Object Detection and Trajectory Clustering from Low-Level Point Tracks

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Research Areas

- Computer vision in large-scale camera networks: calibration and tracking
- Integrating digital images and LiDAR
- Image and video change analysis
- Image processing and machine learning for radiation therapy applications

Potential Military Applications

- SIGINT / IMINT / GEOINT / MASINT analysis and understanding
- Large-scale image and range sensor fusion; activity recognition; change detection and understanding

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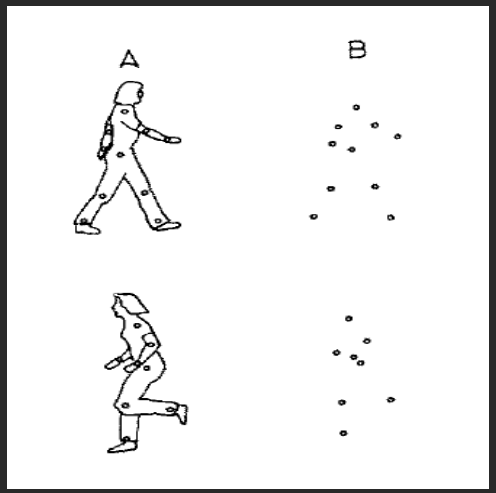
Perceptual Organization

- A swarm of moving green dots represents tracked features
- Human observers can still identify/count moving objects (Johansson 75)



Automatically Extracting Dominant Motions

A. Cheriyadat and R. Radke, ICDSC 07, IEEE JSTSP 08

Motivation: Crowd Behavior Analysis

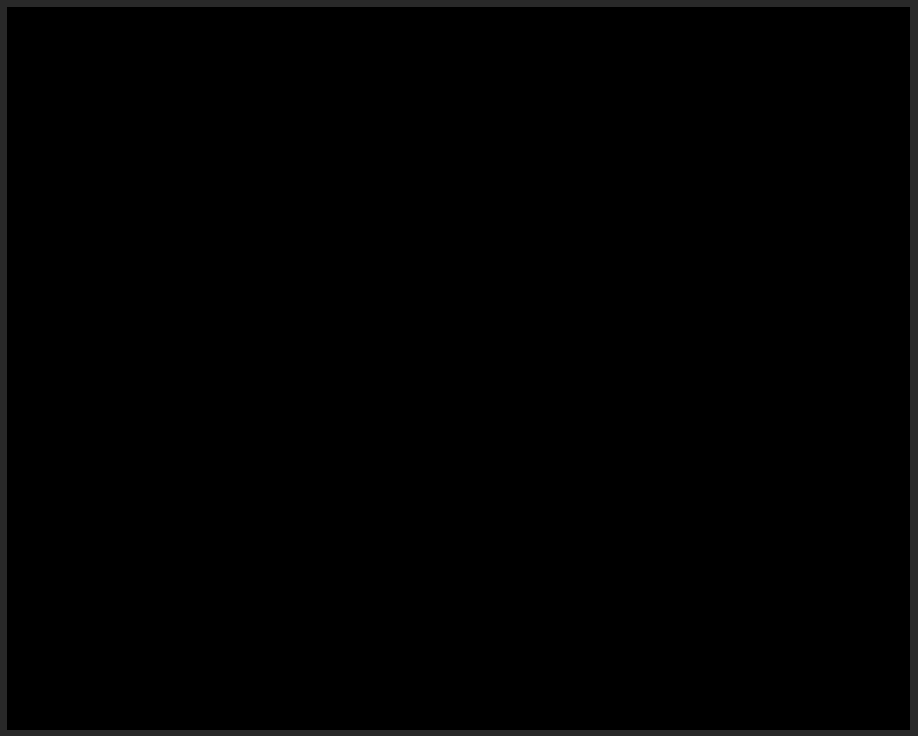


- Challenges: inter- and intra-object occlusions, shadows, illumination changes, difficulty in model fitting

