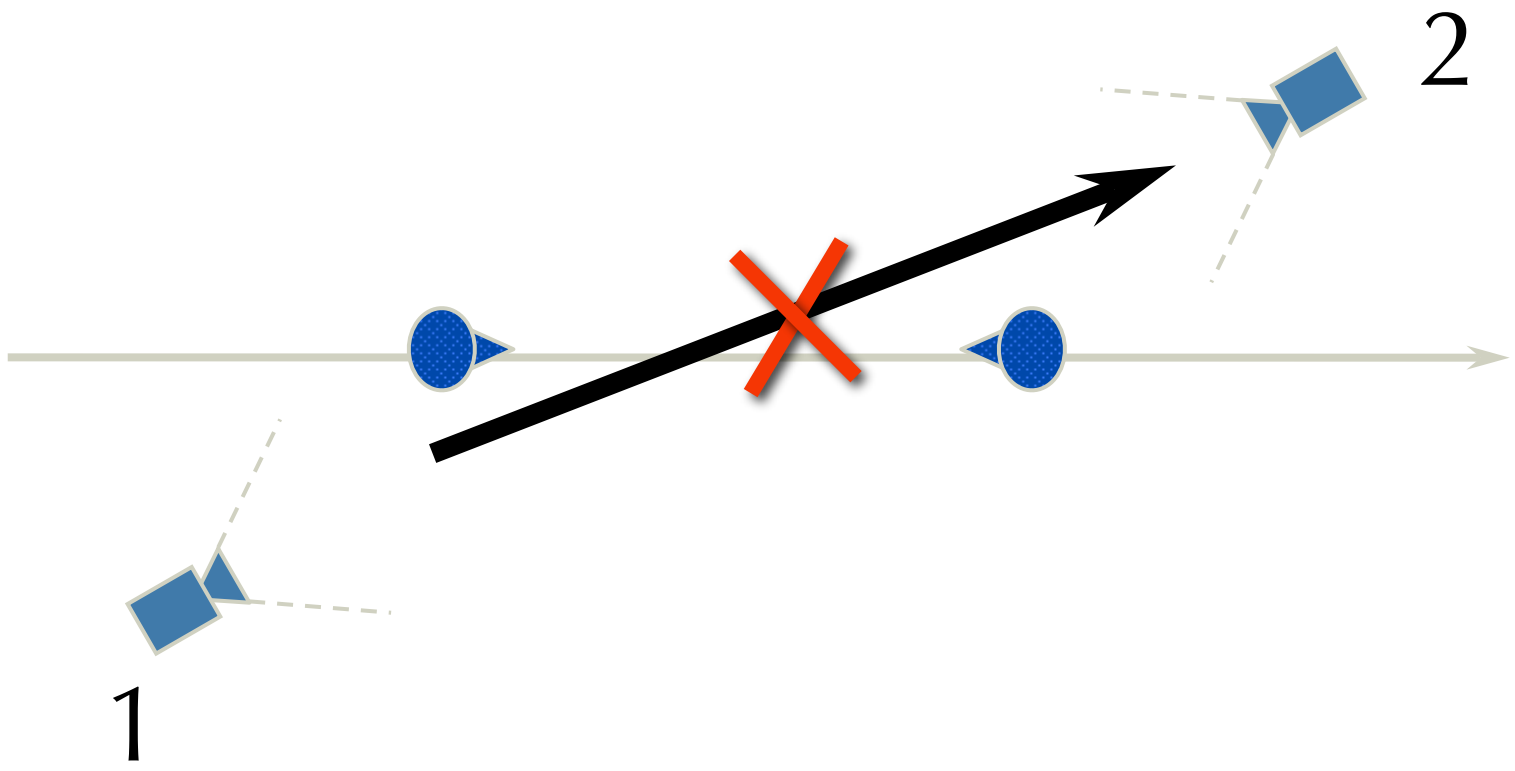


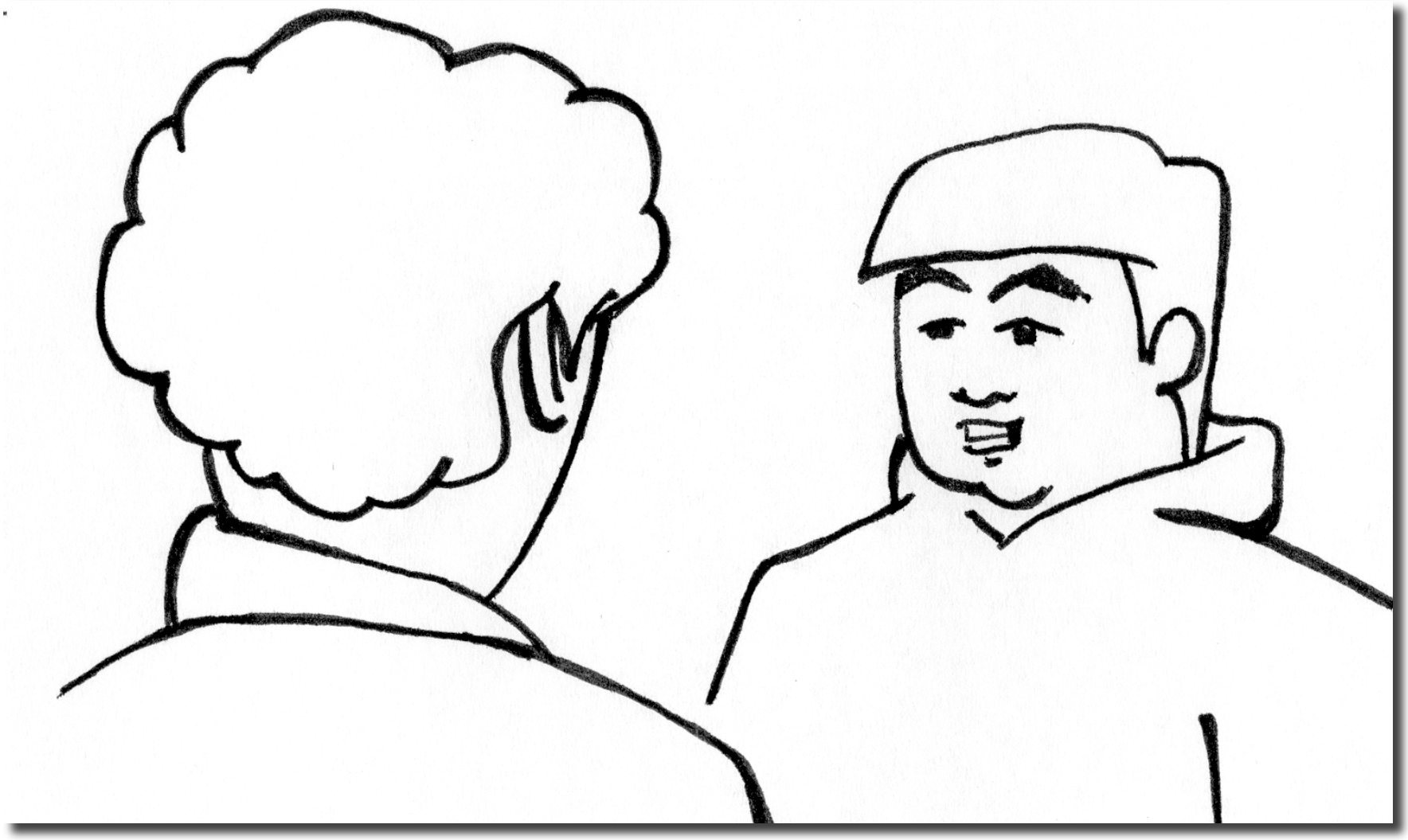
Some rules in film editing

