

# *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.*



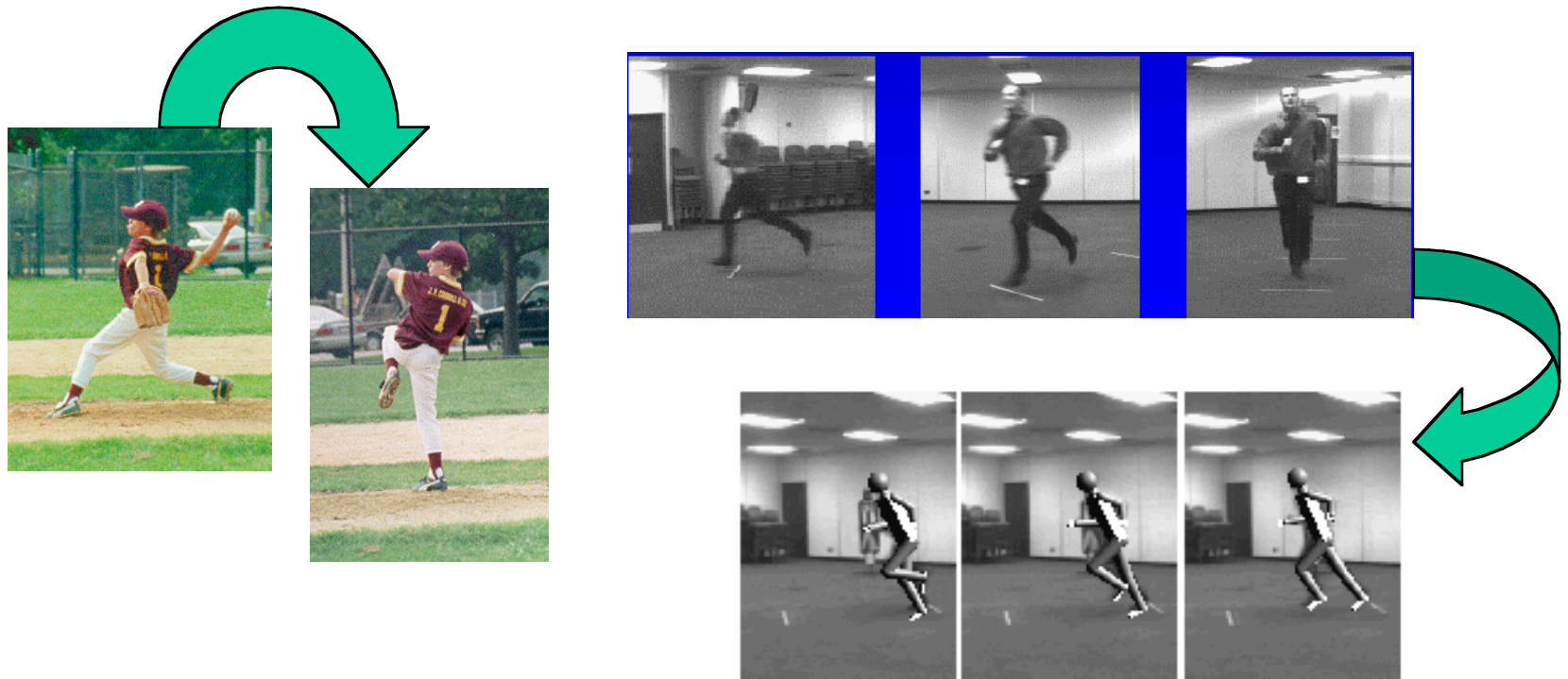
- Let me see my son's motion from the following viewpoint
- Let me see what has changed in his motion in the past year
- Show me his swing now and a week ago
- How often does he swing at pitches low and away
- What is his normal sequence of pitches with men on base and less than 2 outs

## *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  
*nt@mit*

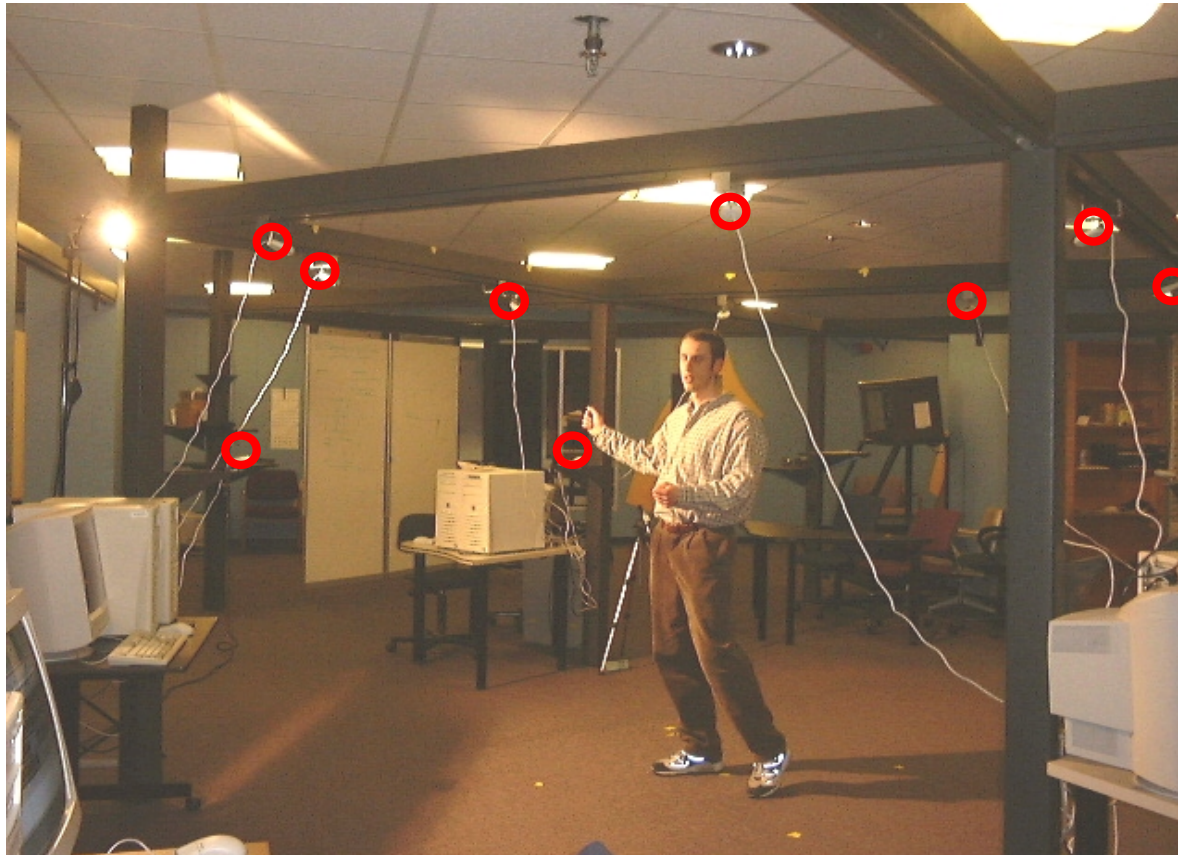
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*ViewCube:*

