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Video Analytics and Anomaly Detection

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Video Analytics & Anomaly Detection Conclusions

- Known Spatial & Temporal Pattern Detection
  - Anomaly Detection: Counter-Flow Detection
    - 100% Detection, 0 False Alarms on Cleveland Airport System
  - Forensic Search
    - 1000X Compression, Computation scales with #matches
      - Logan Airport ~ current 30 day backup. Potential for significant improvement
- Unknown Spatio-Temporal Pattern Detection
  - Anomaly Detection
    - Useful for suspicious movement, large crowd; unpredictable behavior
  - Forensic Search
    - Efficient techniques for unusual unknown pattern search in large video archive with limited input.
- Many other applications share this framework
  - Explosives Detection with Fluorescence Sensors

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Autonomous Video Surveillance

Networked Cameras are Everywhere

Information Overload

Computation Overload:
Most video footage stored but rarely analyzed.

Storage Overload
At Logan Airport: about 30 days of footage stored

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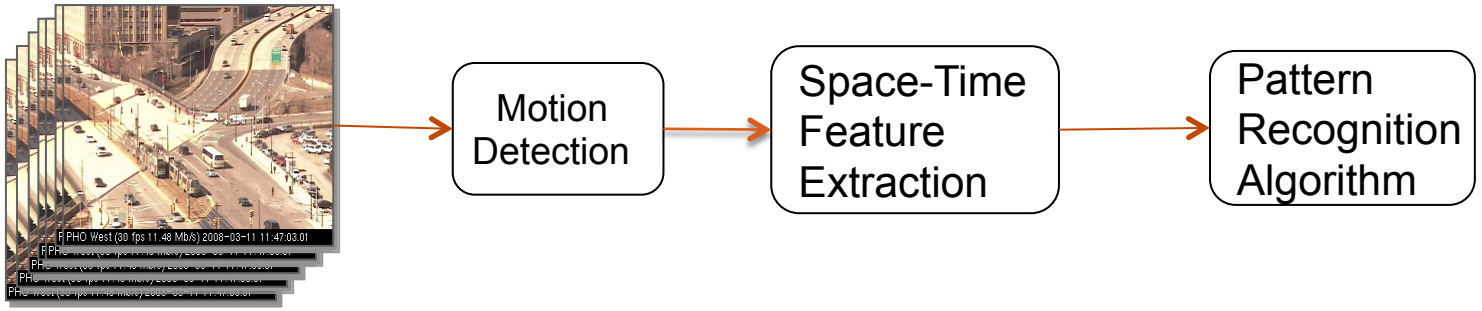
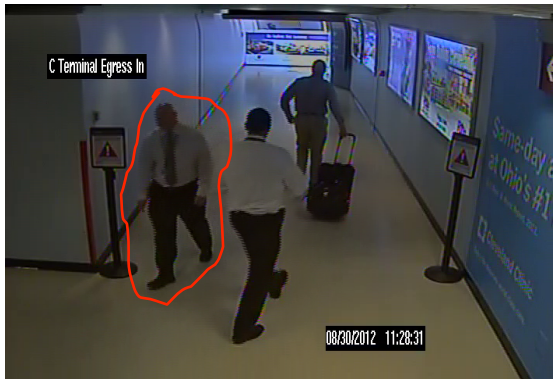
Common Framework: Space-Time Feature Based Algorithm

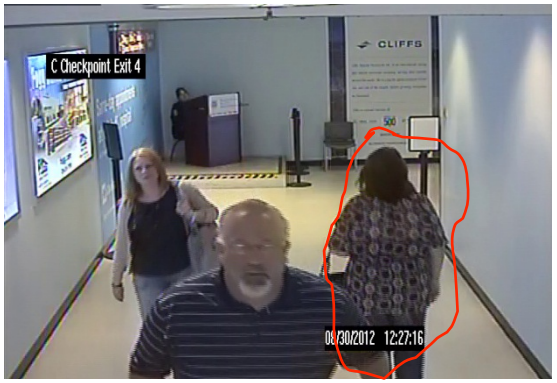


- Approach applies to other domains

Known Spatial-Temporal Patterns

- **Counter-flow direction.**





- Joint project with DHS , Cleveland-Hopkins Airport and ALERT.
- Metrics:
  - Real-time with multiple cameras, 100% detection rate, low false alarms.
  - Replicate conditions of Cleveland Airport
- Challenges:
  - False Alarms: Waving hands/legs, Camera noise, Occlusion and clutter
- Approach: low-level features (tracklets) across space-time