Don't cross the line of interest

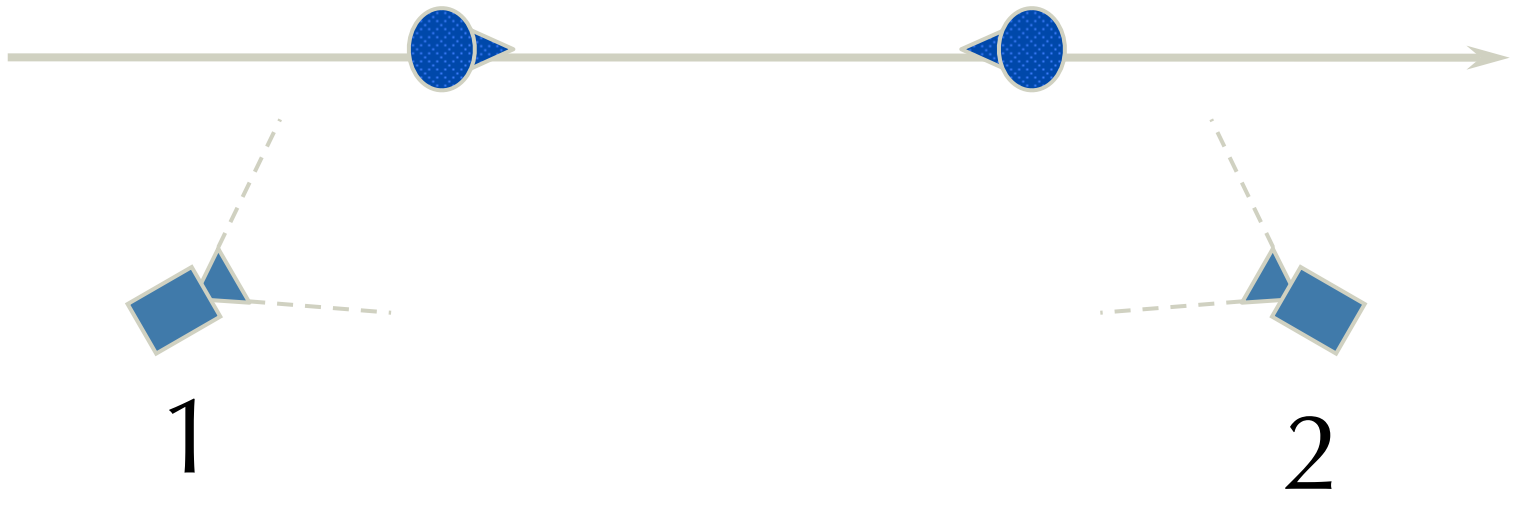
- Avoid jump cuts
- Let the actor lead
- Break movement

