Data-driven Crowd Analysis in Videos

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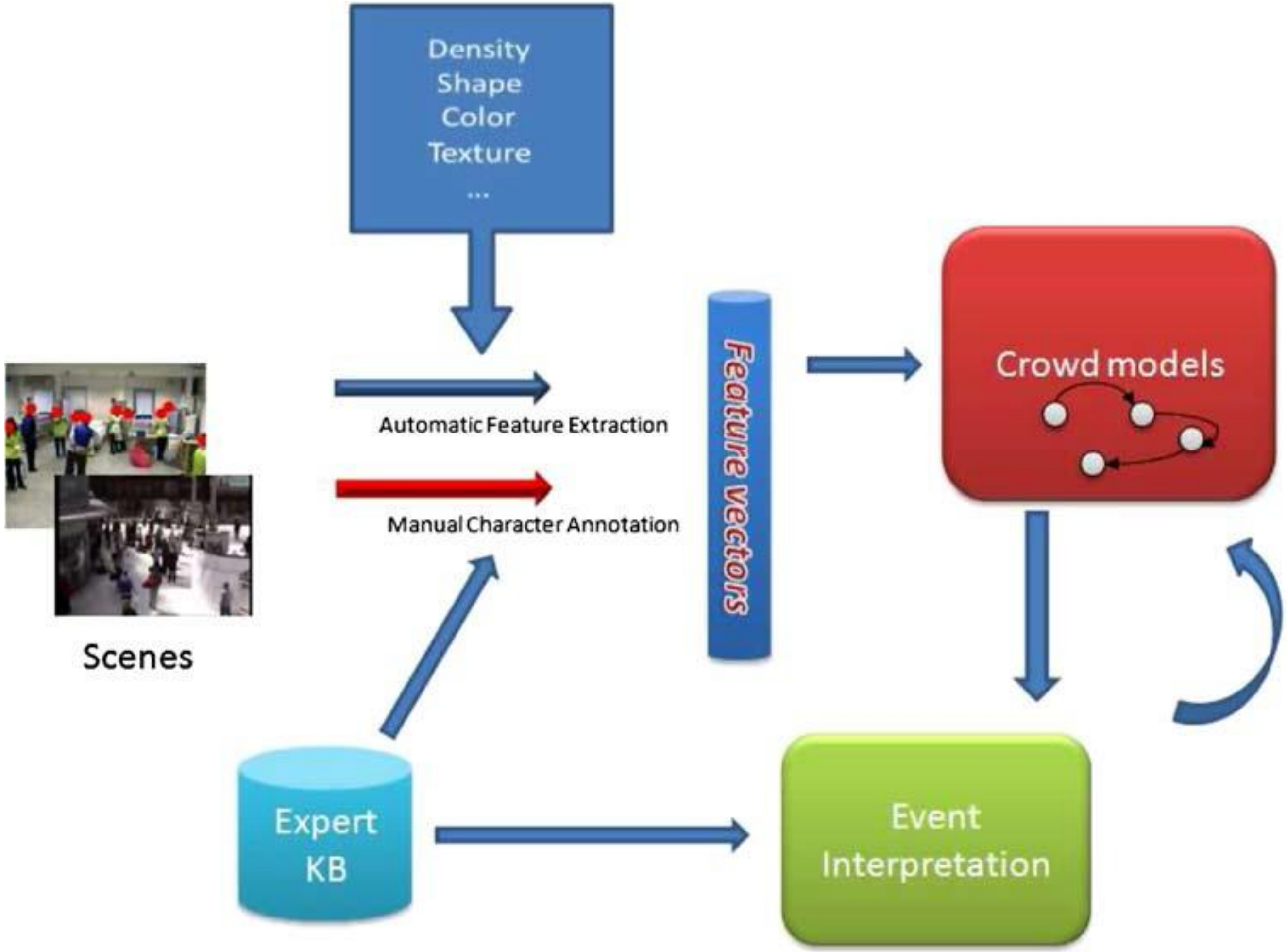
WILLOW project

Crowd Analysis

Crowd management
Public space design
Virtual environments
Visual surveillance

[Crowd analysis: a survey](), Zhan, B., Monekosso, D.N., Remagnino, P., Velastin, S.A., Xu, L., Machine Vision and Applications, Vol 19, No 5-6, p. 345-357, DOI: 10.1007/s00138-008-0132-4.