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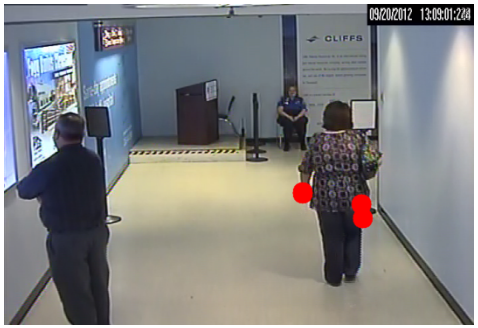
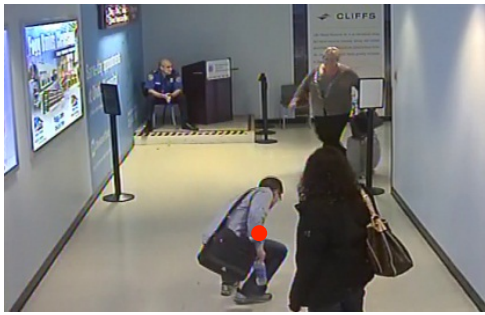
Performance/Results

- **Experiment:**
  - Replicated conditions of Cleveland Airport including video encoders, processors, memory, etc.
  - 10 cameras processed simultaneously for 18 hours in real-time.
  - Examined 7.5 hours of video containing 2800 people and 70 counter-flow events.
- **Generated 100% detection, 0 false alarm.**





- **Current Work:** Fusion of multiple cameras to reduce false alarms

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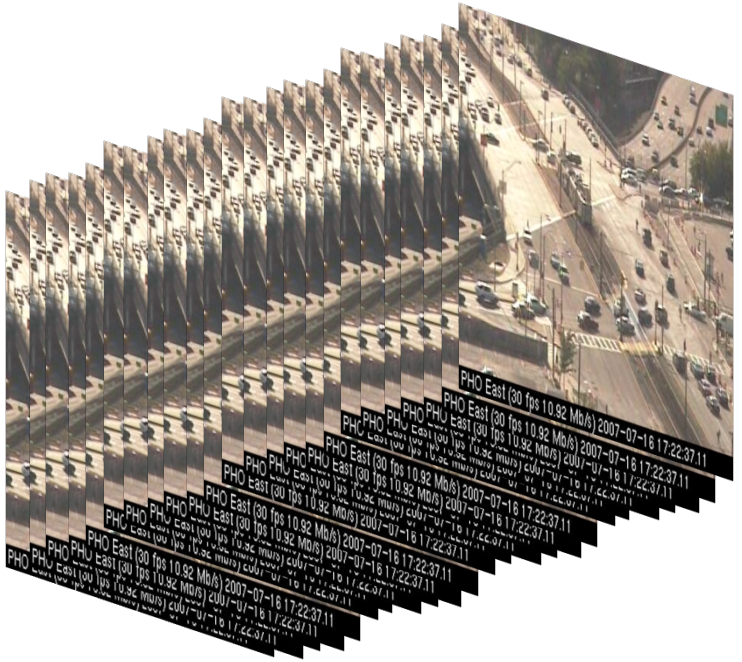
Searching for Known Patterns in Video Archive

