# NTT Visit:
# *Image Database Retrieval*
# *Variable Viewpoint Reality*

Professor Paul Viola

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Nick Matsakis, Jeff Norris, Todd Atkins
Mark Pipes



## *Overview of Visit*

- Morning: Image Database Retrieval
  - Gatekeeper: Face detection and recognition
  - Complex Feature Image Database Retrieval (Tieu)
  - Flexible Template Retrieval (Yu)
- Interlude
  - Video/Audio Source Separation (Fisher)
  - Mathematical Expression Recognition (Matsakis)
- Lunch
- Visit Prof. Brooks lab

## *Overview of Visit - 2*

- Afternoon: Variable Viewpoint Reality
  - Real-time 3D reconstruction of people (Snow)
  - Automatic camera calibration (Snow + Lee)
  - Tracking of articulate human models (Lee + Winn)
  - Modeling of human dynamics (Viola + Fisher)



## *Show 3D Soccer software…*

## *VVR: Motivating Scenario*



- Construct a system that will allow each/every user to observe any viewpoint of a sporting event.
- Provide high level commentary/statistics
  - Analyze plays

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## *For example …*

Computed using a single view…
some steps by hand

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## *VVR Spectator Environment*

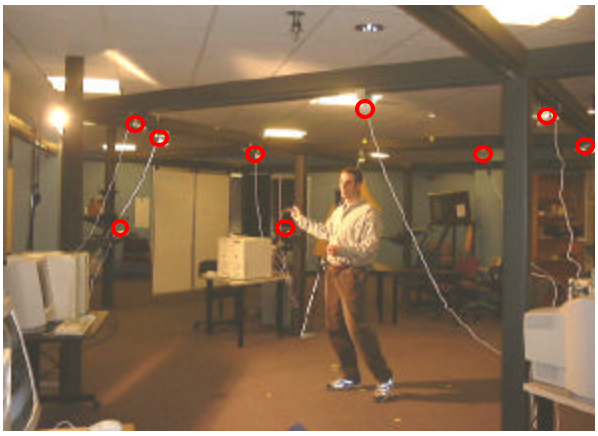
- Build an exciting, fun, high-profile system
  - Sports: Soccer, Hockey, Tennis, Basketball
  - Drama, Dance, Ballet
- Leverage MIT technology in:
  - Vision/Video Analysis
    - Tracking, Calibration, Action Recognition
    - Image/Video Databases
  - Graphics
- Build a system that provides data available nowhere else…
  - Record/Study Human movements and actions
  - Motion Capture / Motion Generation



## *Window of Opportunity*

- 20-50 cameras in a stadium
  - Soon there will be many more
- US HDTV is digital
  - Flexible, very high bandwidth digital transmissions
- Future Televisions will be Computers
  - Plenty of extra computation available
  - 3D Graphics hardware will be integrated
- Economics of sports
  - Dollar investments by broadcasters is huge (Billions)
- Computation is getting cheaper

## *ViewCube:*
## *Reconstructing action & movement*



- Twelve cameras, computers, digitizers
- Parallel software for real-time processing

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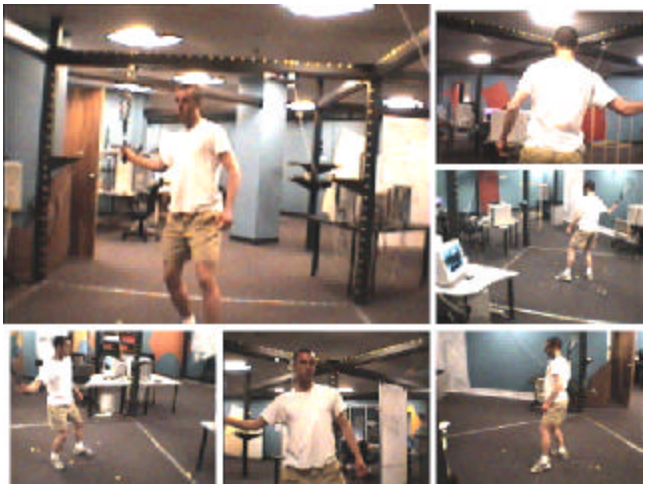
## *The View from ViewCube*



Multi-camera Movie

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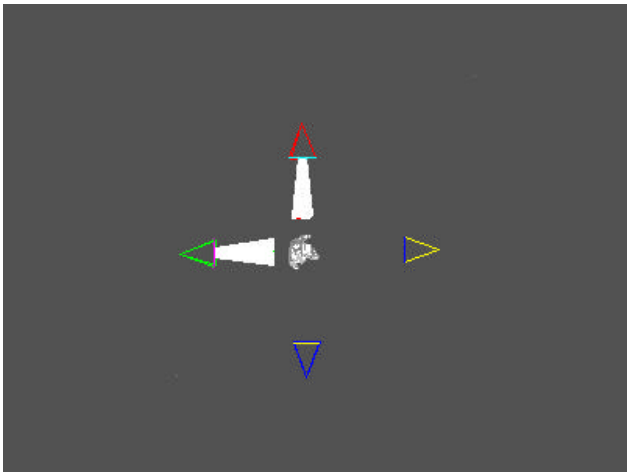
## *Projecting Silhouettes to form 3D Models*

