Variable Viewpoint Reality

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The BIG picture: User selected viewing of sporting events.

- show me that play from the viewpoint of the goalie
- ... from the viewpoint of the ball
- ... from a viewpoint along the sideline
- what offensive plays does Brazil run from this formation
- how often has Italy had possession in the offensive zone
The BIG picture: User selected viewing of sporting events.

- Let me see my son’s motion from the following viewpoint
- Let me see what has changed in his motion in the past year
- Show me his swing now and a week ago
- How often does he swing at pitches low and away
- What is his normal sequence of pitches with men on base and less than 2 outs
A wish list of capabilities

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

• Search databases for similar events
• Recover human dynamics
VVR Spectator Environment

• Build an exciting, fun, high-profile system
  – Sports: Soccer, Hockey, Tennis, Basketball, Baseball
  – 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
For example …

Computed using a single view…

some steps by hand
ViewCube: Reconstructing action & movement

- Twelve cameras, computers, digitizers
- Parallel software for real-time processing
The View from ViewCube

Multi-camera Movie

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Robust adaptive tracker

Video Frames → Adaptive Background Model

Pixel Consistent with Background → X,Y,Size,Dx,Dy

Local Tracking Histories

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Examples of tracking moving objects

• Example of tracking results
Dynamic calibration
Multi-camera coordination
Mapping patterns to groundplane
Projecting Silhouettes to form 3D Models

Real-time 3D Reconstruction is computed by intersecting silhouettes.
First 3D reconstructions ...
A more detailed reconstruction...
Finding an articulate human body

Human → Segment → 3D Model → Virtual Human

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Automatically generated result:

Body Tracking Movie
Analyzing Human Motion

• Key Difficulty: Complex Time Trajectories  
Complex Inter-dependencies

• Our Approach: Multi-scale statistical models
Detect Regularities & Anomalies in Events?
Example track patterns

• Running continuously for almost 3 years
  – during snow, wind, rain, dark of night, …
  – have processed 1 Billion images
• one can observe patterns over space and over time
• have a machine learning method that detects patterns automatically
Automatic activity classification
Example categories of patterns

- Video of sorted activities
Analyzing event sequences

Resulting classifier

**people**
(1993 total with 0.1% FP)

**groups of people**
(712 total with 2.2% FP)

**clutter/lighting effects**
(647 total with 10.5% FP)

**cars**
(1564 total with 3.4% FP)

Histogram of activity over a single day

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...and this works for other problems

- Sporting events
- Eldercare monitoring
- Disease progression tracking
  - Parkinson’s
- … anything else that involves capturing, archiving, recognizing and reconstructing events!