- Applications: surveillance, search and rescue, crisis management

Related Work

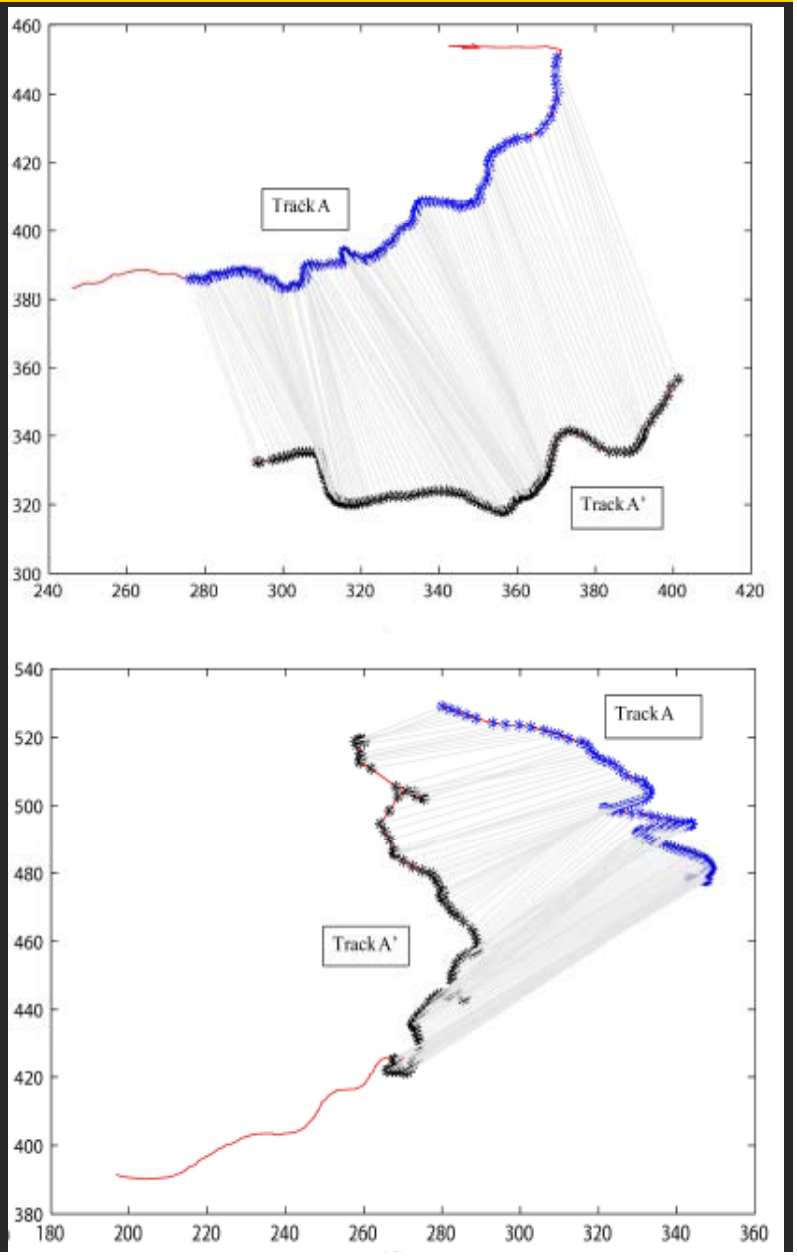
Low-Level Feature Point Tracking



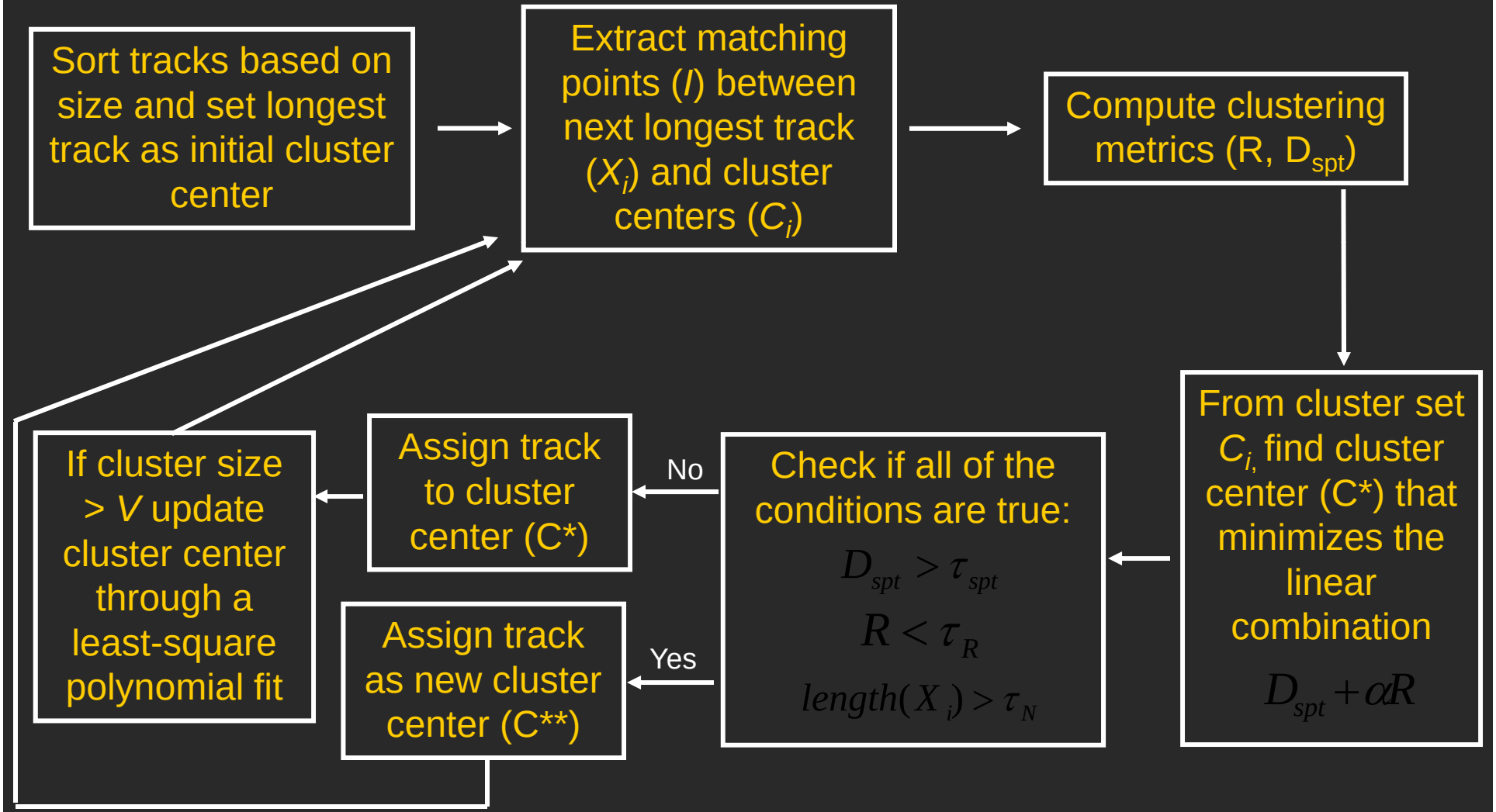
- Tomasi-Kanade and Rosten-Drummond features
- Tracked with hierarchical KLT algorithm
- Many feature tracks are partial or inaccurate