*Reconstructing action & movement*



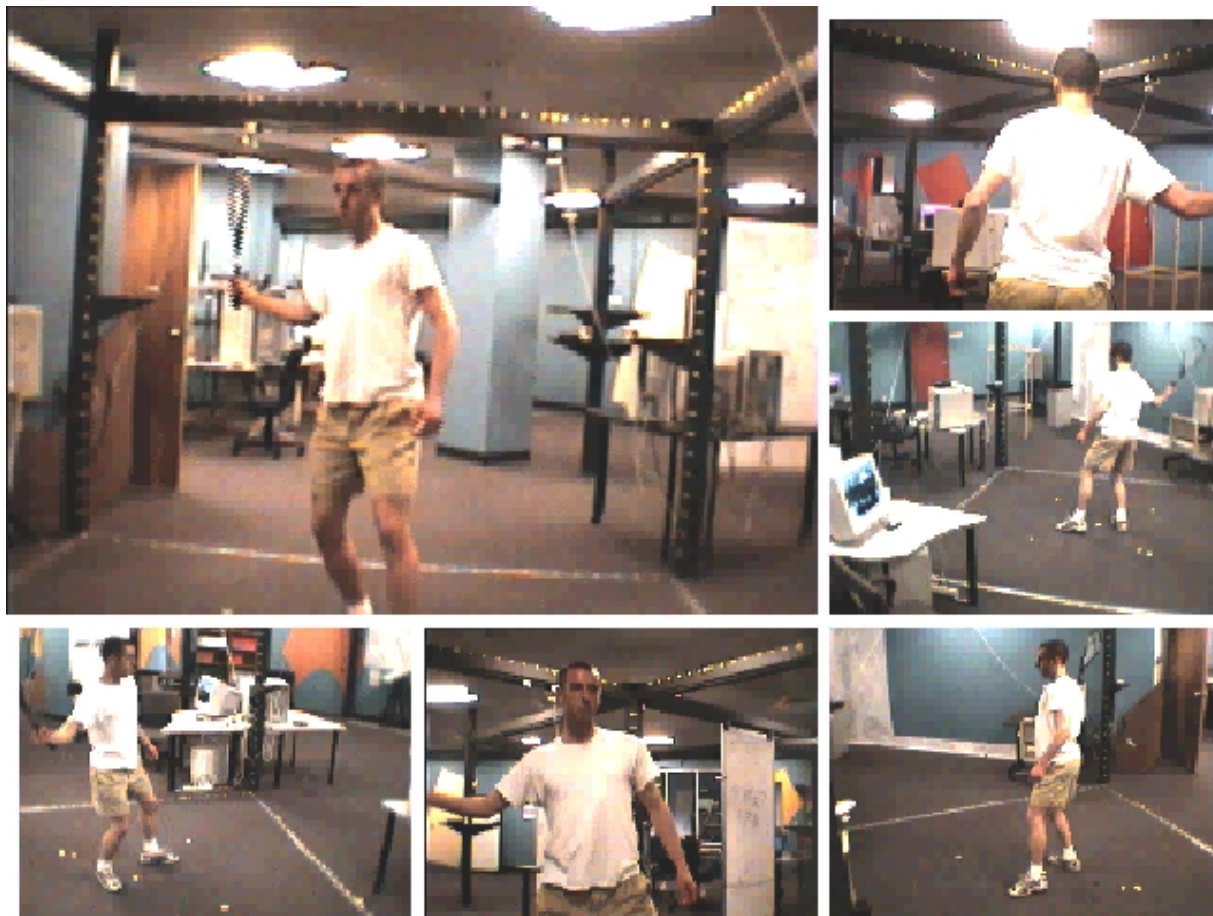
- Twelve cameras, computers, digitizers
- Parallel software for real-time processing

