CS448A: Experiments in Motion Capture

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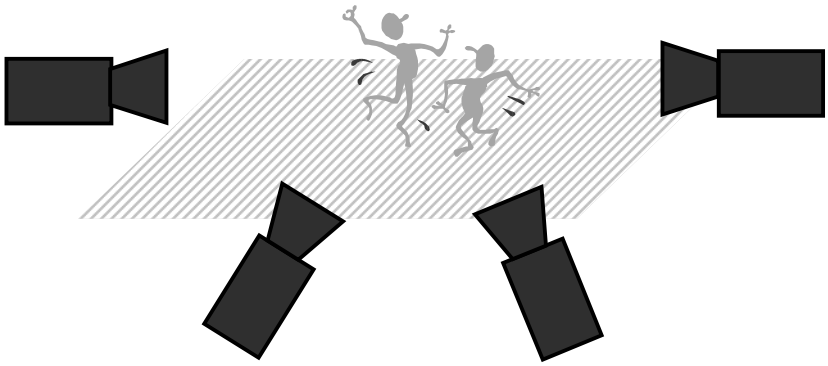

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CS448A: Experiments in Motion Capture

- Project Course
- Lectures on all key-algorithms
- 3-4 Homeworks (implement key-algorithms)
- Lot's of programming and experimenting!
- Final Group Project
- In-Class presentation of Paper from reading list

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CS448A: Experiments in Motion Capture

Lambsoft

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Motion Capture - Pipeline

- Tracking
- Model Fitting/Acquisition
- Kinematics
- Dynamics
- Learning
- Applications

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Visual Tracking

Visual Tracking: Unsolved for general settings

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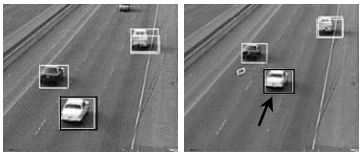
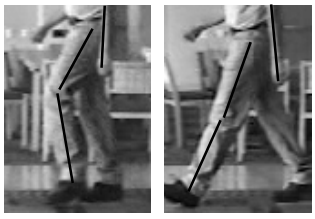
Visual Tracking

t t+1





Standard Techniques:

- Template Matching
- Edges / Shape / Color
- Background Subtraction
- Optical Flow

New Challenges:

- Complex Variation
- Self Occlusion
- Noise (Folds, Low Contrast)

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Example

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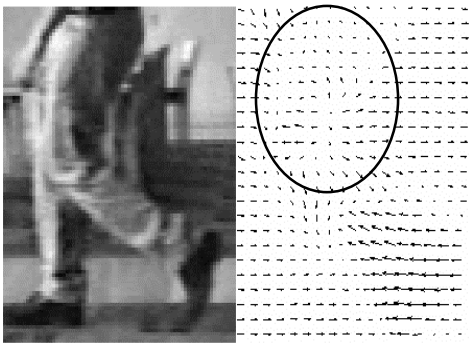
Optical Flow



local
ambiguities

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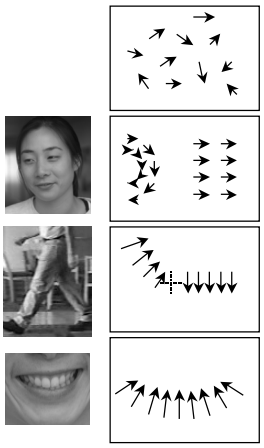
Kinematic Model Constraints



- Optical Flow/Feature tracking: no constraints
- Layered Motion: rigid constraints
- Articulated: kinematic chain constraints
- Nonrigid: implicit / learned constraints

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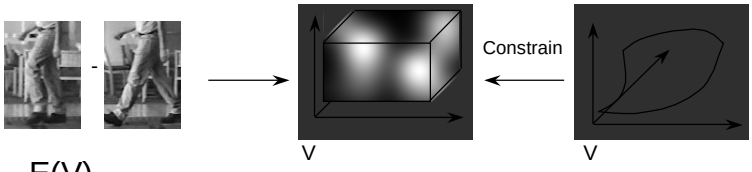
Tracking = Constrained Optimization



E(V)

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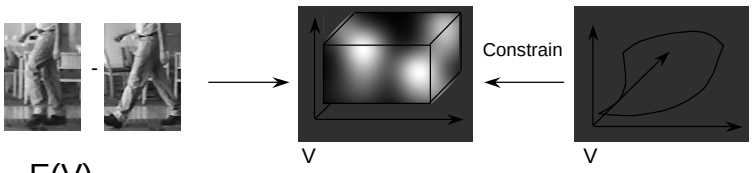
Tracking = Constrained Optimization