Track Matching Metric

- Distance between tracks measured using longest common subsequences
- Fast point matching algorithm based on dynamic programming
- Parameters to control matching flexibility in space and time

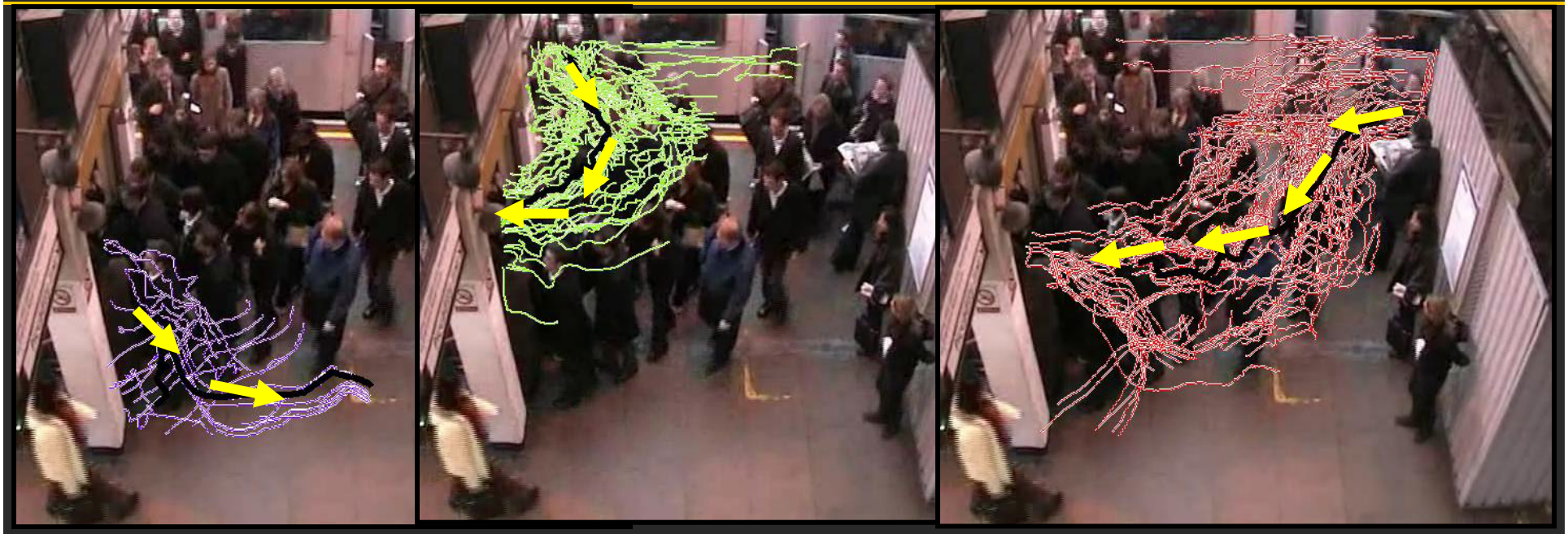


Dominant Motion Clustering Algorithm



Station Sequence

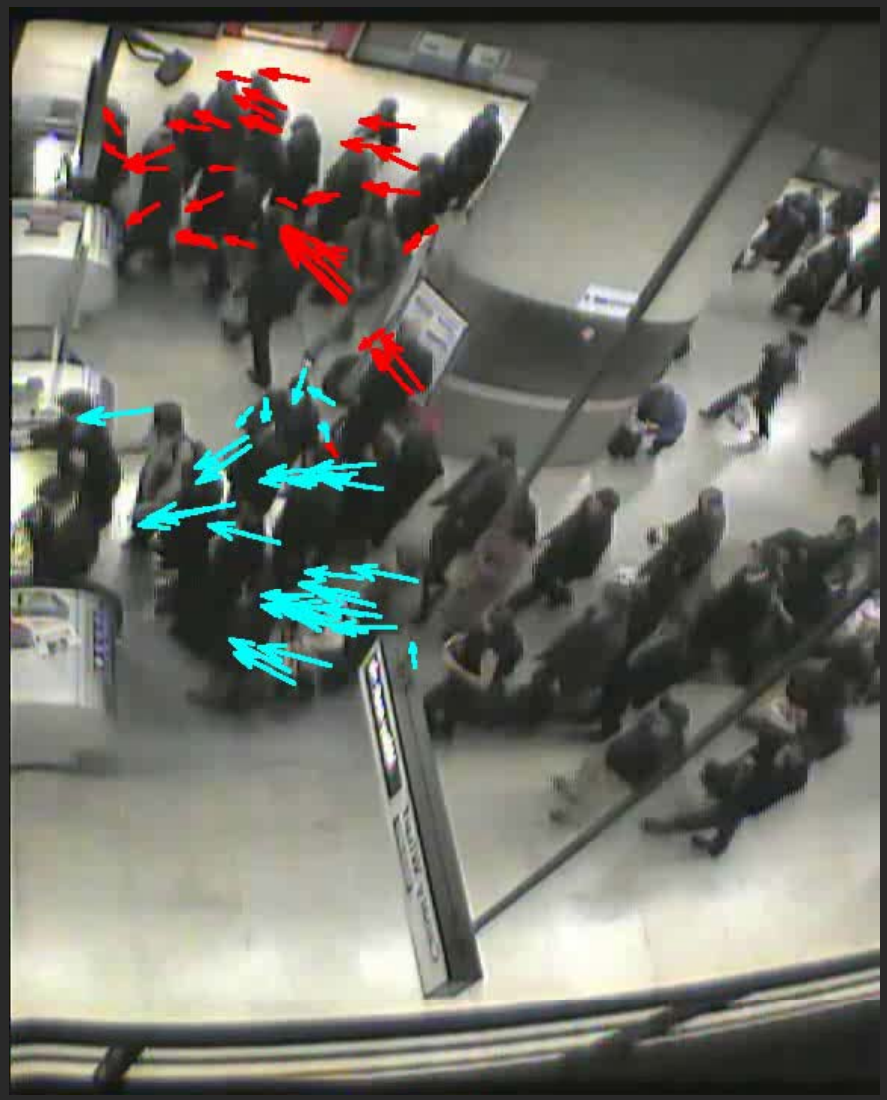
Station Sequence



Automatically extracted clusters:

- Entering platform
- Exiting platform from left