Don’t cross the line of interest





Don’t cross the line of interest

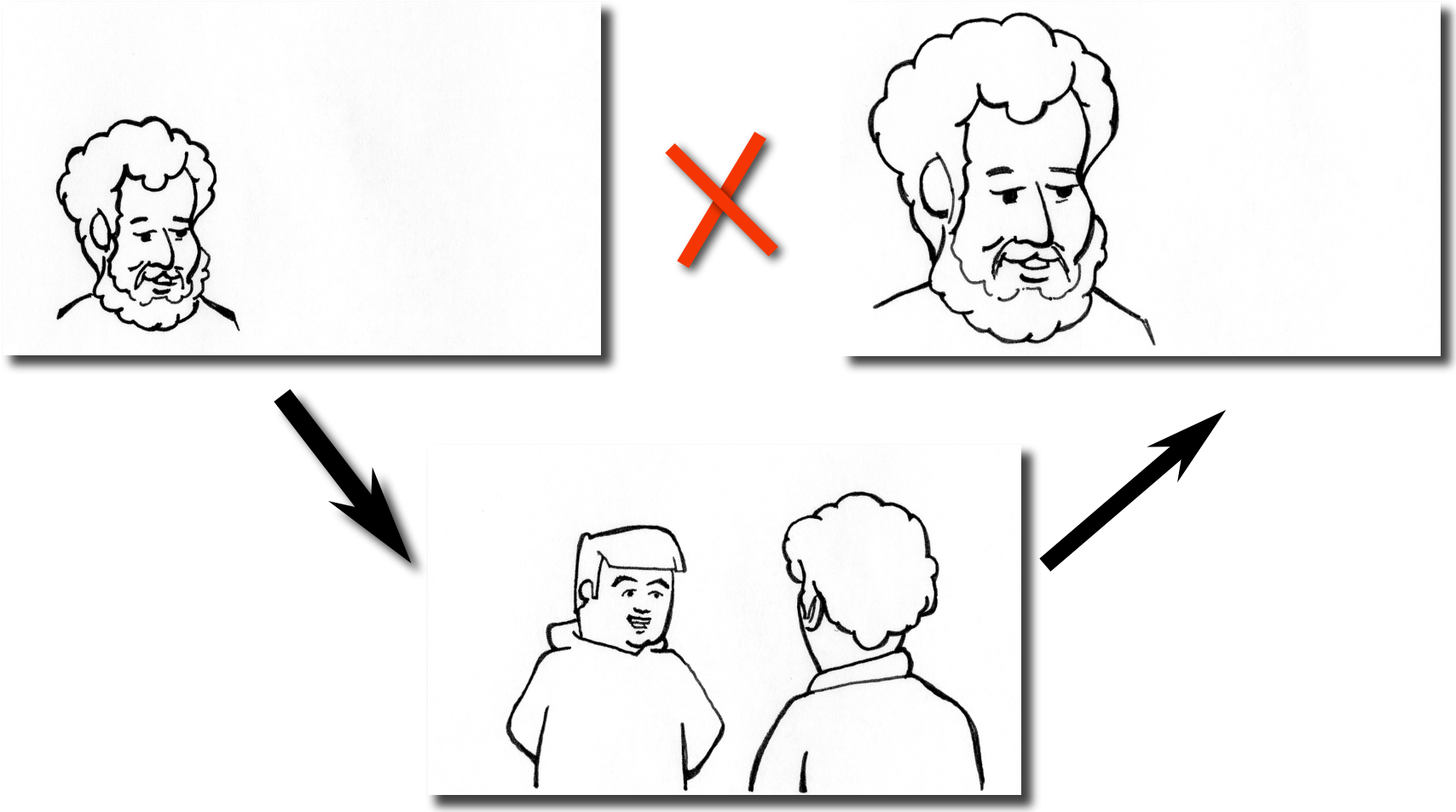


Some rules in film editing

- Don't cross the line of interest
- Avoid jump cuts
- Let the actor lead
- Break movement

Avoid jump cut

two sequential shots of the same subject are taken from camera positions that vary only slightly