*Viola & Grimson*



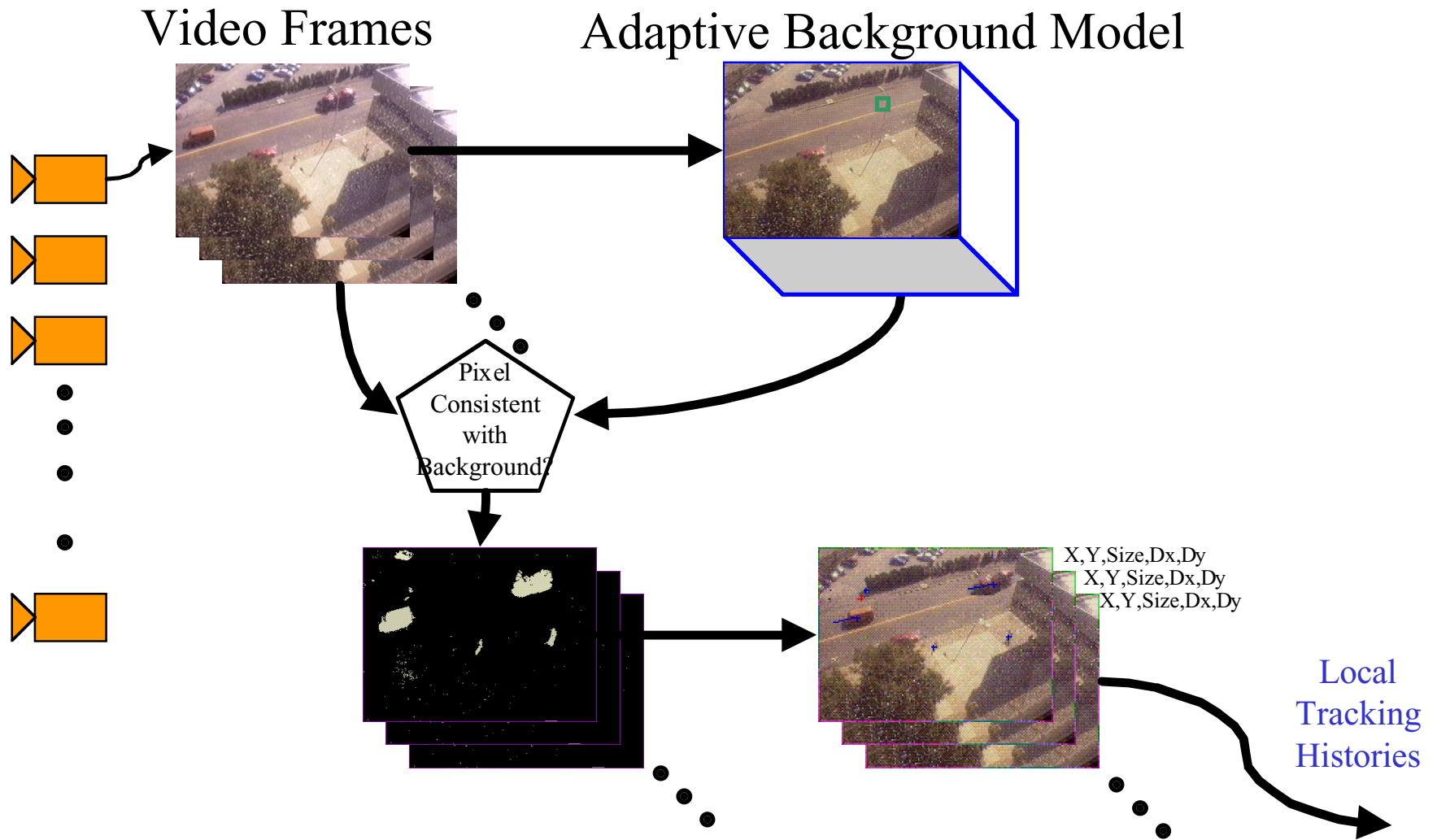
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# *The View from ViewCube*



Multi-camera Movie

# Robust adaptive tracker

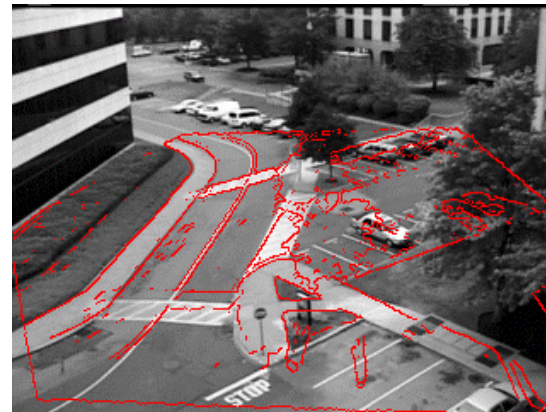
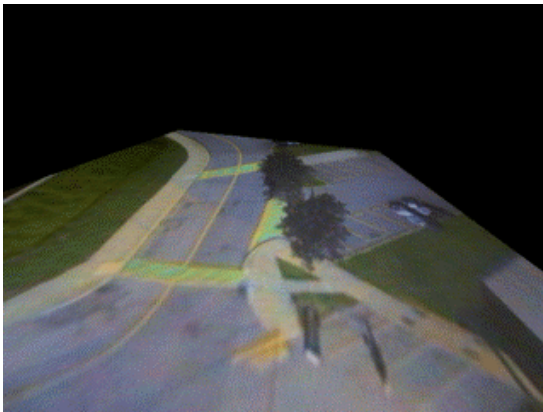
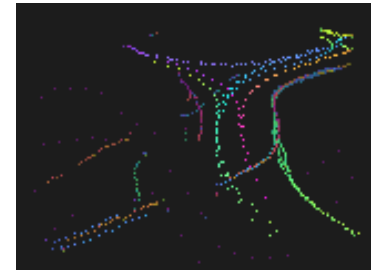
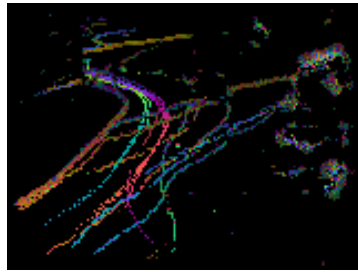