- Motivation: Forensics

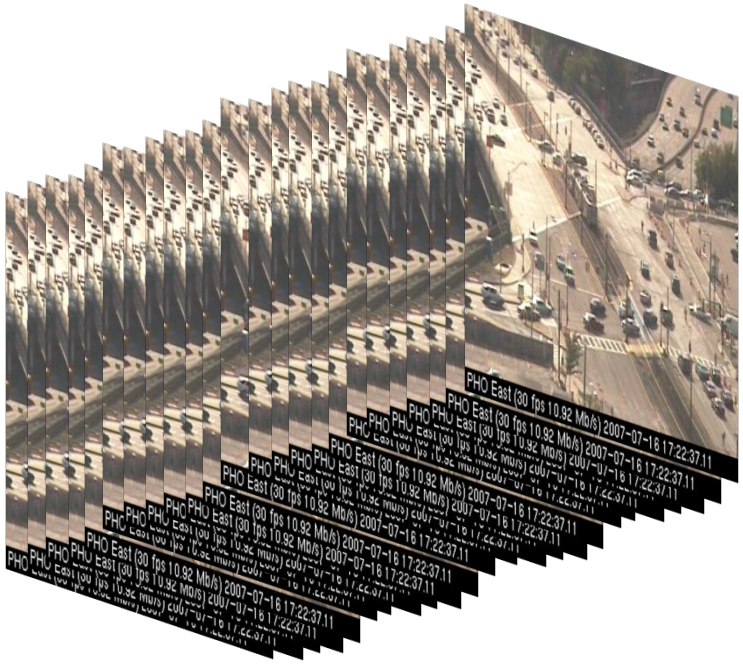


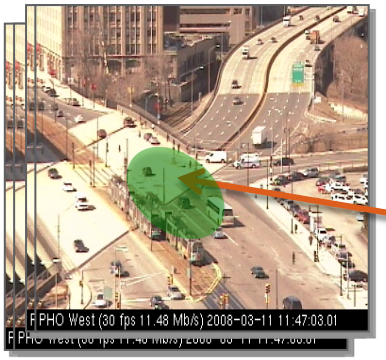
- Challenges:
  - Data Deluge:
    - days, weeks or months of video (Tera, Peta, exa bytes of data
  - Storage Overload:
    - Logan Airport: 30 day backup
  - Computational Overload
    - Archive data not pre-processed

- Goals:
  - Efficient search
    - Time scales with # events (not length of video). Do not want to process archive!!
  - Improve storage
    - Can we go back 300 days instead of 30 days?

Castanon - S, ACM Multimedia 2012

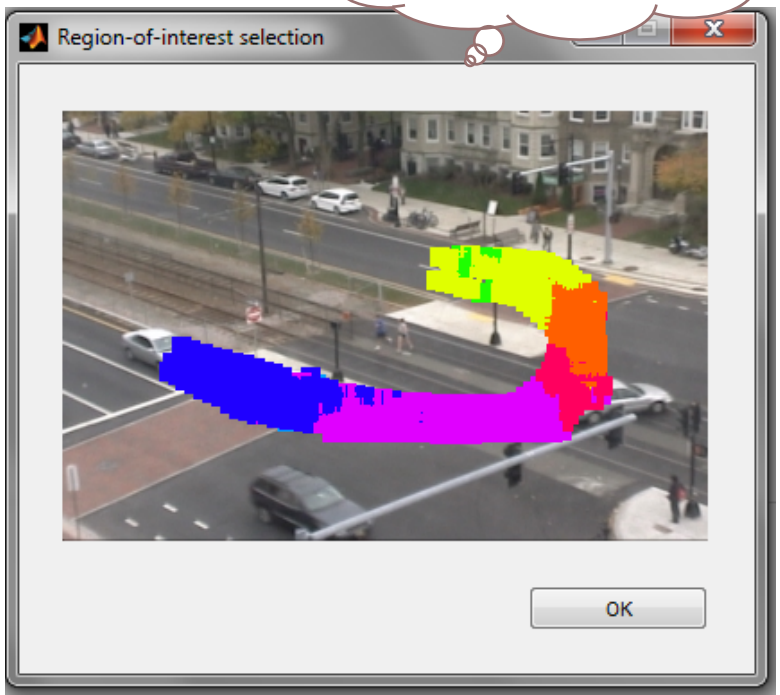
How to describe what to look for?