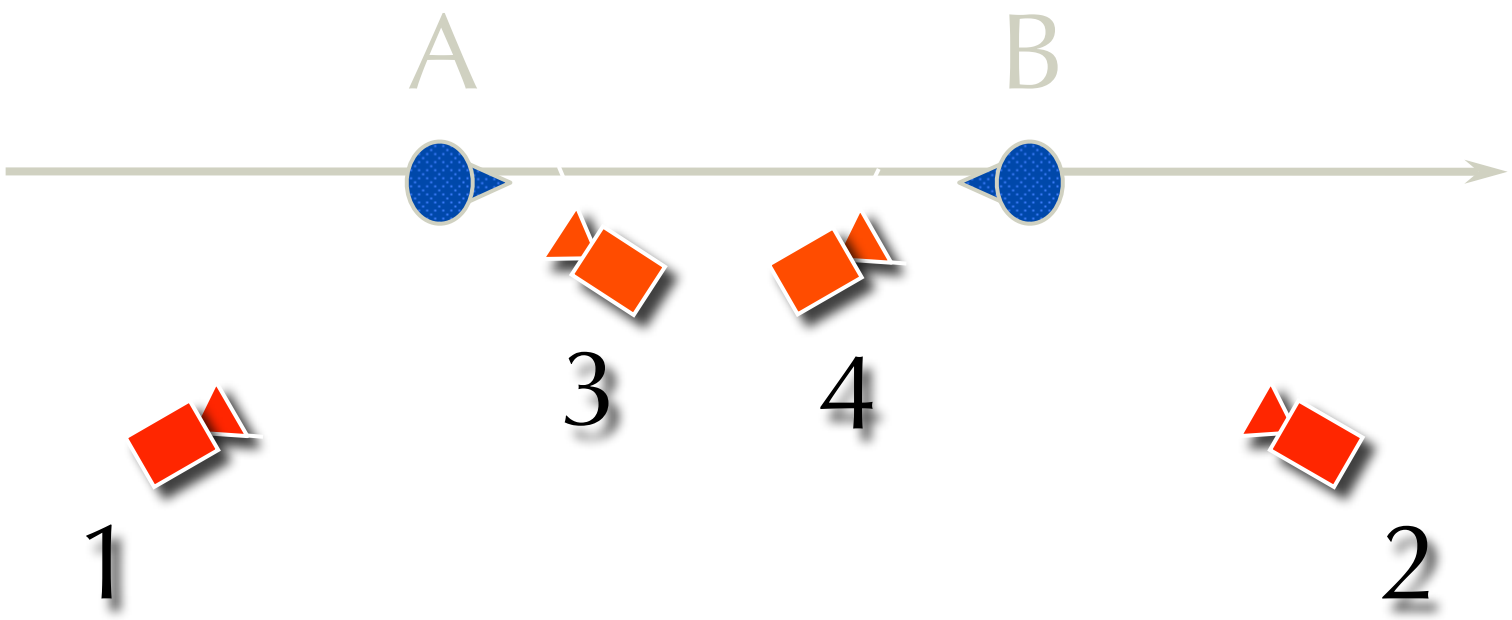
Some rules in film editing

- Don't cross the line of interest
- Avoid jump cuts

  Let the actor lead

  Break movement

Two-person conversation



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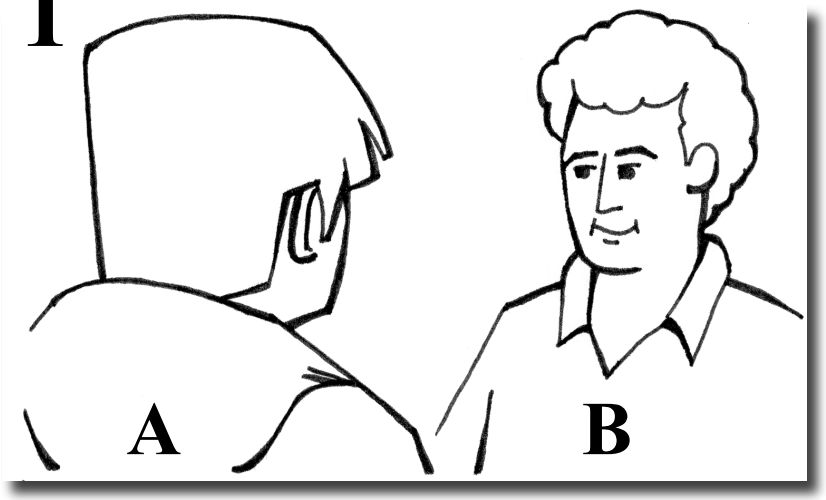

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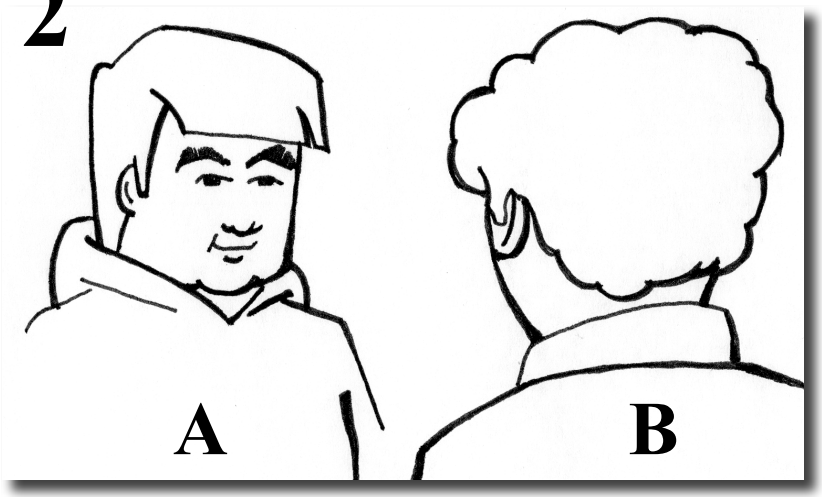