Real-time 3D Reconstruction is computed by intersecting silhouettes



3D Reconstruction Movie

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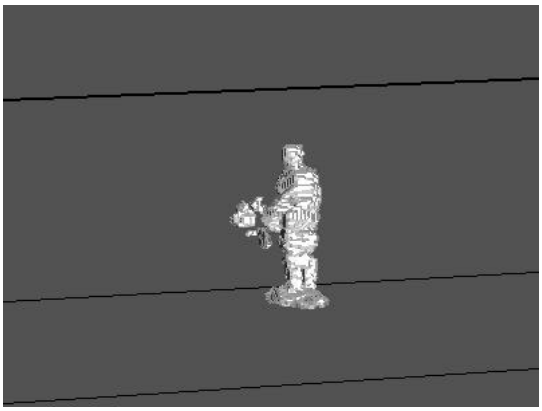
## *First 3D reconstructions ...*



3D Movement Reconstruction Movie

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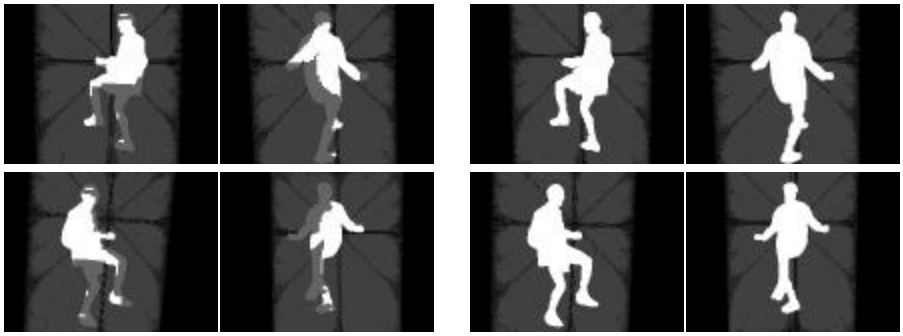
## *Dynamic Calibration*

**Calibration is a critical an expensive part 3D reconstruction**
**Our approach is dynamically self-calibrating**



**Initial Calibration**
**- poor reconstruction**

**Automatically Improved**
**Calibration -> better results**

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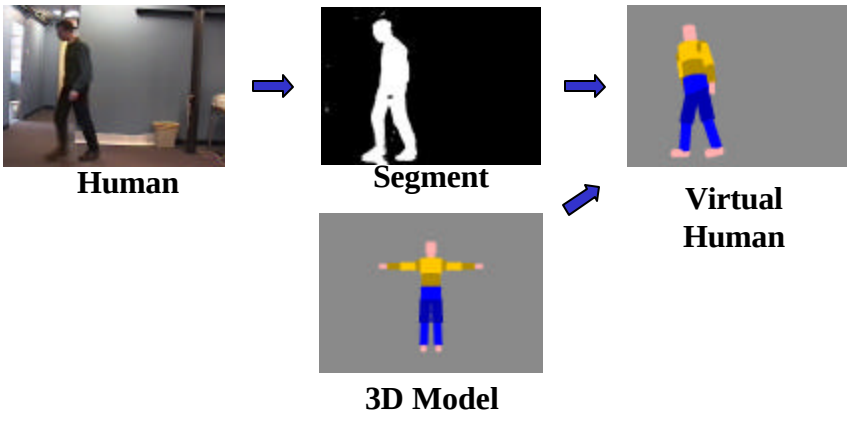
## *Finding an articulate human body*



**Human**

**Segment**

**Virtual Human**

**3D Model**

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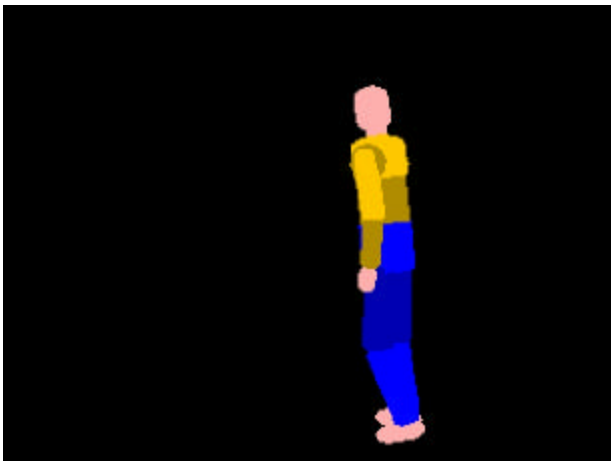
## *Automatically generated result:*



Body Tracking Movie



## *Analyzing Human Motion*

- Key Difficulty: Complex Time Trajectories
  Complex Inter-dependencies
- State of the Art: Hidden Markov Models
  - Have a discrete number of states
- Our Approach: Multi-scale statistical models

## *Human Motion is extremely complex:*


*Human Motion*
*is temporal texture*
*or*
*a temporal signature*

Motion Capture Movie

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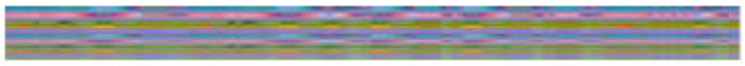
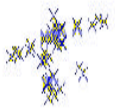
## *Texture Analysis and Synthesis can be applied to Movement Data*

**Synthesis**



**The texture synthesis tools can be applied to movement**

**The texture recognition tools can be applied to movement**



Motion Capture Movie

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