E(V)

Marker-Tracking ⟷ Dense Flow

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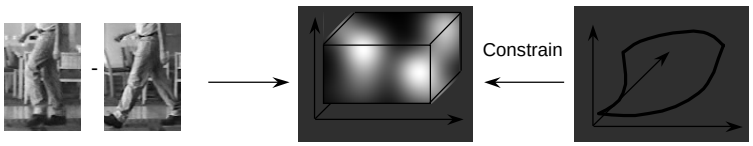
Constraints = Subspaces



E(V)

Analytically derived: ⟷ Learned:

Affine, Twist/Exponential Map

Linear/non-linear Sub-Spaces

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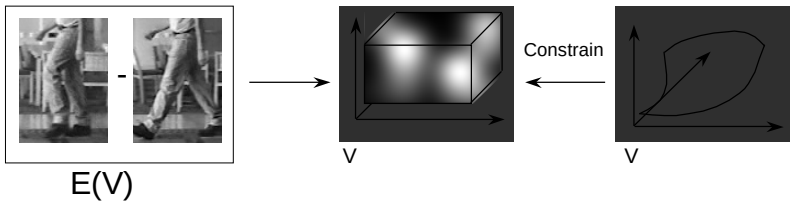
Tracking = Constrained Optimization



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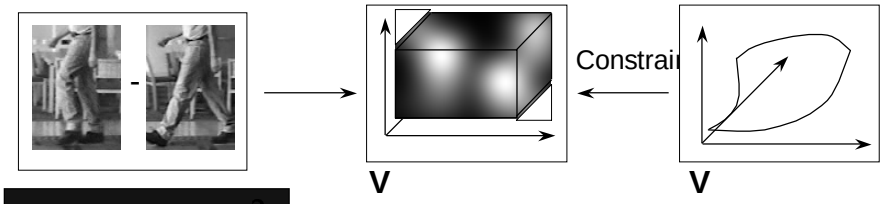
Constrained Function Minimization



$$\left\| \begin{matrix} I_t(1) - \nabla I(1)\vec{v} \\ I_t(2) - \nabla I(2)\vec{v} \\ \dots \\ I_t(n) - \nabla I(n)\vec{v} \end{matrix} \right\|^2 = E(\mathbf{V})$$

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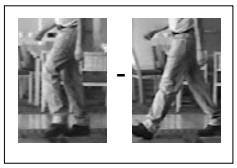
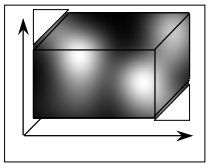
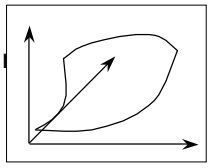
Constrained Function Minimization





Constrai



V V

$$\left\| \begin{array}{l} I_t(1) - \nabla I(1) \vec{v} \\ I_t(2) - \nabla I(2) \vec{v} \\ \quad \ldots \\ I_t(n) - \nabla I(n) \vec{v} \end{array} \right\|_2 = E(\mathbf{V})$$

$$V = M(\theta)$$

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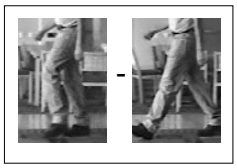
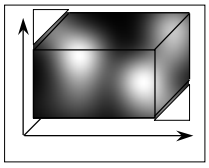
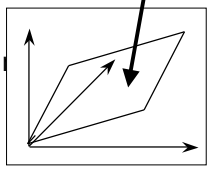
2D Translation: Lucas-Kanade

2D





Constrai



V V

$$\left\| \begin{array}{l} I_t(1) - \nabla I(1) \vec{v} \\ I_t(2) - \nabla I(2) \vec{v} \\ \quad \ldots \\ I_t(n) - \nabla I(n) \vec{v} \end{array} \right\|_2 = E(\mathbf{V})$$