Manual

Find a u-turn



- Video Forensics
- Flexible Queries
  - Unusual Events
    - U-turns, turnstile hoppers
  - Usual Events
    - Person going from Point A to B

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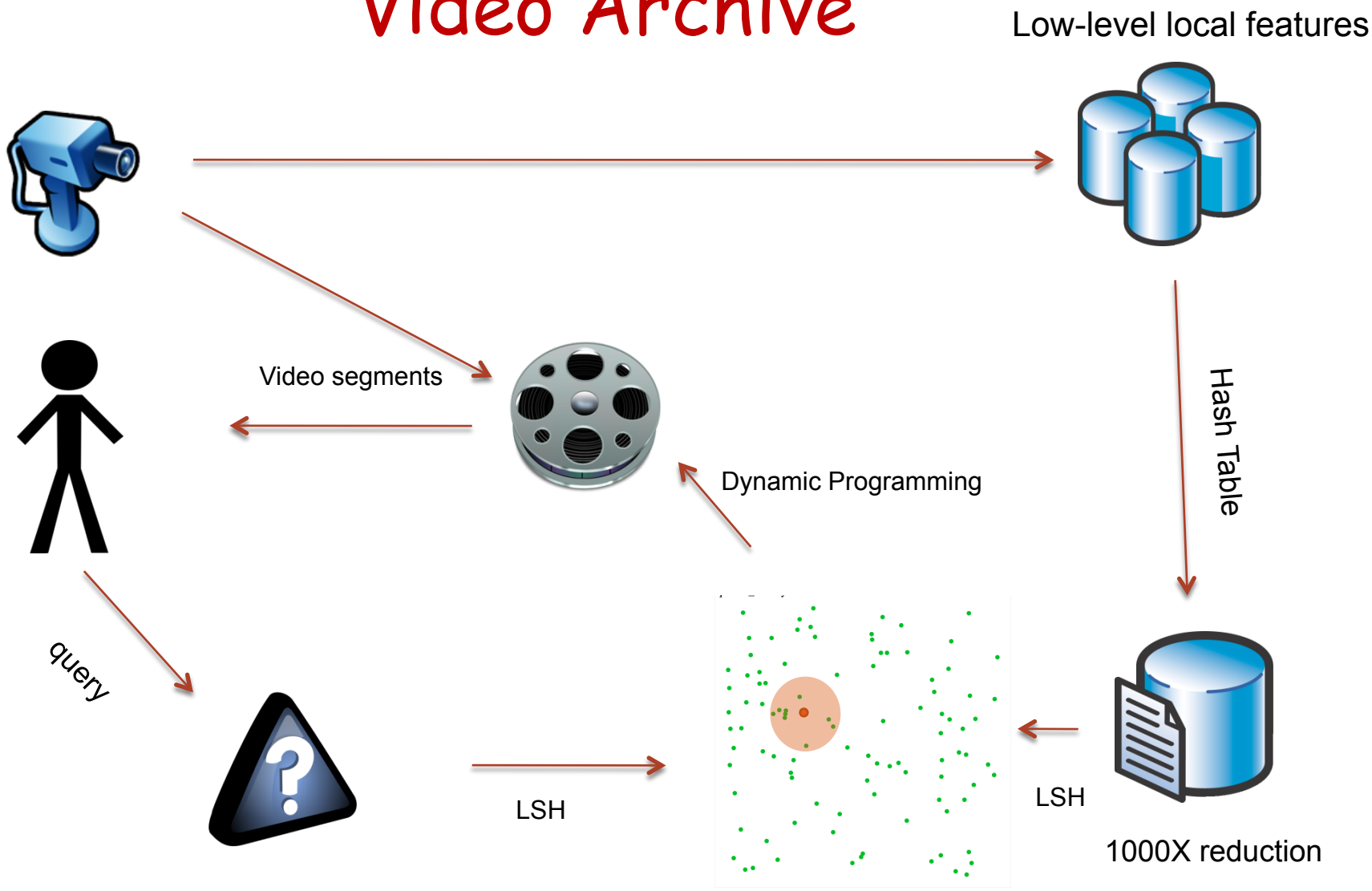
Searching for Known Patterns in Video Archive