# *Examples of tracking moving objects*

- Example of tracking results



# *Dynamic calibration*

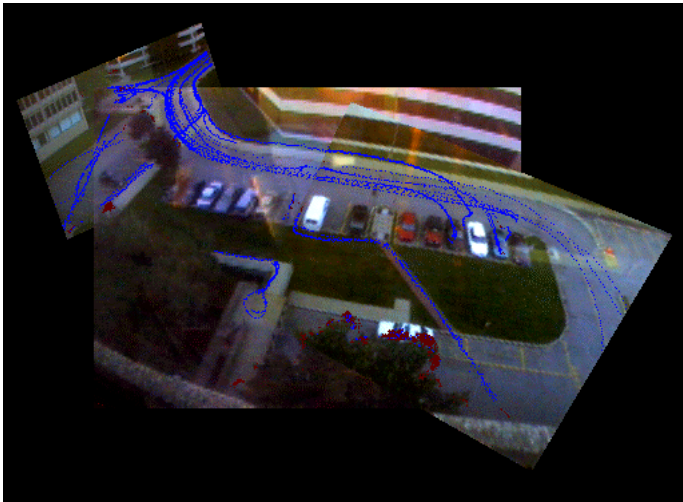


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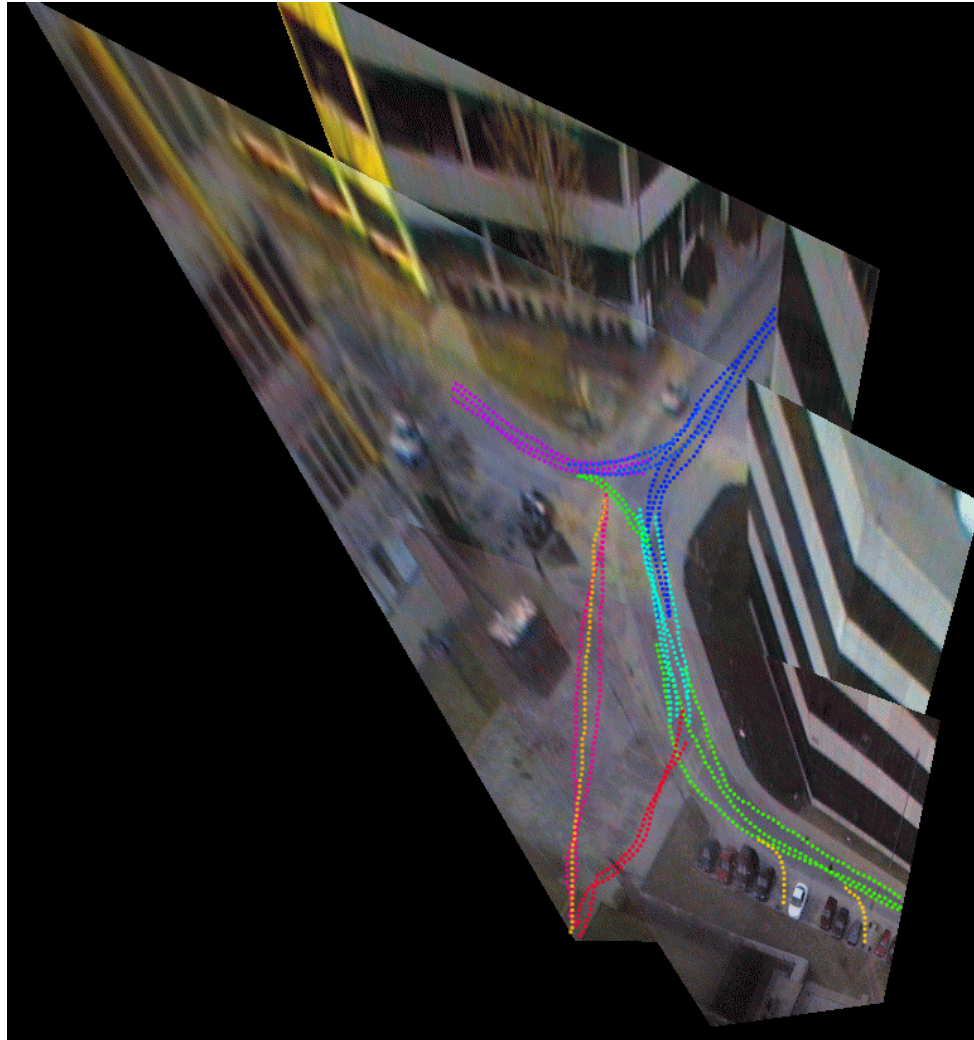


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# *Multi-camera coordination*



# *Mapping patterns to groundplane*



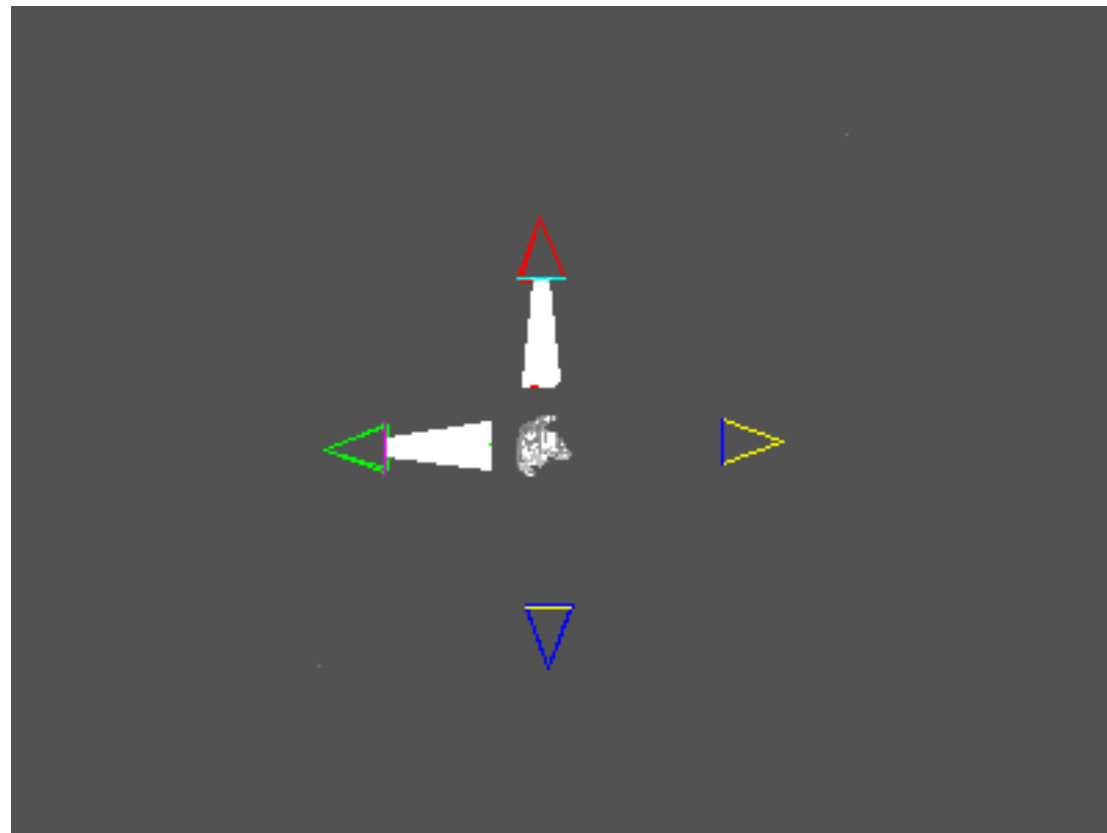
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# *Projecting Silhouettes to form 3D Models*