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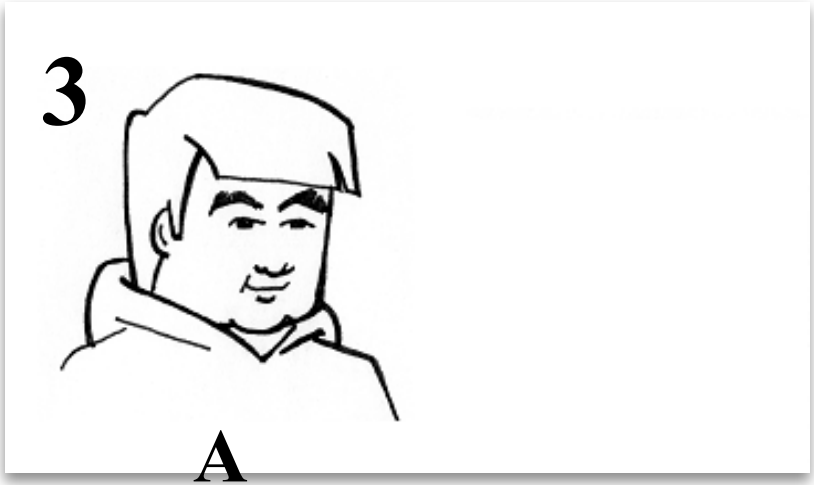