Only Store Hash Table Locally

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Results on Benchmark Video Archive

Task	Video	Search query	Features	Video size	Index size
1	Winter driveway	black cat appearance	color and size	6.55 GB	147 KB
2	Subway	people passing turnstiles	motion	2.75 GB	2.3 MB
3	Subway	people hopping turnstiles	motion	2.75 GB	2.3 MB
4	MIT Traffic	cars turning left	motion	10.3 GB	42 MB
5	MIT Traffic	cars turning right	motion	10.3 GB	42 MB
6	U-turn	cars making U-turn	motion	1.97 GB	13.7 MB
7	U-turn	cars turning left, no U	direction	1.97 GB	13.7 MB
8	Abandoned object	abandoned objects	size and persistence	682 MB	2.6 MB
9	Abandoned object	abandoned objects	size, persistence and color	682 MB	2.6 MB
10	PETS	abandoned objects	size and persistence	1.01 GB	5.63 KB
11	Parked-vehicle	parked vehicles	size and persistence		

Video duration	Ground truth (minutes)	Returned (minutes)	Ground truth (events)	True positives (events)		False negatives (events)		Lookup (seconds)	Ranking (seconds)
4 hours 13 min	2.5	3.8	3	2	—	1	—	7.49	2.50
1 hour 19 min	19.0	15.3	117	116	114	1	121	0.33	0.35
1 hour 19 min	0.9	4.5	13	11	1	2	33	3.05	1.01
1 hour 32 min	4.9	14.4	66	61	6	5	58	0.38	3.50
1 hour 32 min	13.2	27.9	148	135	54	13	118	0.47	2.63
3 min 24 sec	0.5	0.5	8	8	6	0	23	1.23	1.21
3 min 24 sec	0.4	0.4	6	5	4	1	14	0.61	0.40
13 min 47 sec	4.6	3.7	2	2	—	0	—	4.82	0.22
13 min 47 sec	4.6	4.2	2	2	—	0	—	13.33	0.20
7 min 8 sec	3.7	2.3	4	4	—	0	—	?	?
32 min	17.2	16.0	14	14	—	0	—	?	?

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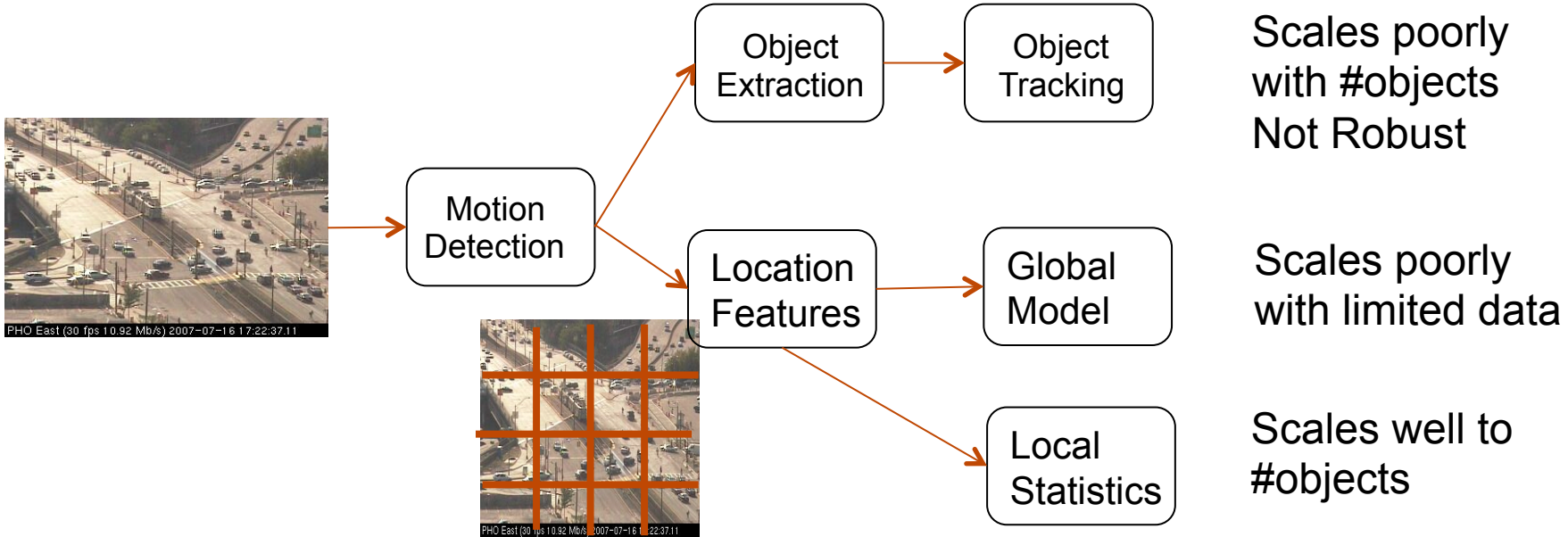
Detecting Unknown Unusual Patterns

