



Automatic Camera Tracking

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Overview



Objective:

- Automatic camera tracking, *Matchmoving*

Input:

- Images of largely static scenes (for now)

Output:

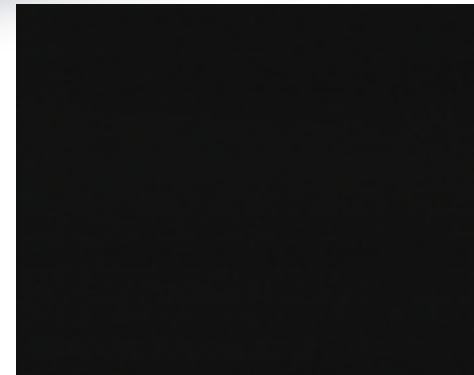
- Camera position for every frame
 - Rotation, translation + Ininsics

Applications



- Movies...
- Modelling...
- Architecture...

Application: Post Production



"Enemy at the Gates", Paramount Pictures, 2001

Enemy before and after



The basic method



- Tracking of high-contrast features
 - point tracks over multiple views
 - matching using multiview tensors
 - camera initialization/autocalibration
 - robust bundle adjustment for P, X
- Large 100000 parameters estimation
 - ~ 1M parameters in 5000 frame sequences

The problems



Past...

1. Track lifetime
2. Degeneracy/critical surfaces
3. Lens distortion
4. Incorporating constraints

Future...

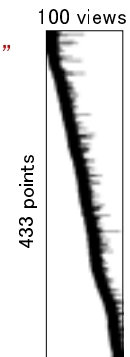
1. Non-static scenes
2. Multiple sequences

Problem I: Track lifetime



Sequences with tracks from start to end are "easy"

- In practice, obtain short tracks due to
 - Large translation
 - Camera pan
 - Foreground occlusion
 - Tracking failure



Track lifetime



Large translation



Tracking difficulty



Camera pan & foreground occlusion

Strategies for short-lived tracks



- **Sequential**
 - Bootstrap using 3-view reconstruction
 - Merge new structure through sequence
- **Hierarchical**
 - Compute independent 3-view reconstructions
 - Combine overlapping reconstructions
- **Bundle adjustment**
 - Crucial adjunct to all techniques
- **Need:**
 - Projective factorization ...
 - ... with missing data/covariances

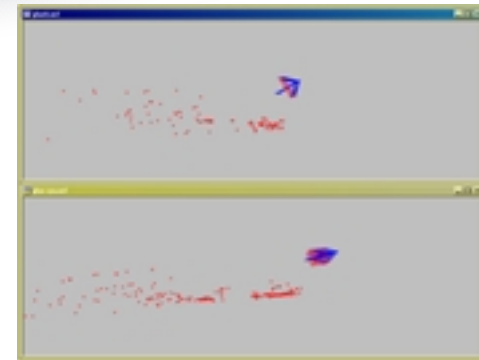
Issue 2: Critical surfaces



- Degenerate configurations e.g. points and camera on quadric appear rare
 - Space of degenerate sequences is measure zero in space of all sequences
- Real sequences often “within noise” of degeneracy
 - e.g. near-planar scene, near-linear camera motion

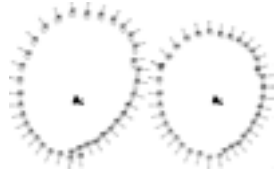


Example ambiguities



Issue 3: Constraints

- Closure
 - Manually or automatically identified
 - Bundle adjustment
 - “Hinges” [Fitzgibbon *et al* 00]

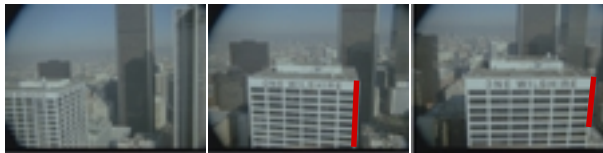


Scene constraints

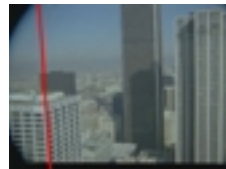


- Vanishing points are the images of points at infinity.
 - Points a known distance from the camera provide valuable cues
- Intersection of nearly parallel lines requires care

Line estimation without constraints
→ 10 pixel drift



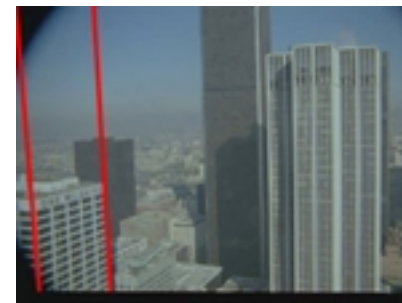
2 views



20 views

Vertical lines share a point at infinity

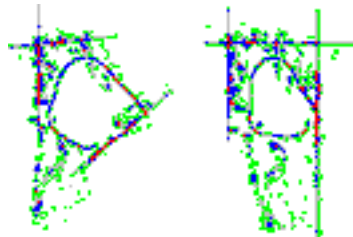
Simultaneous fitting amortizes error over time and space



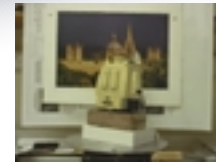
Issue 4: Lens distortion



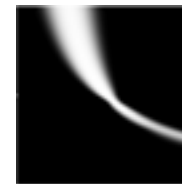
- Effects of distortion
- Automatic correction
 - Bundle adjustment



Future: Non-static scenes



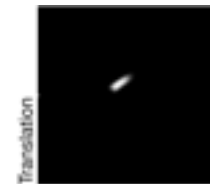
- Multibody
 - Calibration constraints
- Multipoint
 - Wolf & Shashua 01



Background



Robot



Translation

Focal Length

Future: Nowhere-static scenes



Objective: Determine camera pan [Fitzgibbon 01]



Input flowers



Flowers videotexture



Registered flowers

Conclusions



Success depends on

- Statistical modelling
- Dealing with degeneracy
- Using available constraints