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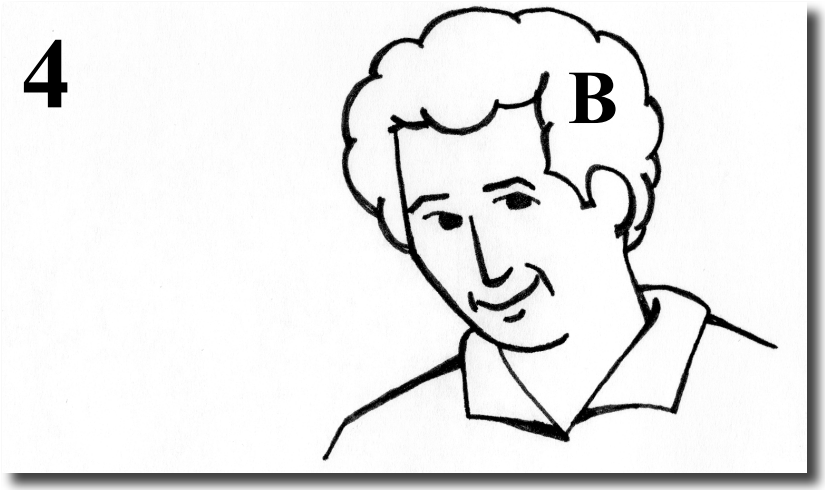
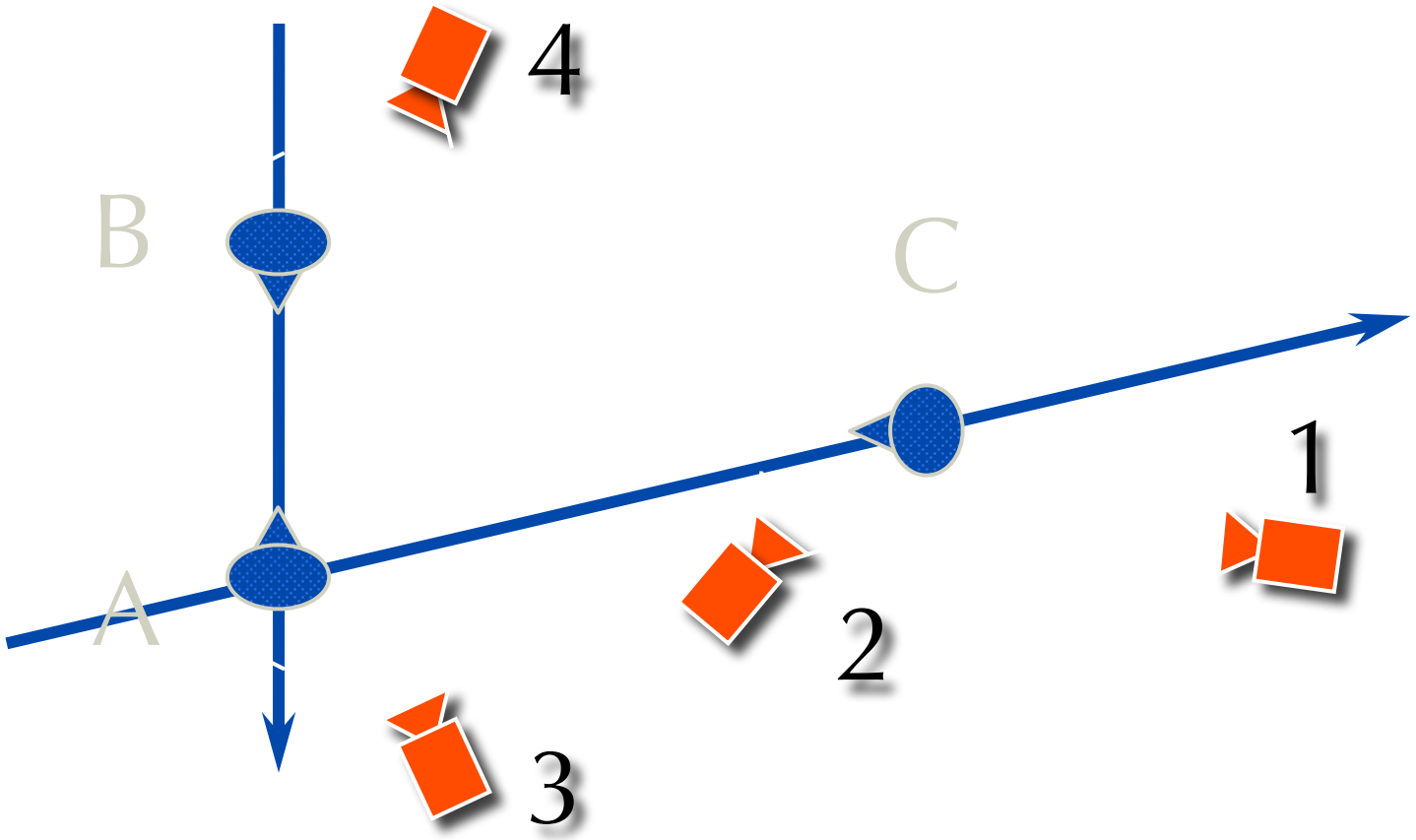