- Exiting platform from right

Escalator Sequence



Airport Sequence

- Left to right, right to left, entering office, loitering

Campus Sequence

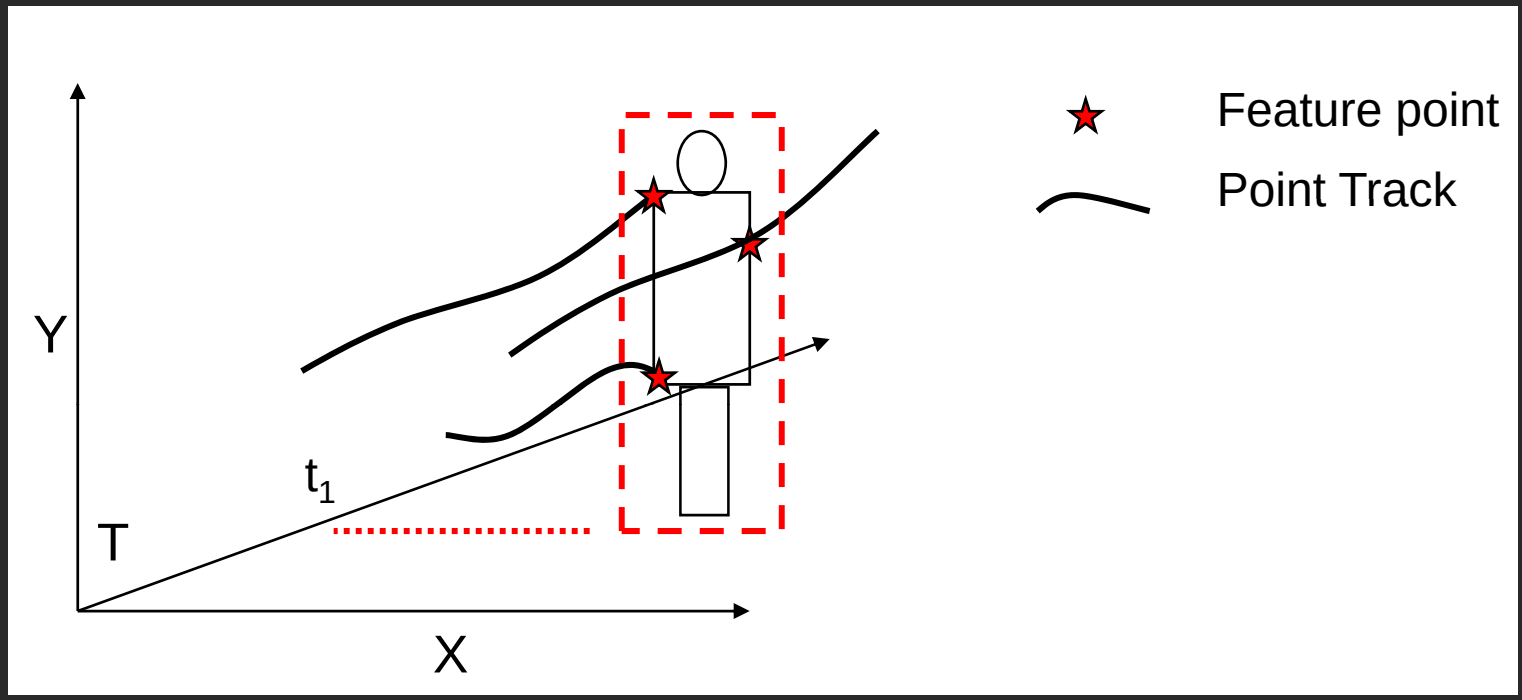
- Two dominant motions
- One anomalous motion: pedestrian doing a U-turn (detected as a small cluster)

Coherent Motion Regions

We collect point tracks into spatio-temporal coherent motion regions (i.e. potential objects), using a greedy algorithm to select the best set of CMRs.