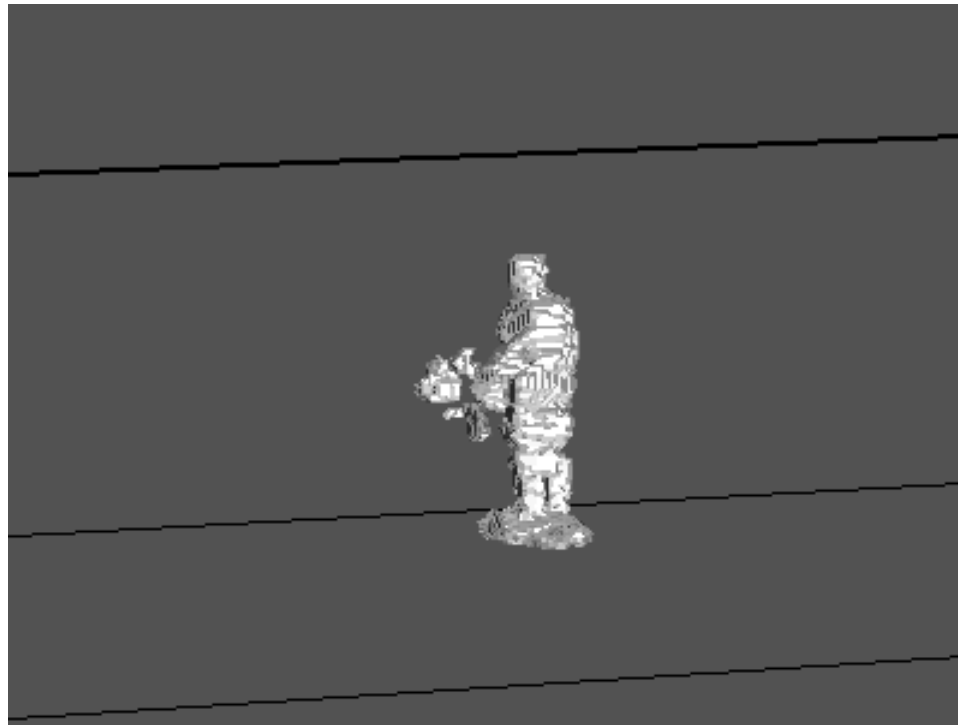
Real-time 3D  
Reconstruction  
is computed by  
intersecting  
silhouettes