Three-person conversation



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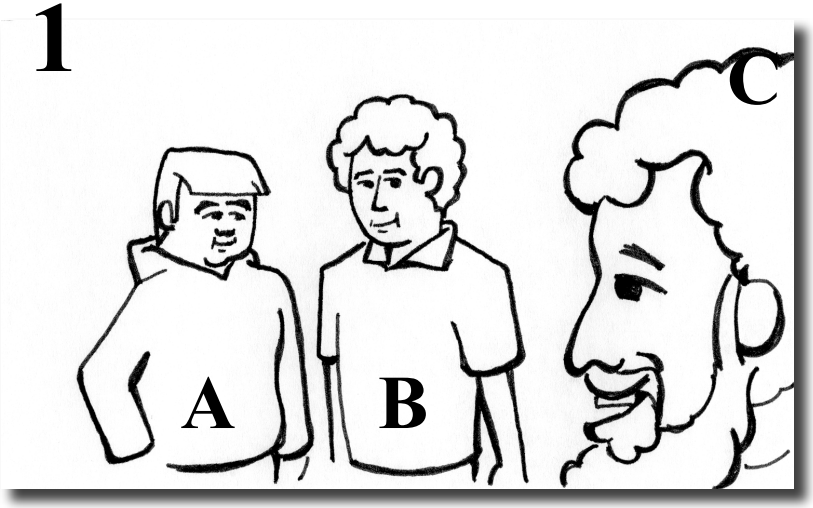

