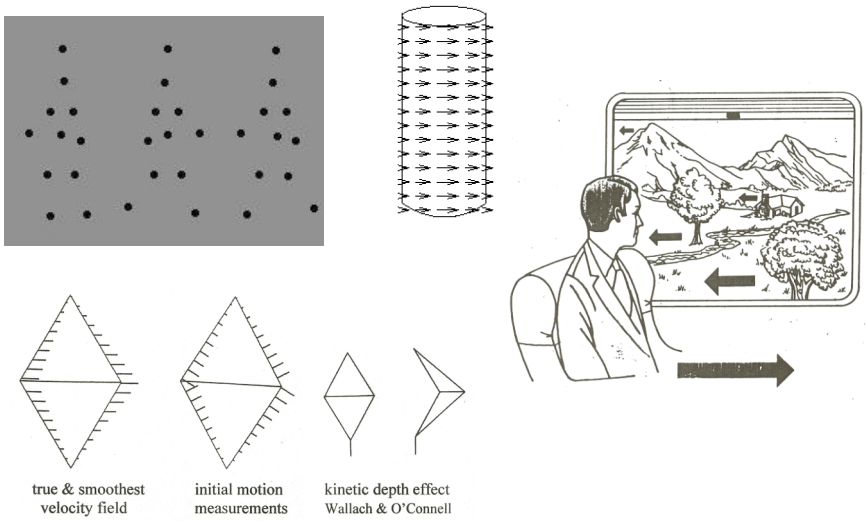
Analysis of Motion

Recovering 3-D structure from motion

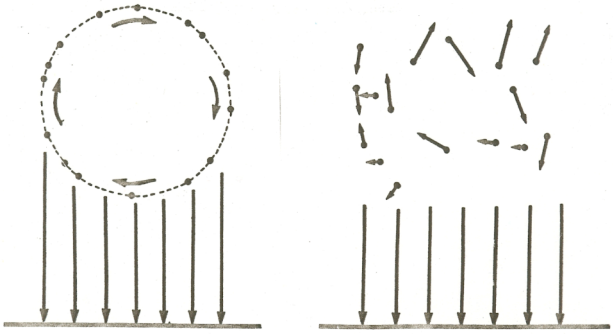
CS332 Visual Processing
Department of Computer Science
Wellesley College

Recovering 3D structure from motion



Ambiguity of 3D recovery

birds' eye views



We need *additional constraint* to recover 3D structure uniquely

"rigidity constraint"

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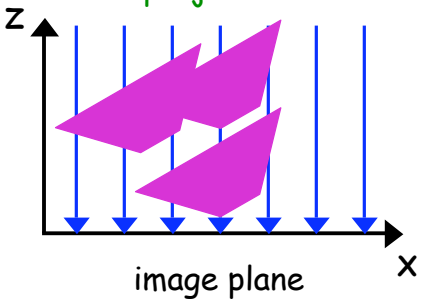
Image projections

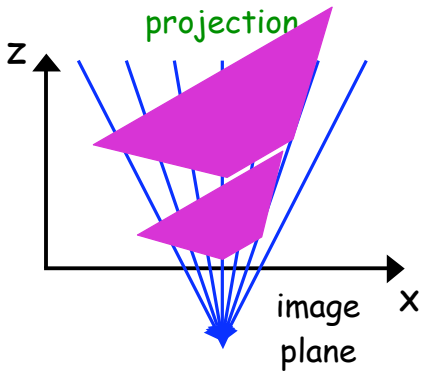
orthographic projection



(X, Y, Z) → (X, Y)

- only relative depth
- requires object rotation

perspective projection



(X, Y, Z) → (X/Z, Y/Z)

- only scaled depth
- requires translation of observer relative to scene

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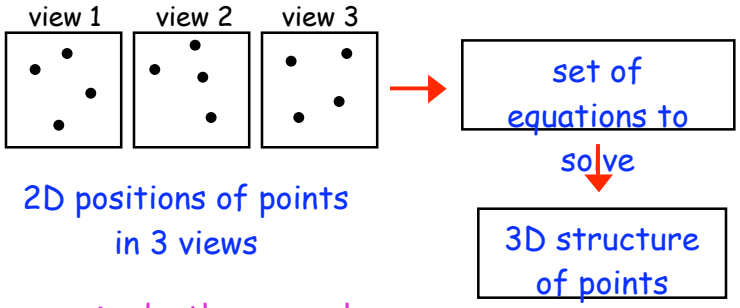
Using the rigidity constraint

Ullman: Given 3 distinct orthographic views of 4 non-coplanar points in motion, if there exists a rigid 3-D structure consistent with these views, *then this structure is unique.*



2D positions of points in 3 views

caveat: depth reversals

What is needed to compute a unique rigid 3D structure?