- Location-based attributes
  - highly correlated in space-time-feature space
- Learn Global Joint Space-time-Feature Model
  - Topic Modeling, MRFs, Mixture models, Sparse Dictionaries (Wang'10,Kim'09,Mahadevan'11, Cong'11, …)

- Main Drawback with Global Models
  - Nominal behavior is too complicated



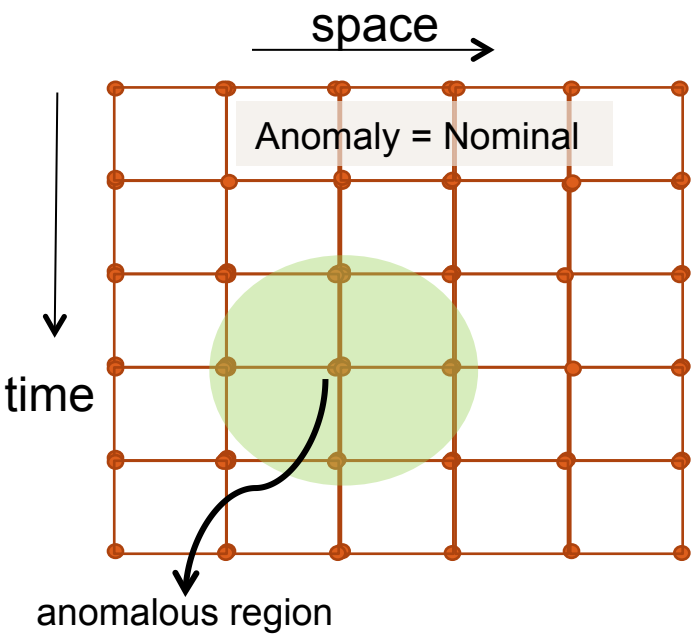
Our Key Insight: Local Anomaly Model

- Ball of radius R centered at v

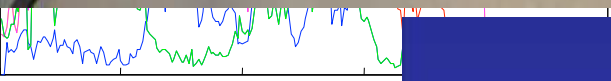
$$B_u = \{u \mid d(u, v) \leq R\}$$

  - Marginals outside equal

$$f_u(\mathbf{X}_{B_u^c}) = f_0(\mathbf{X}_{B_u^c})$$



  - Video Implication:
    - features have same joint distribution outside some patch
    - Cannot see anomaly from features outside region