$$V = \begin{bmatrix} dx, dy \\ dx, dy \\ \ldots \\ dx, dy \end{bmatrix}$$

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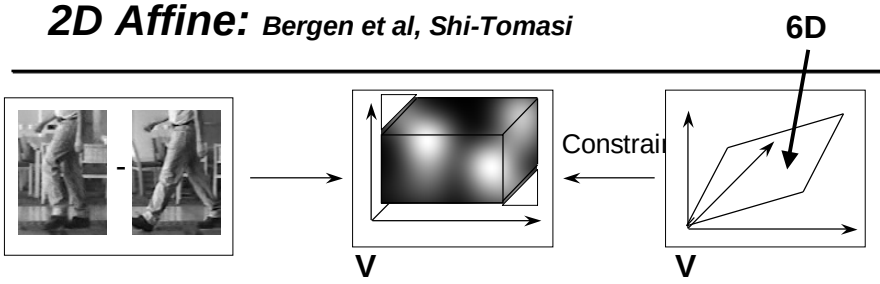
2D Affine: *Bergen et al, Shi-Tomasi*



$$\left\| \begin{array}{l} I_t(1) - \nabla I(1) \vec{v}_1 \\ I_t(2) - \nabla I(2) \vec{v}_2 \\ \quad \ldots \\ I_t(n) - \nabla I(n) \vec{v}_n \end{array} \right\|^2 = E(\mathbf{V})$$

$$\vec{V}_i = \begin{bmatrix} a1, a2 \\ a3, a4 \end{bmatrix} \begin{bmatrix} x_i \\ y_i \end{bmatrix} + \begin{bmatrix} dx \\ dy \end{bmatrix}$$

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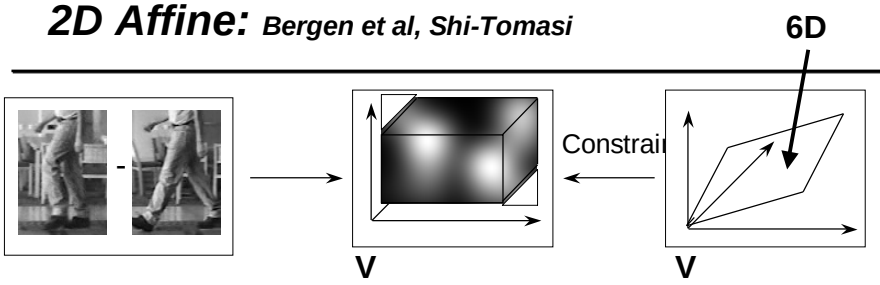
2D Affine: *Bergen et al, Shi-Tomasi*



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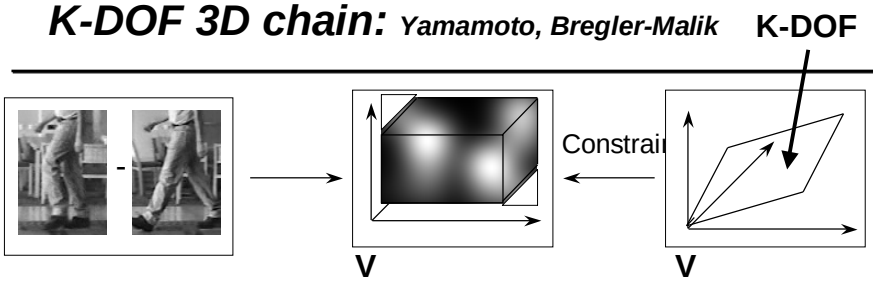
K-DOF 3D chain: *Yamamoto, Bregler-Malik*



$$\left\| \begin{matrix} I_t(1) - \nabla I(1) \dot{\mathbf{y}}_1 \\ I_t(2) - \nabla I(2) \dot{\mathbf{y}}_2 \\ \dots \\ I_t(n) - \nabla I(n) \dot{\mathbf{y}}_n \end{matrix} \right\|^2 = E(\mathbf{V})$$

$$\mathbf{V} = M(\theta)$$

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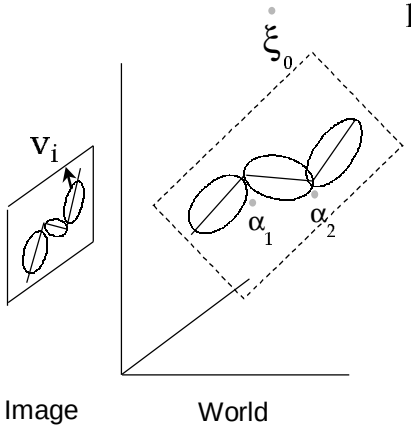
Twist and Product of Exp. Maps