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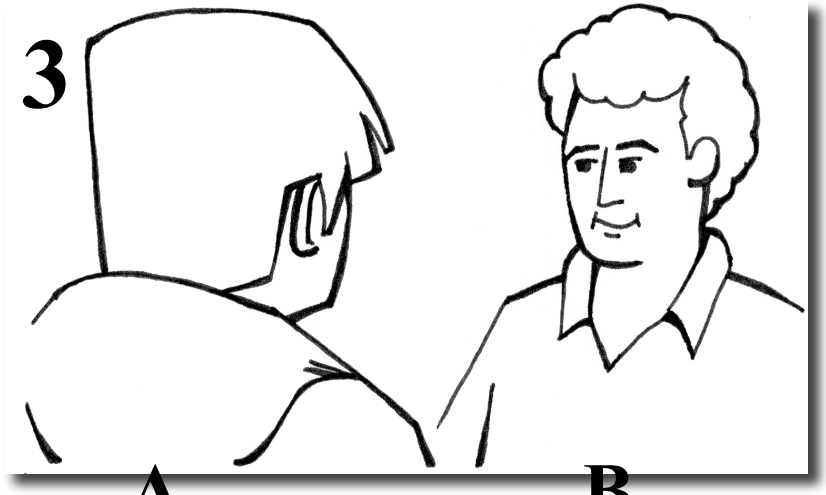


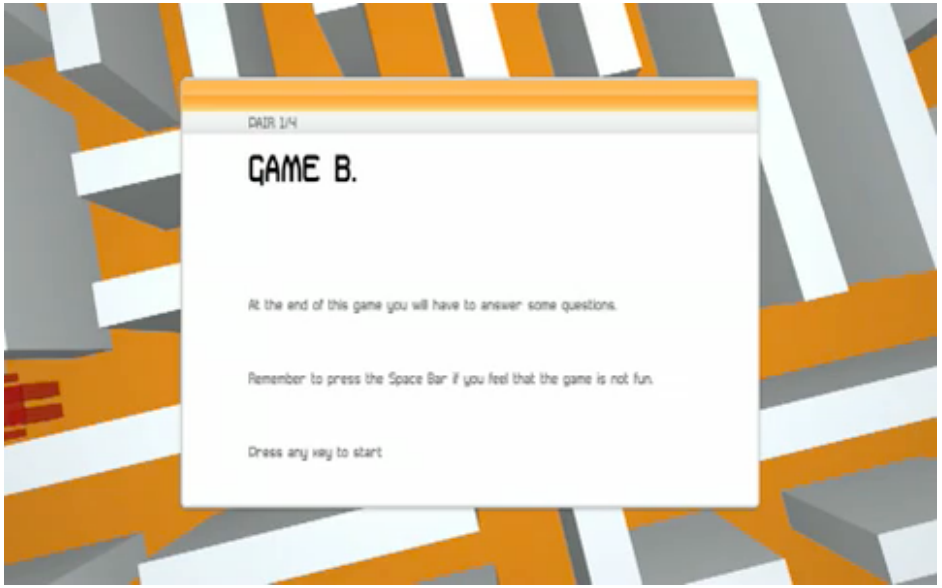
4

Bad

Good

Camera Tracking in Game

- Affective camera control



fixed camera profile

adaptive camera control