Video Anomaly Detection Based on Local Statistical Aggregates

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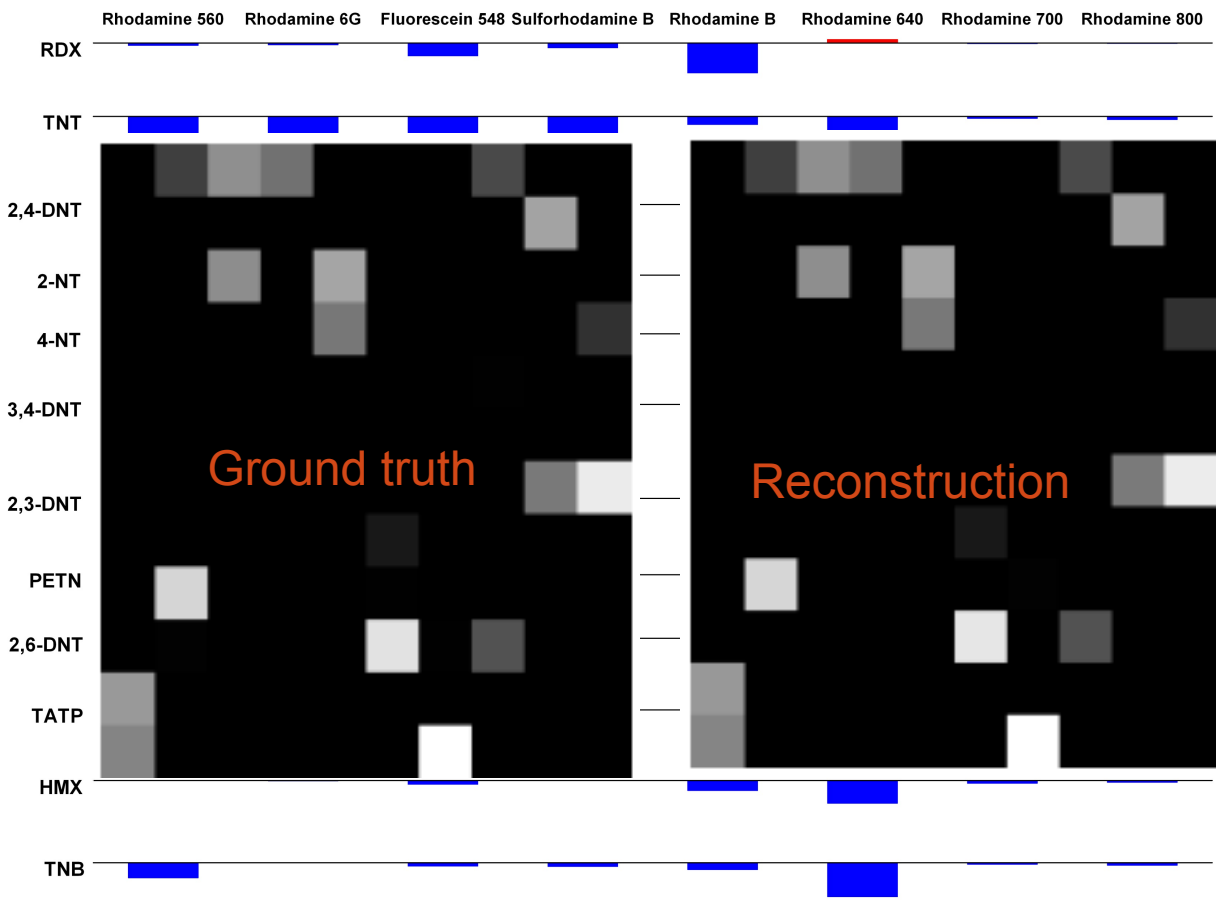
Detection of Explosive Analytes with Fluorescence Sensor

- Bill Euler (URI)
  - Sensor Array
    - "Fingerprint"
- Pure Explosive
  - Known pattern
- Explosive mixtures
  - unknown patterns
    - Sparse patterns
    - Poisson Statistics
- Solution:
  - Non-linear Compressed sensing
  - Novel Extensions to existing literature
  - Optimal algorithms



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