3D Reconstruction Movie

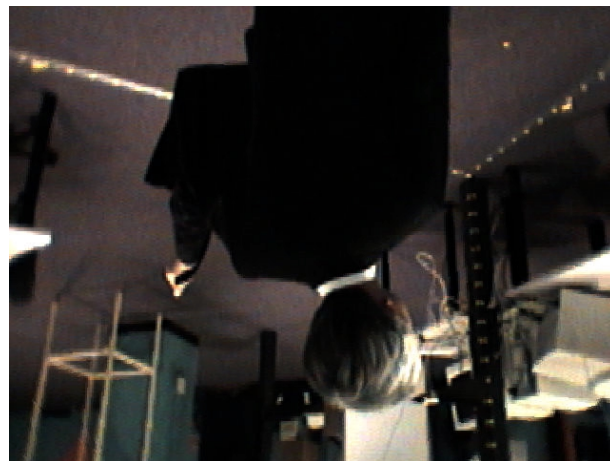


# *First 3D reconstructions ...*



3D Movement  
Reconstruction Movie

*A more detailed reconstruction...*



**Model**

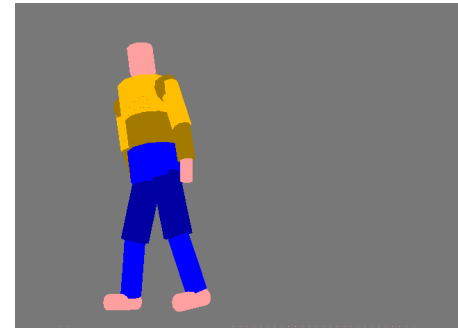
# *Finding an articulate human body*



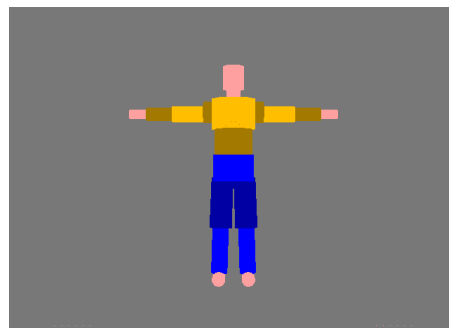
**Human**



**Segment**

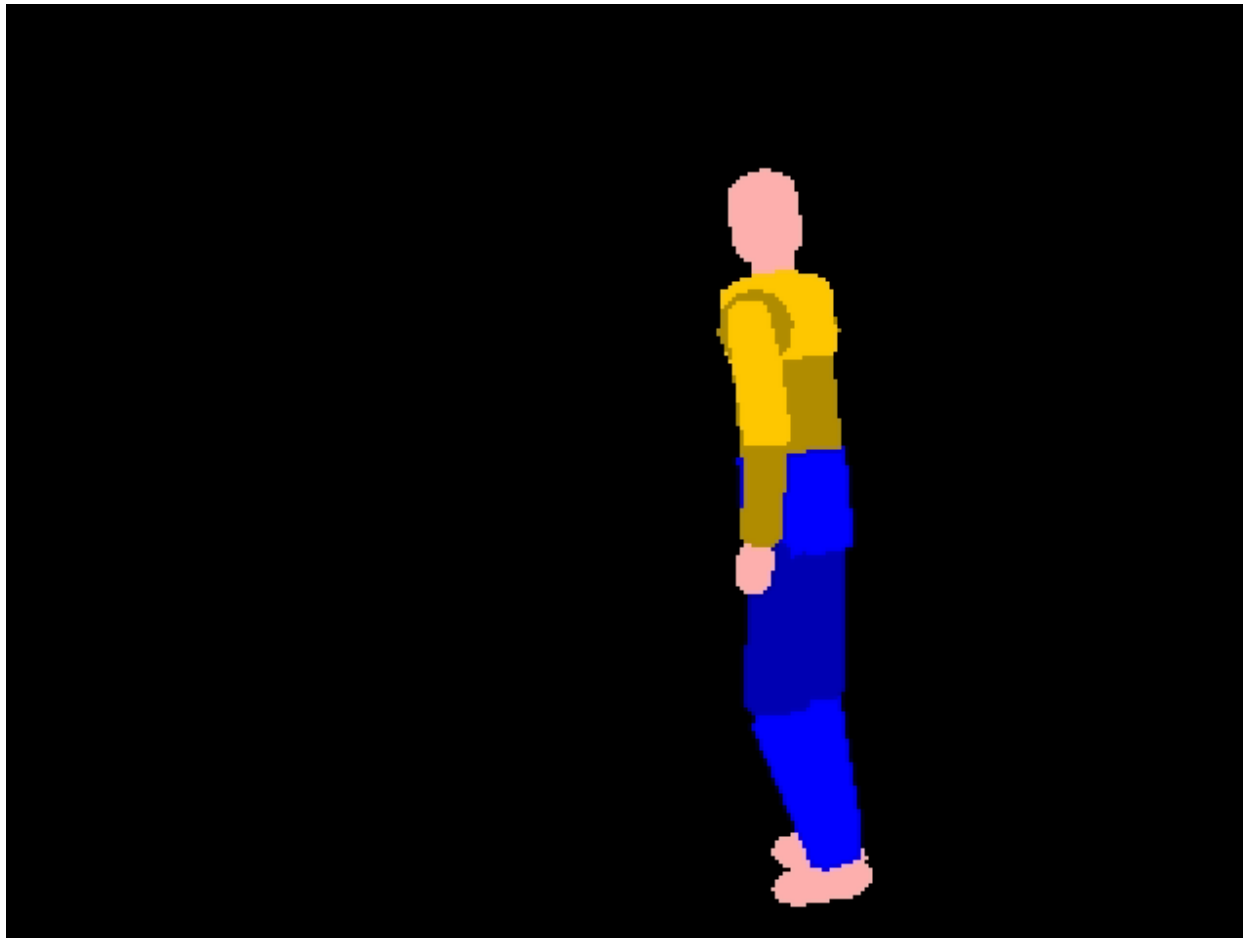


**Virtual  
Human**



**3D Model**

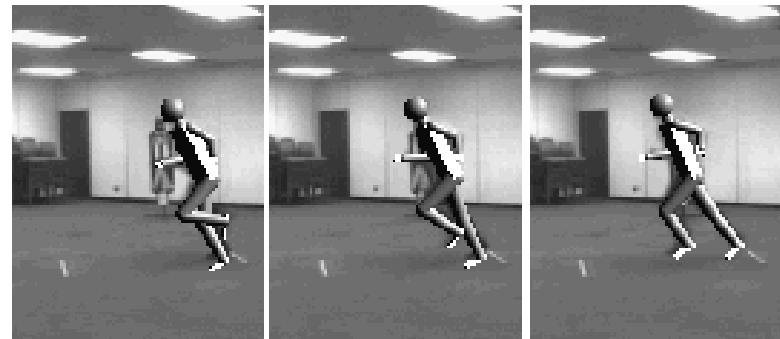
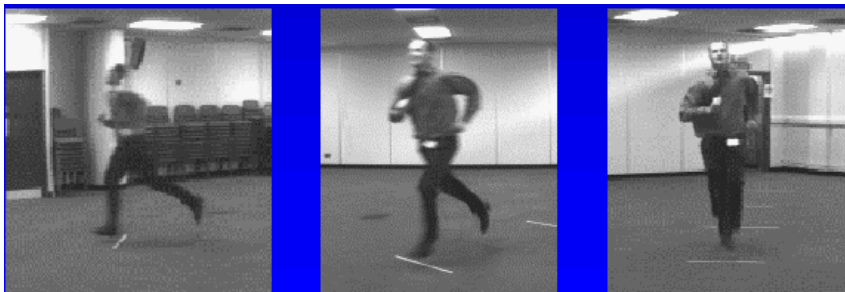
*Automatically generated result:*