A. Cheriyadat, B. Bhaduri, and R. Radke, CVPR POCV 08

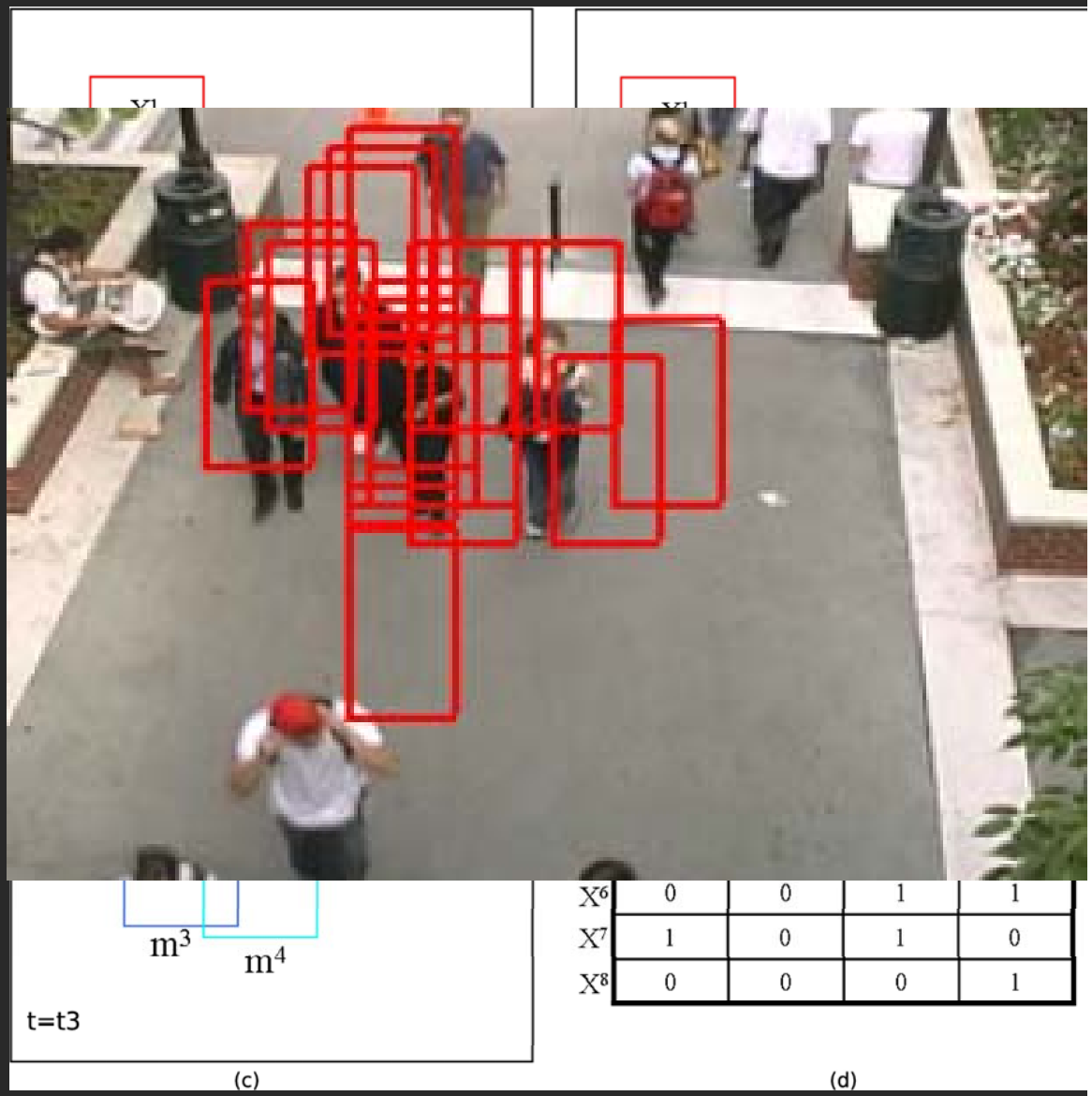
Coherent Motion Regions



- CMR: a contiguous chunk of (x,y,t) space that completely contains a set of point tracks
- May contain tracks with little to no spatial or temporal overlap
- We didn't consider temporal aspects previously

CMR Candidates

- User supplies rough CMR dimensions
- Slide spatial window over each frame
- Generate columns of a binary matrix that represents potential CMRs



X^6	0	0	1	1
X^7	1	0	1	0
X^8	0	0	0	1

CMR Strength

- We define a track similarity measure S(i, j)
- Basic idea: point tracks from the same object should have low maximum distance and low variance in distance

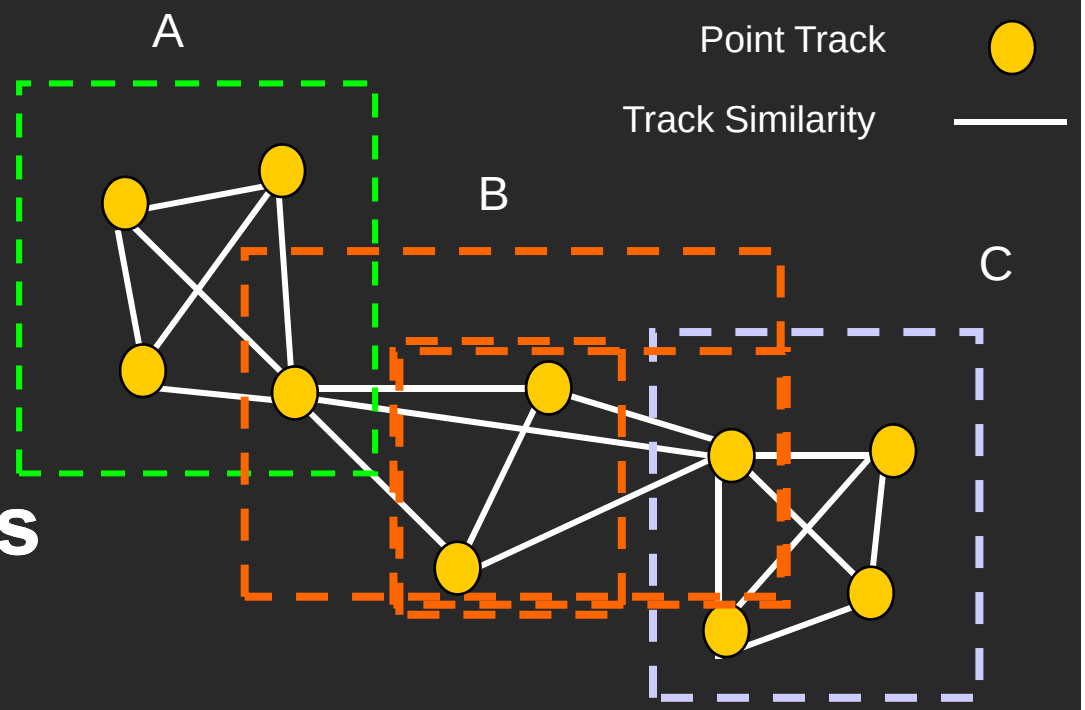
$$S(i, j) = \exp\{-\alpha * (\max(D(i, j) + \mathrm{var}(D(i, j)))\}$$