orthographic projection



$$p_i = \begin{bmatrix} S\,0\,0\,0 \\ 0\,S\,0\,0 \end{bmatrix} e^{\hat{\xi}_0} e^{\hat{\xi}_1 \alpha_1} e^{\hat{\xi}_2 \alpha_2} q_i$$

$$\frac{\delta}{\delta t}$$

$$v_i = M_i \begin{bmatrix} \dot{\xi} \\ \dot{\alpha} \end{bmatrix}$$

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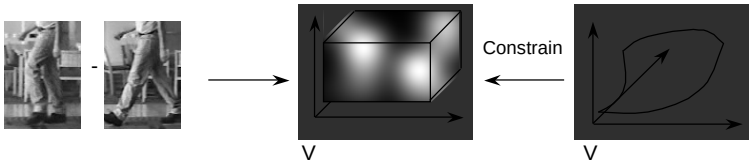
Analytically derived Constraints



$$\left\| \begin{array}{l} I_t(1) - \nabla I(1)\,\vec{v}_1 \\ I_t(2) - \nabla I(2)\,\vec{v}_2 \\ \quad \ldots \\ I_t(n) - \nabla I(n)\,\vec{v}_n \end{array} \right\|^2 = E(V) \qquad V = M \begin{bmatrix} \xi \\ \alpha_1 \\ \ldots \\ \alpha_K \end{bmatrix}$$

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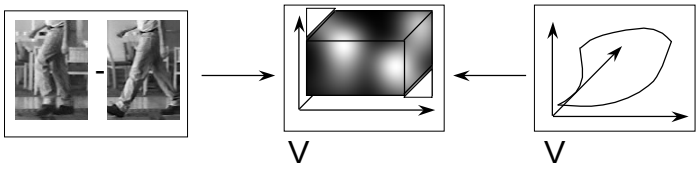
Example Track



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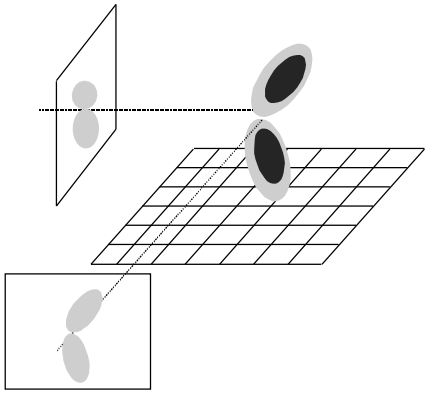
Multiple Views



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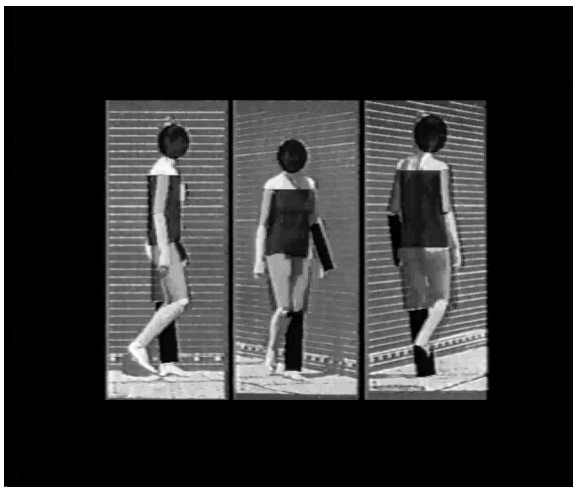
Example Track -2-



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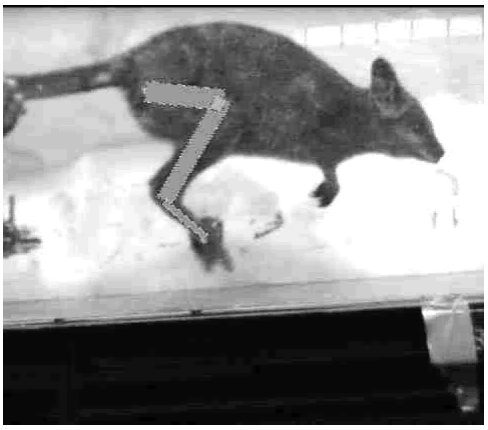
Tracking + Acquistion of Kinematics

- Acquire Kinematic Chains.