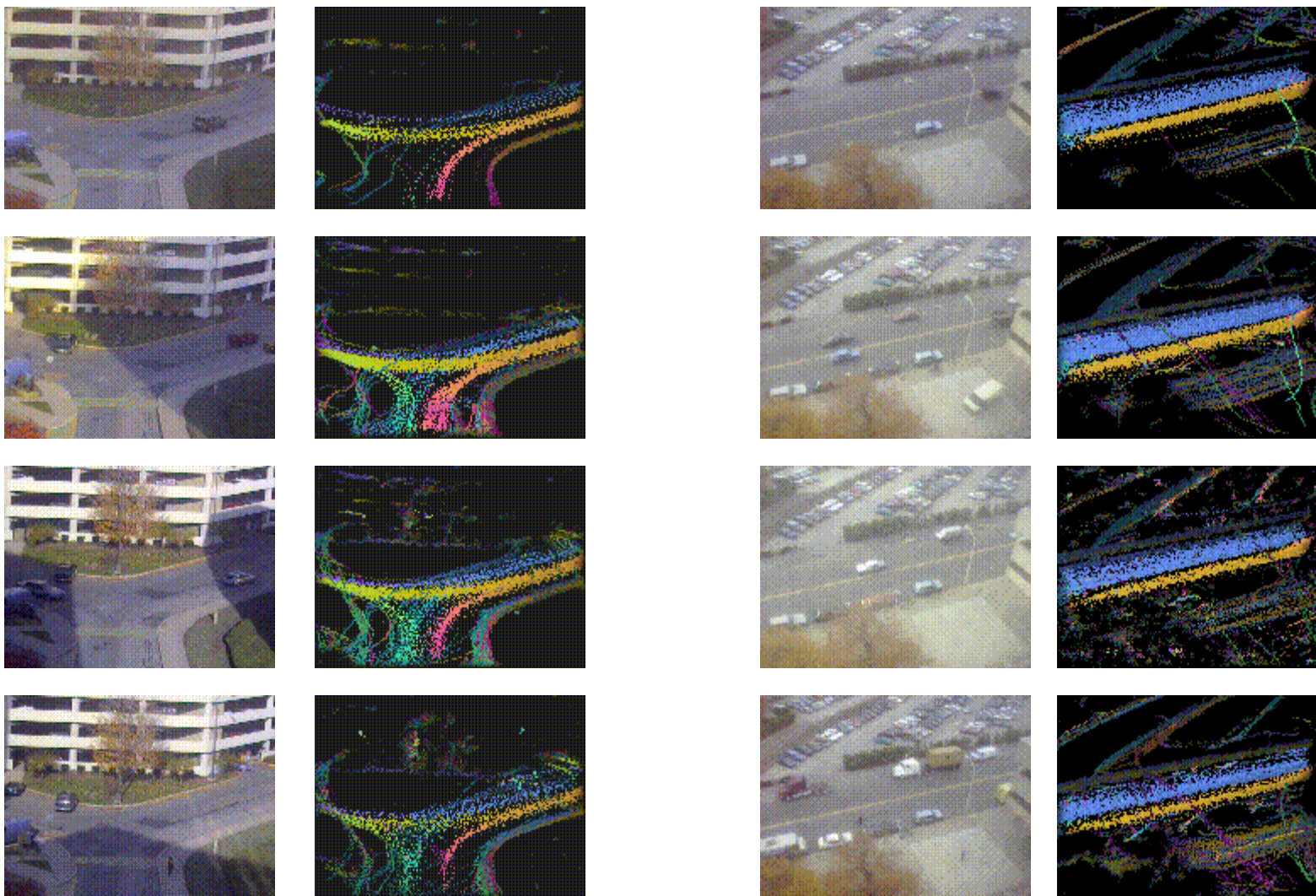
Body Tracking Movie

# *Analyzing Human Motion*

- Key Difficulty: Complex Time Trajectories  
Complex Inter-dependencies
- Our Approach: Multi-scale statistical models