- We define the strength of a CMR as:

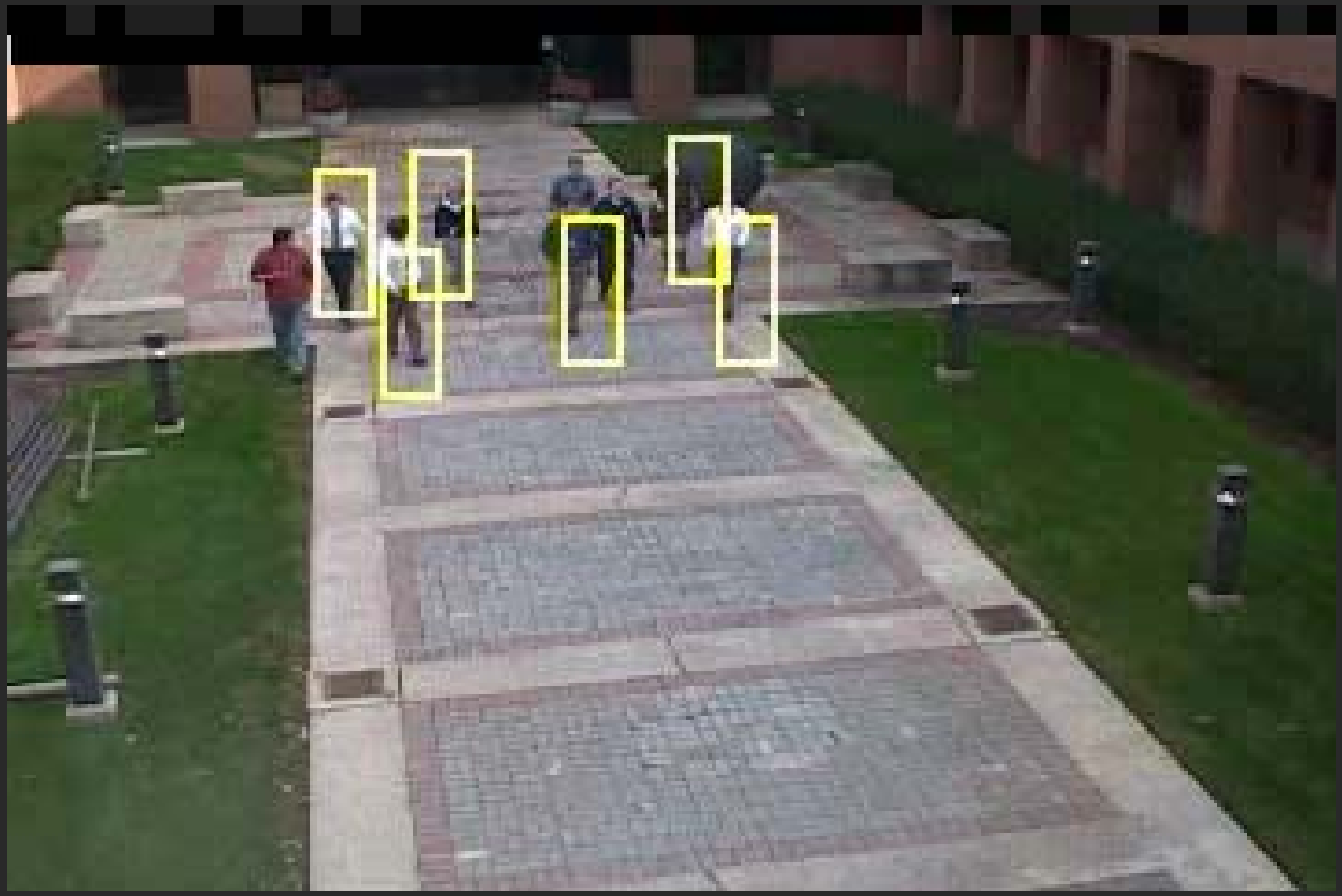
$$L(j) = A(j)^T SA(j)$$

Optimal CMR Subset

- We use a greedy algorithm
- Select strongest CMR
- Break connections to remaining candidates and iterate
- Explicitly enforces ≤ 1 CMR per track