Kathy Pullen

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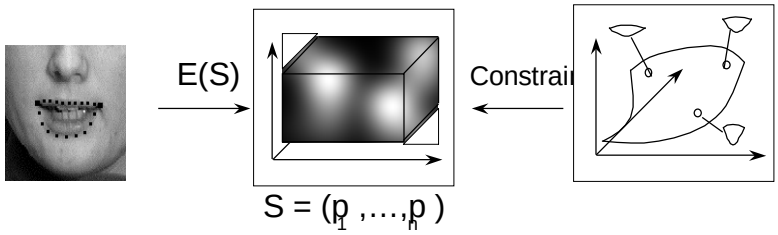
Non-Rigid Constrained Spaces



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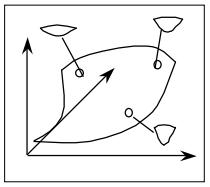
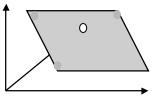
Non-Rigid Constrained Spaces

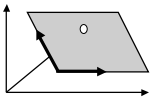


Linear Subspaces:

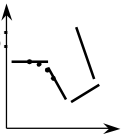
- Small Basis Set



- Principal Components Analysis



Nonlinear Manifolds:



Mixture Models

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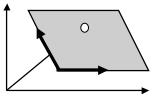
Nonrigid Examples

Constrain



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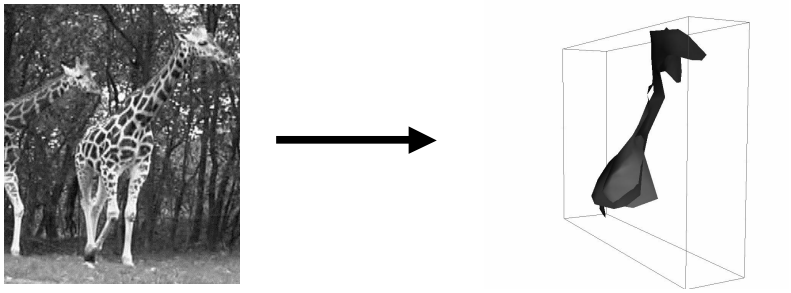
Nonrigid 3D Acquisition



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Human Dynamics

- Forces applied on masses
- Exploit models from Biomechanics
- Motor control / High-level processes
- Learning Statistical Models of Dynamics
- "Motion-Phonemes": ***Movemes***
- Laban Movement Analysis

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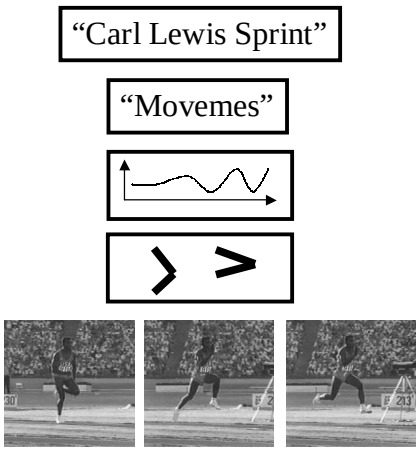
Probabilistic Models / Bayesian Techniques



High-Level Categories

Composition

Dynamical Models

Kinematic Model Constraints

Image Sensors

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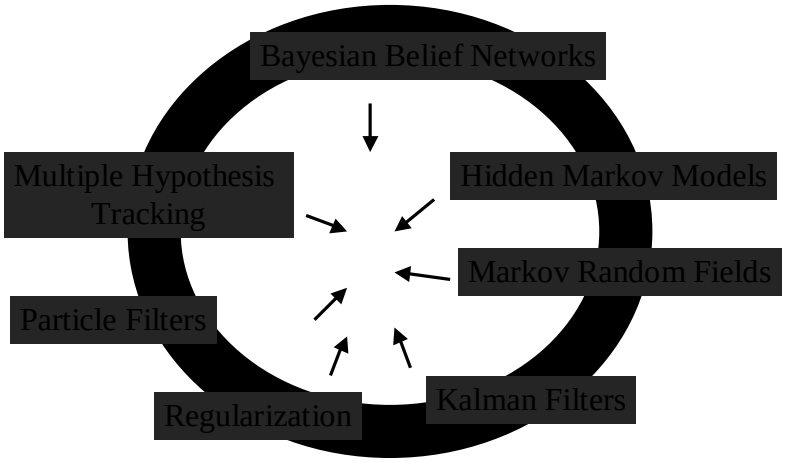
Probabilistic Models / Bayesian Techniques