# *Detect Regularities & Anomalies in Events?*



*Viola & Grimson*

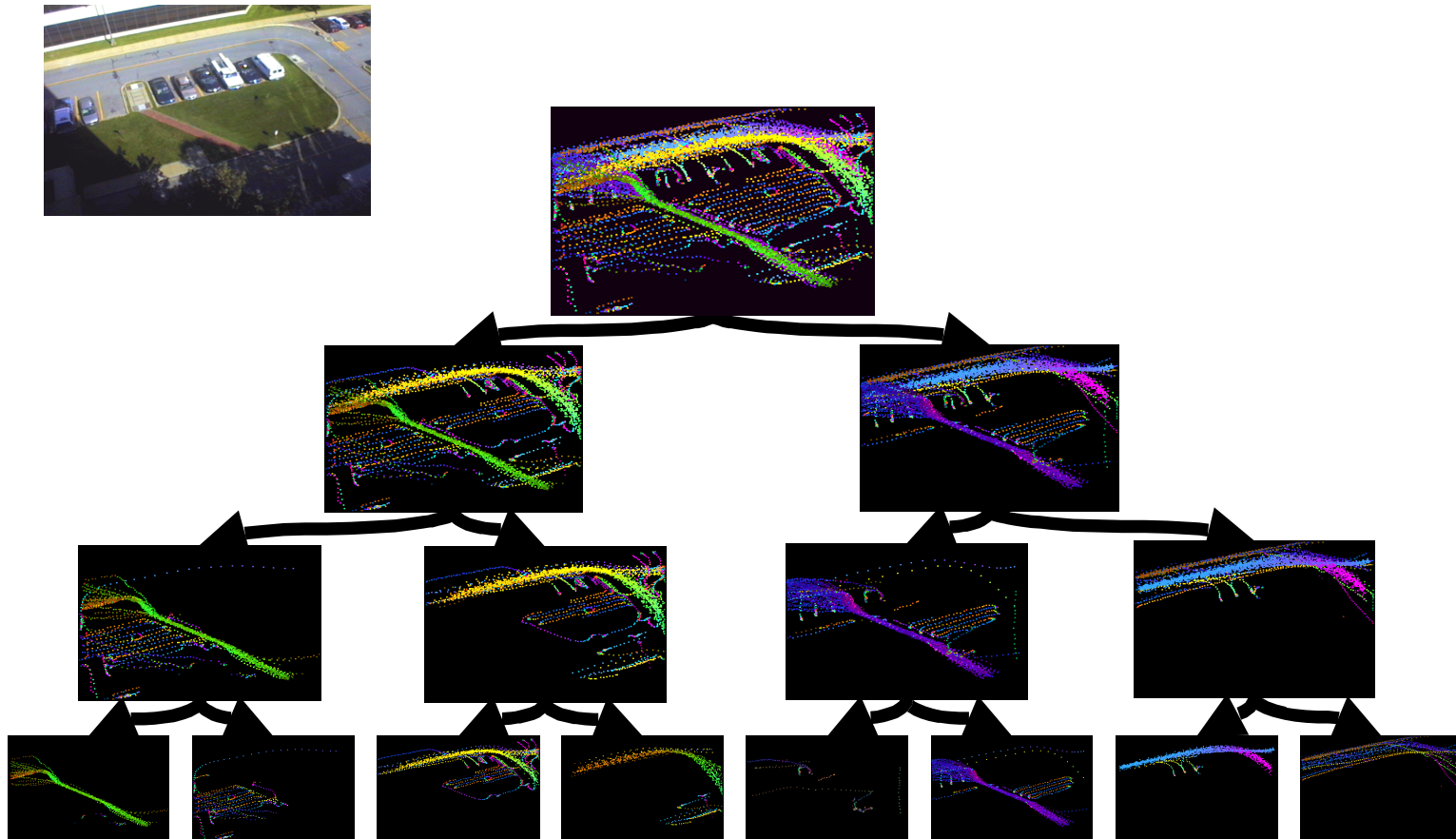


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## *Example track patterns*

- 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

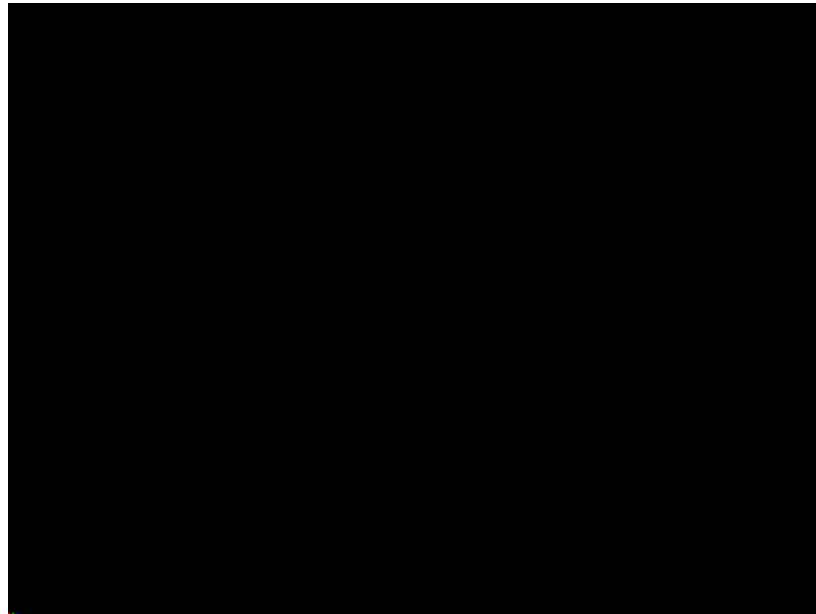
# *Automatic activity classification*



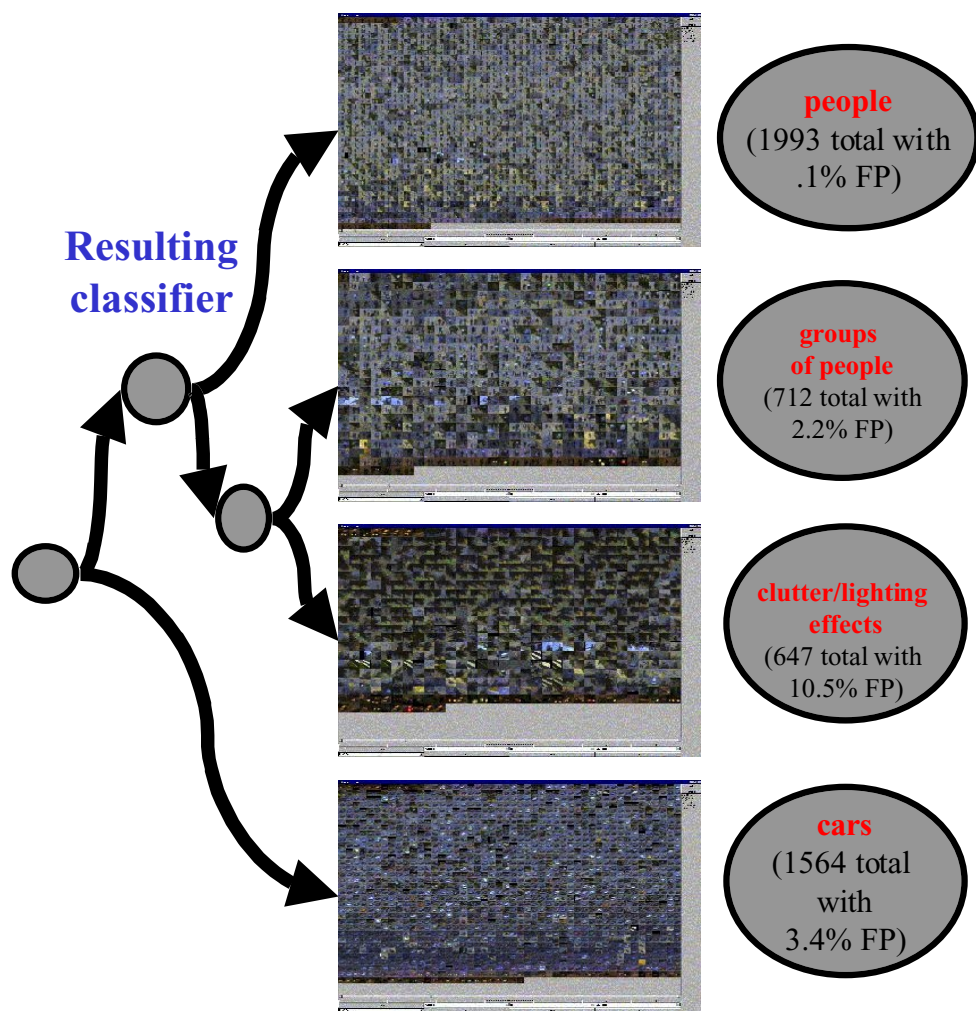


## *Example categories of patterns*

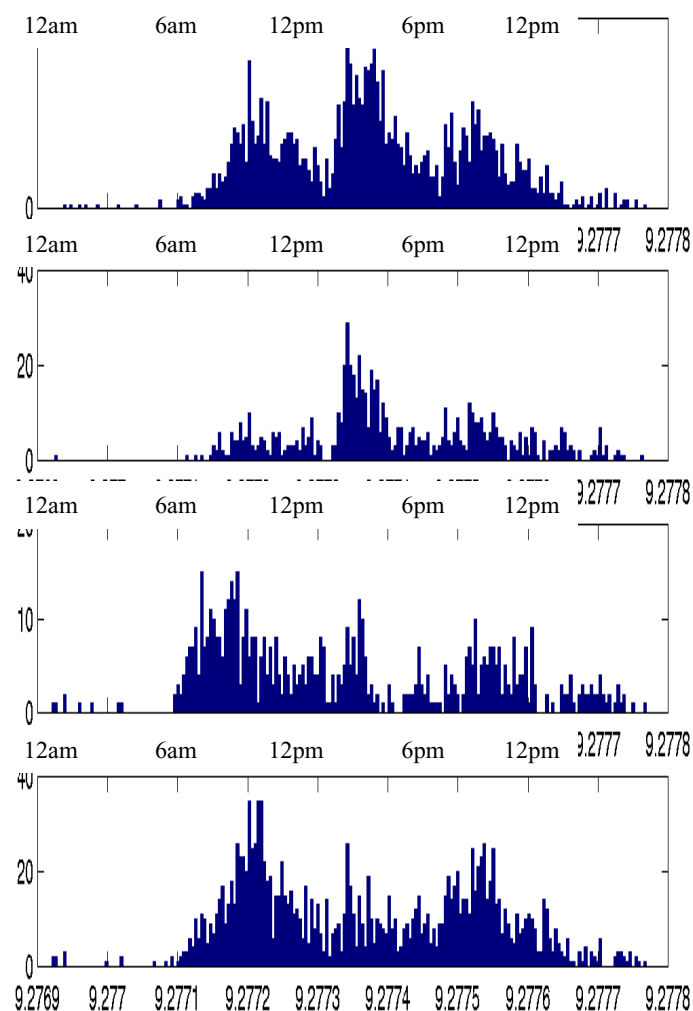
- Video of sorted activities



# Analyzing event sequences



Histogram of activity over a single day



*...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!