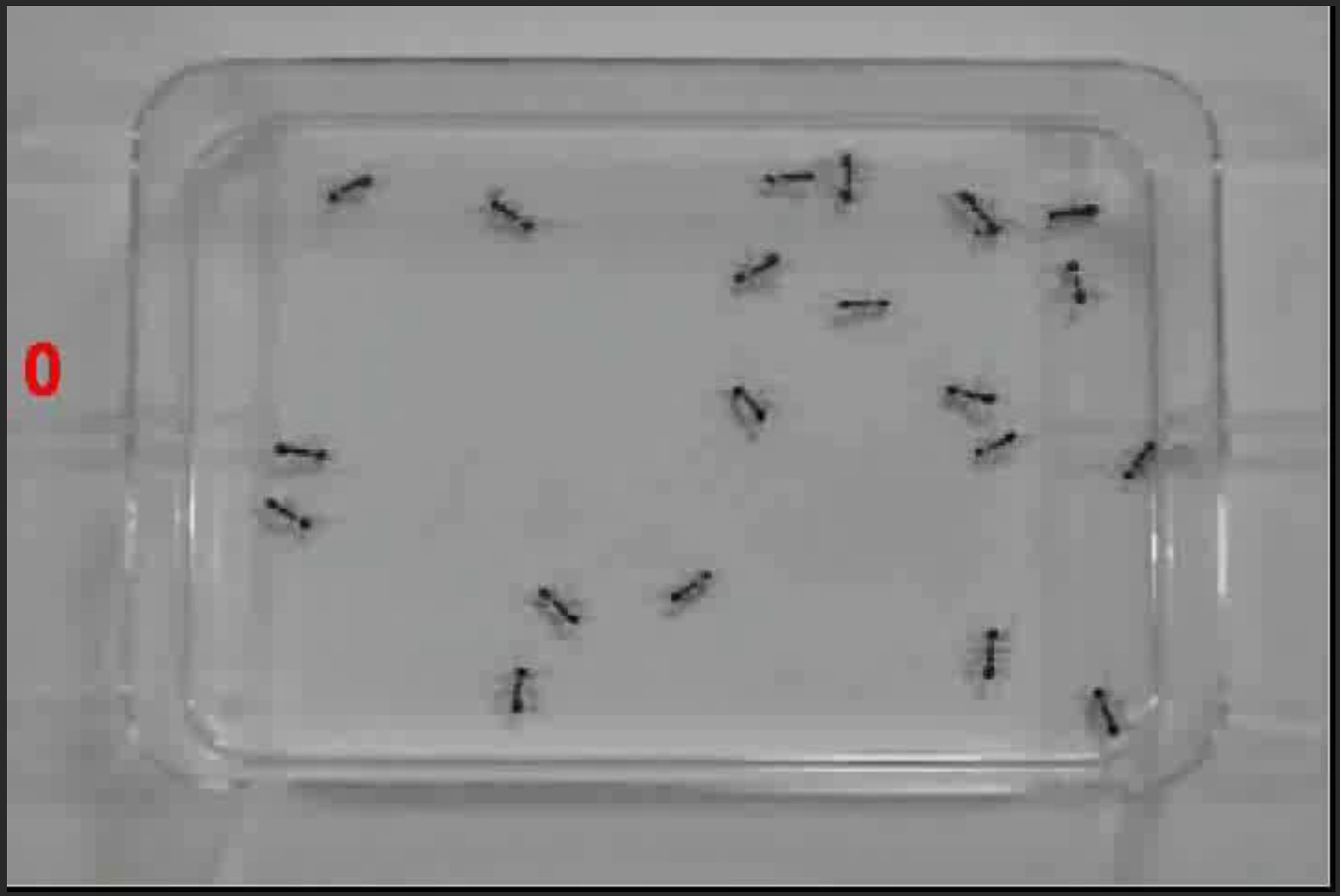


GE Sequence



CalTrans Sequence

Ants Sequence



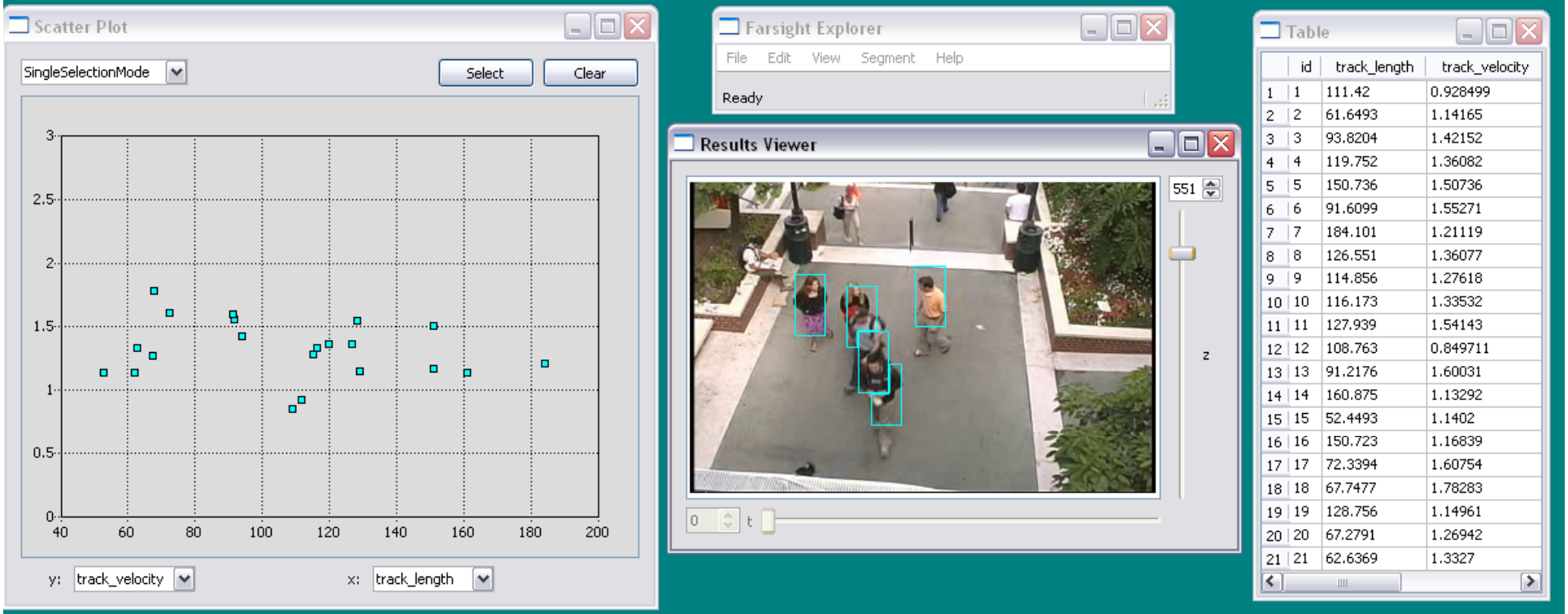
Night Highway Sequence

Independent Motion Segmentation

We apply non-negative factorization of a matrix of point track velocities to obtain fast, accurate segmentation of independent motions.

A. Cheriyadat and R. Radke, in review

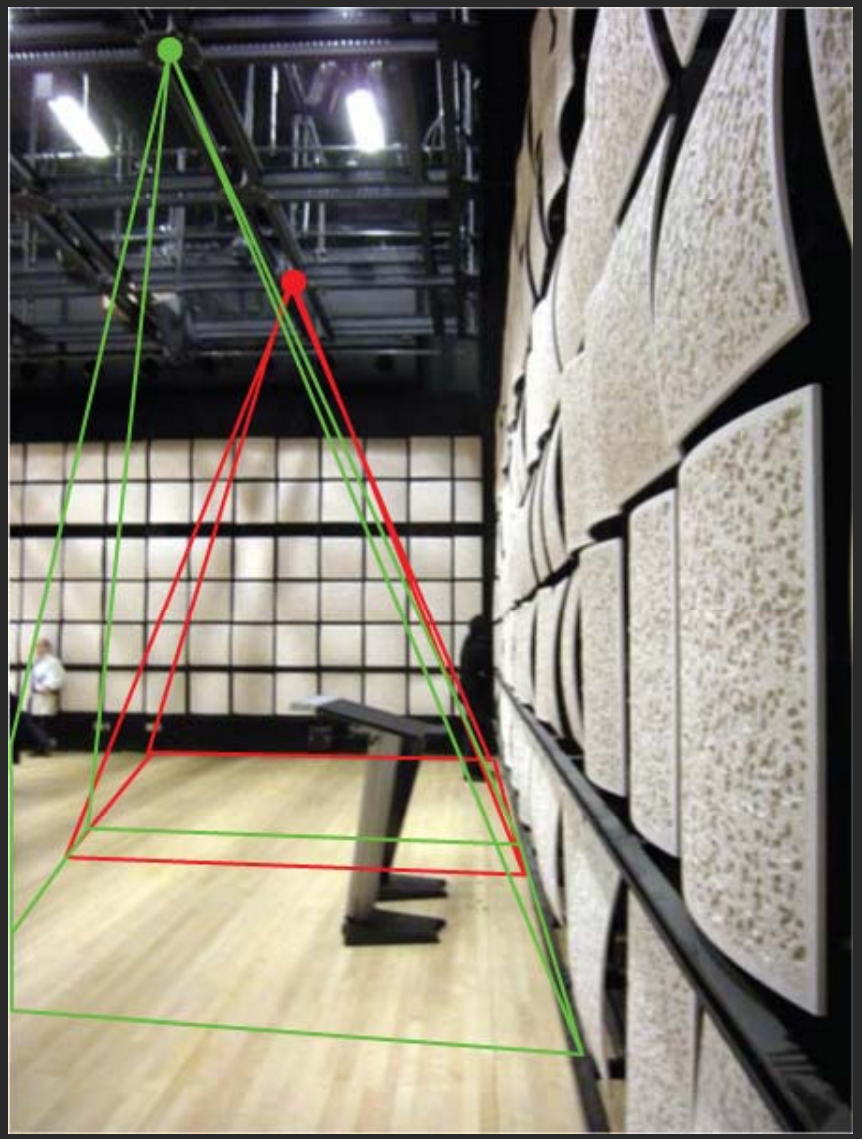
Integration into FARSIGHT



- A powerful interface for interactive visualization and editing of results developed at RPI for biological applications

EMPAC Video Analytics Testbed

- 50x40x30 ft^3 black-box studio at EMPAC, RPI
- 12 ceiling-mounted fixed-focus network cameras, 4 wall-mounted PTZ network cameras
- Testbed for camera network, tracking, activity recognition, crowd motion research
- Platform for URPs



Future Work

- Tuning “significant” dominant motions
- Variable-size CMRs
- Application to portal monitoring environment
- Multi-source fusion
- Independent motion segmentation

Thanks

- Collaborators: Anil Cheriyadat, Bhudendra Bhaduri (ORNL)
- Support: DHS, NSF, DARPA

- Papers: http://www.ecse.rpi.edu/~rjradke/pubs.htm
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