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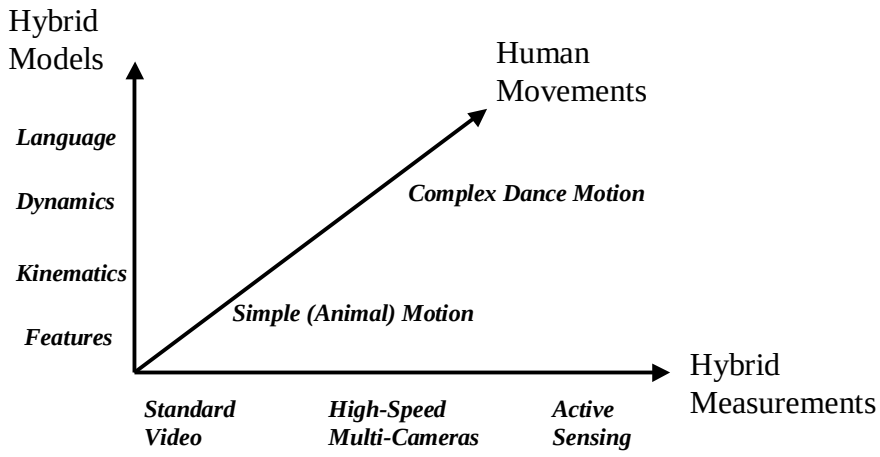
HM^3



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Performance Capture based Animation

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Rotoscope / Mocap: History

- Disney:

Step-mother of Cinderella

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Rotoscope / Mocap: History

- Disney:

Eleanor Audley

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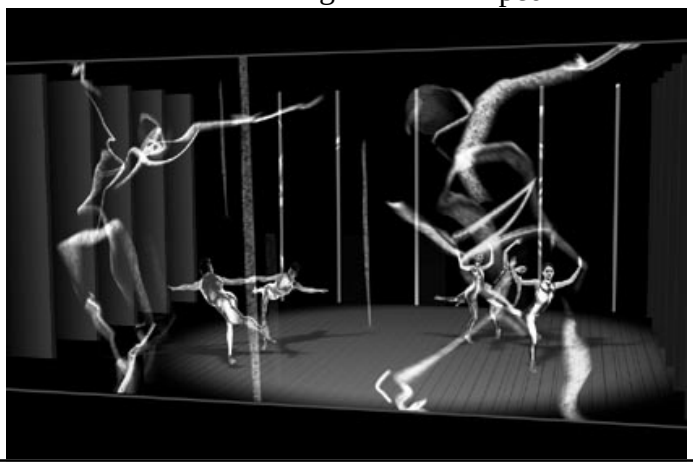
Rotoscope / Mocap: History

- Rebecca Allen / Twyla Tharp: The Catherine Wheel
- Paul Kaiser / Merce Cunningham: → "Biped"



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Performance Capture based Animation

Lambsoft

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Performance Capture based Animation

Lambsoft

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Performance Capture based Animation

-> Popovic Files

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CS448A: Homeworks

- 3 Homeworks on Tracking: Lucas-Kanade, Extensions, Kalman
- 1 Homework on Camera Calibration
- [1 Homework on Model Acquisition/Fitting]

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CS448A: Paper Presentation

- Presentation for 20 min (depending on class size)
- Choose from Reading List
- or – find it yourself

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CS448A: Project

- Start thinking about it now
- In-class brainstorming session
- Proposal with 2 Milestones
- Group work

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CS448A: Project Ideas

- Full-Body Tracker:
  - Offline / Real-time
  - Resolution: 3D Blob, Kinematic Model
- Hand Tracker:
  - 2D vs 3D / how many cameras
  - Features: Color, Silhouette, Flow, Regions, Edges
  - Explicit kinematic model vs learned PCA model
- Face Tracker:
  - Markers / no Markers
  - same issues as above

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CS448A: Project Ideas

- Generic 3D Model Acquisition based on Marker tracking
- Kinematic model fine-tuning
- Pan-Tilt tracker
  - Integrate with 3D blob tracker or other
  - Angle, Zoom, Focus, ….
- Gesture Recognition
  - HCI applications -> iRoom
- Application of Mocap to Animation
  -Full Body / Face
- …

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CS448A: How to get in

- email to: cs448a-staff@cs
  - Your name, email, website
  - Probability of taking this class
  - Your background (Classes, childhood, etc…)
  - What you would like to do for a project

- website: graphics/courses/cs448a

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