Sample results:

	orthographic projection	perspective projection
correspondence	4 points 3 views *	7 points 2 views
velocity field	5 points 1-1/2 views	5 points 1 view

* Ullman

Rigidity constraint alone is sufficient to compute 3D structure from motion, **BUT**…

Human recovery of 3D structure from motion:

- Needs extended time to obtain an accurate 3D structure, and derivation is not all-or-none
- Can cope with significant deviations from rigidity
- Integrates multiple sources of information

These factors motivated the design of Ullman's *incremental rigidity scheme*

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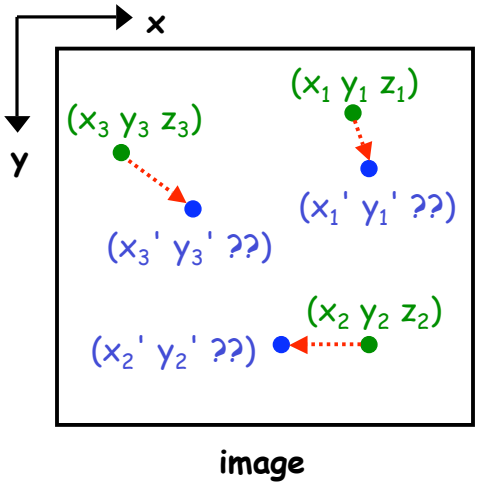
Incremental Rigidity Scheme



depth: Z

initially, Z=0 at all points

Find new 3D model that *maximizes rigidity*

Compute new Z values that minimize change in 3D structure

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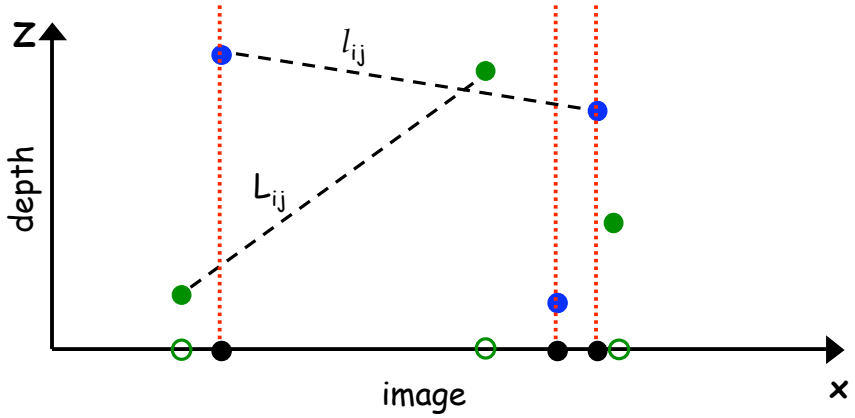
Bird's eye view:



- current model
- new image

Find new Z_i that minimize

$\Sigma (L_{ij} - l_{ij})^2 / L_{ij}^3$

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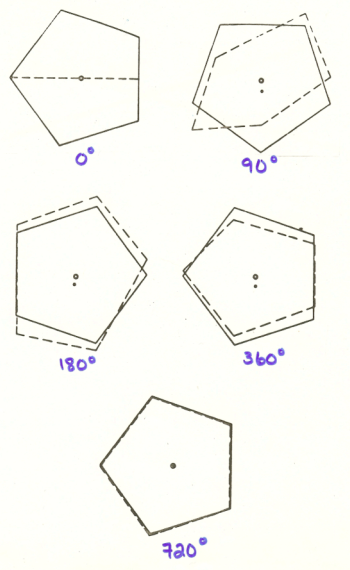
Incremental rigidity scheme: results



bird's eye views

new 3D model after every 10° rotation

——— true structure

- - - - - computed 3D model

builds 3D model incrementally over extended time

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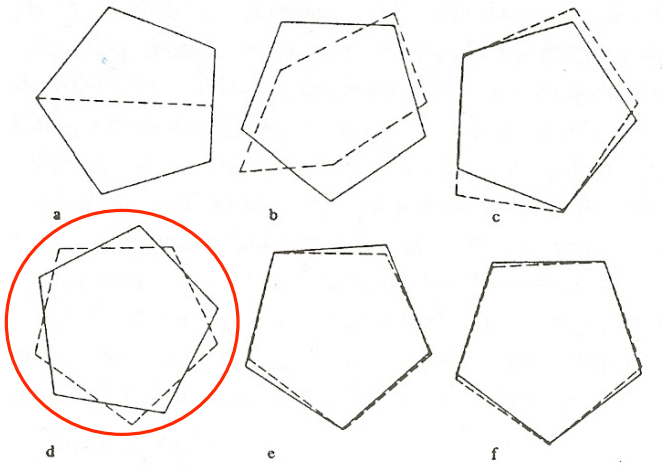
Spontaneous depth reversal



true structure

computed 3D model

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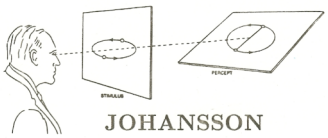
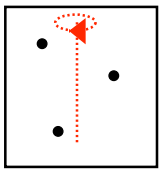
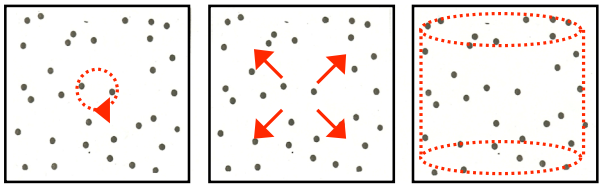
Human recovery of 3D structure from motion

- 2-3 points sufficient





- requires extended time to build up accurate percept of 3-D structure



Anderson & colleagues

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