Crowd Analysis



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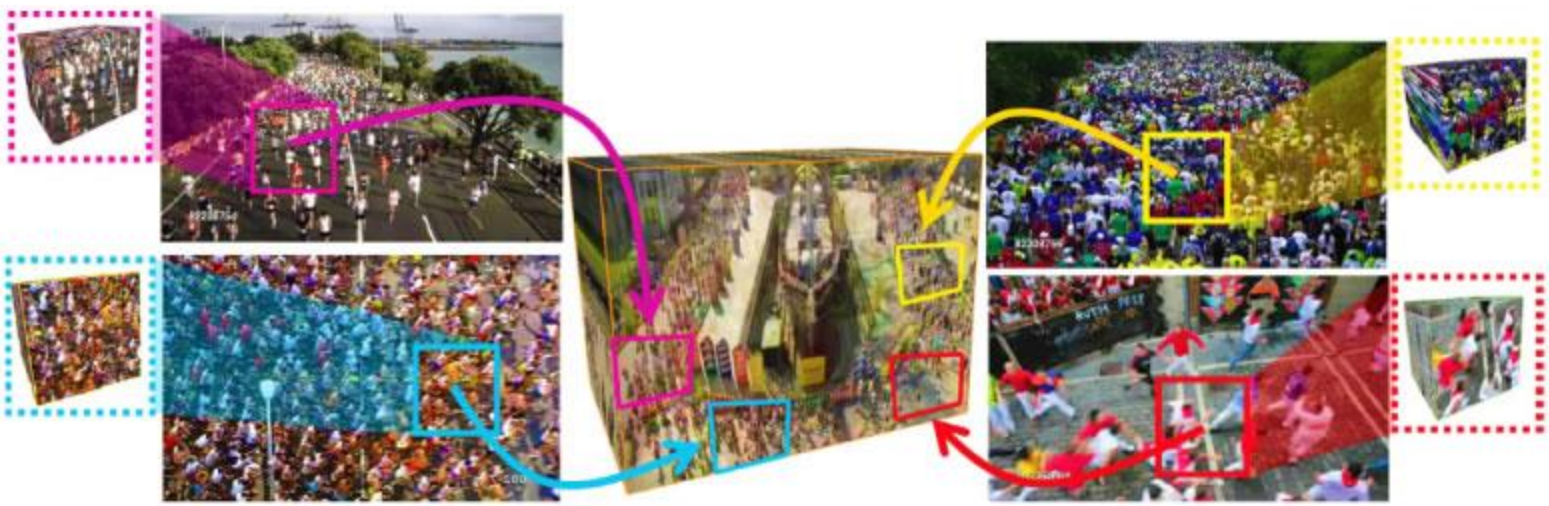
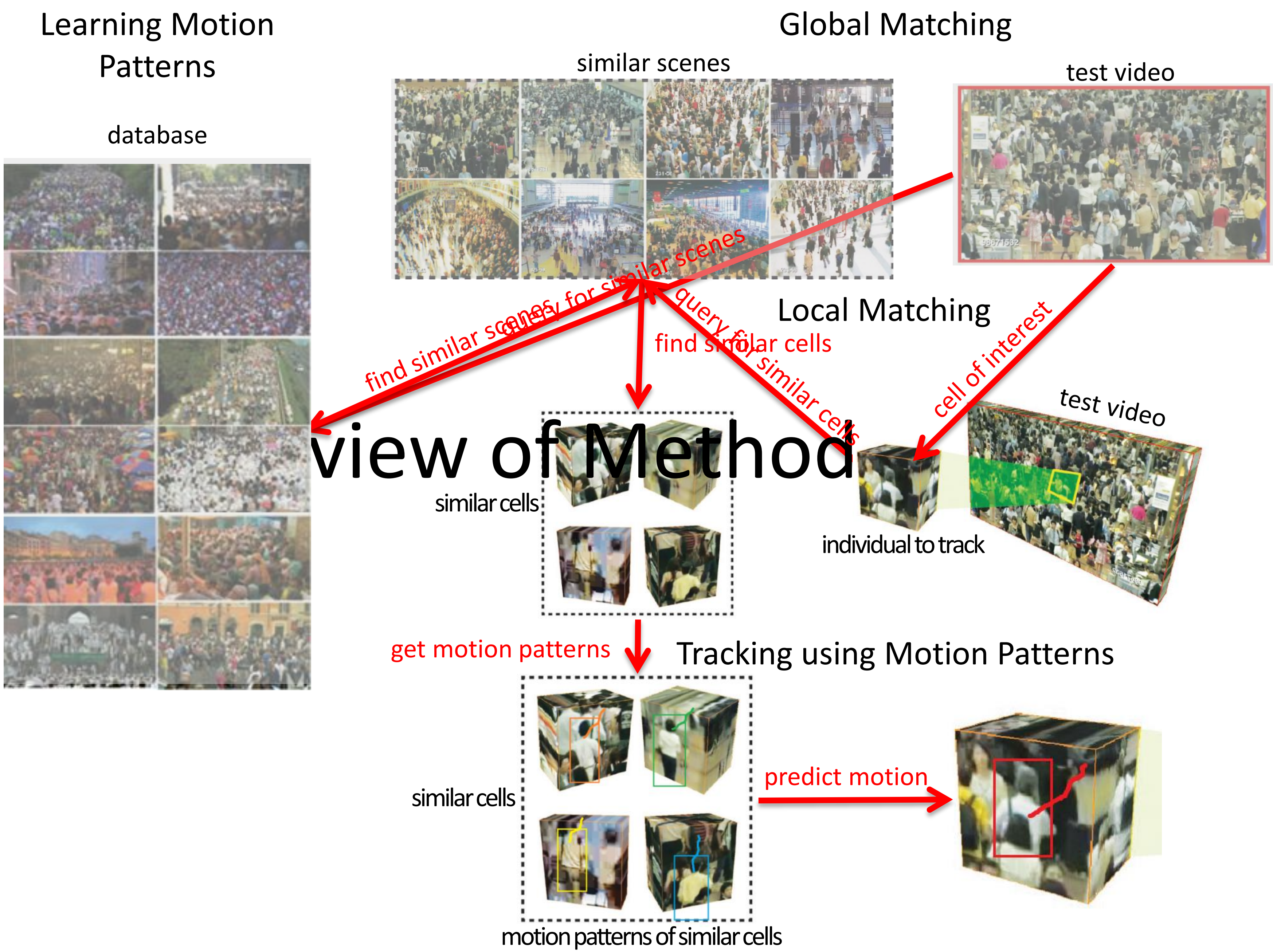
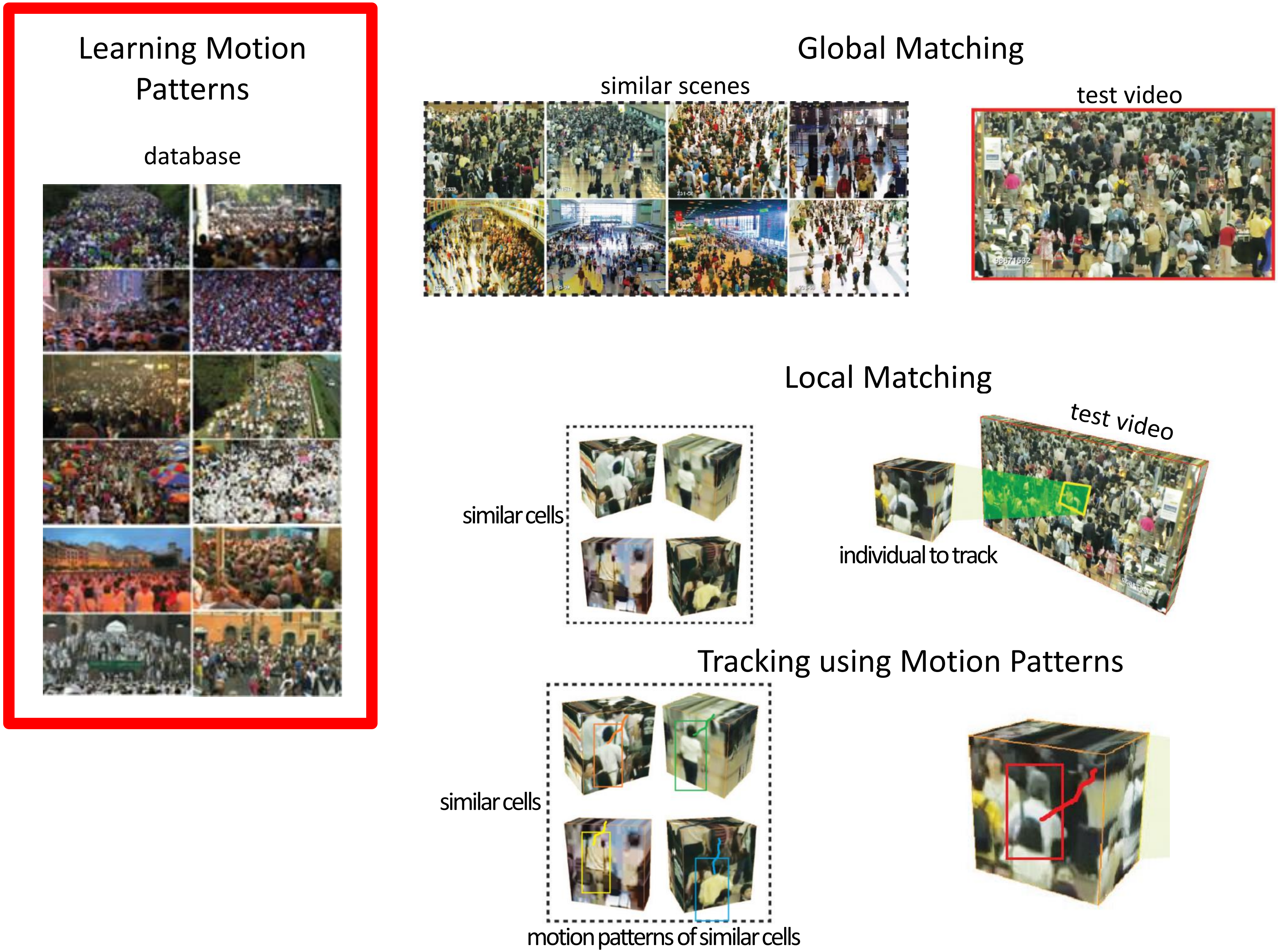
Data-driven Crowd Analysis

- Any given video can be thought as being a mixture of previously observed videos.



view of Method



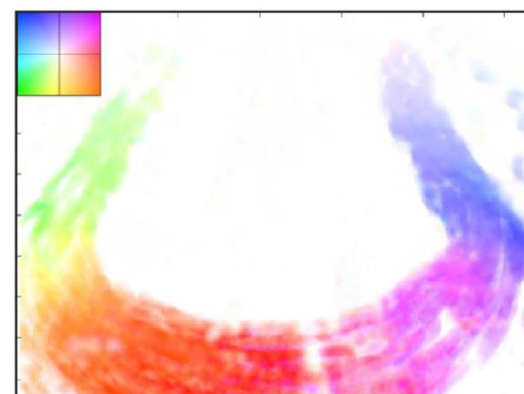

Learning Motion Patterns
database
Global Matching
similar scenes
test video
Local Matching
test video
similar cells
individual to track
Tracking using Motion Patterns
similar cells
motion patterns of similar cells

Learning Motion Patterns

<u>Low-level Representation</u>: Dense Optical Flow

- For each pixel in each frame, calculate average optical flow.

- Combine the optical flow vectors into a global motion field for a temporal window.
  - temporal window ω = 60 frames
  - spatial window 20 pixel x 20 pixel

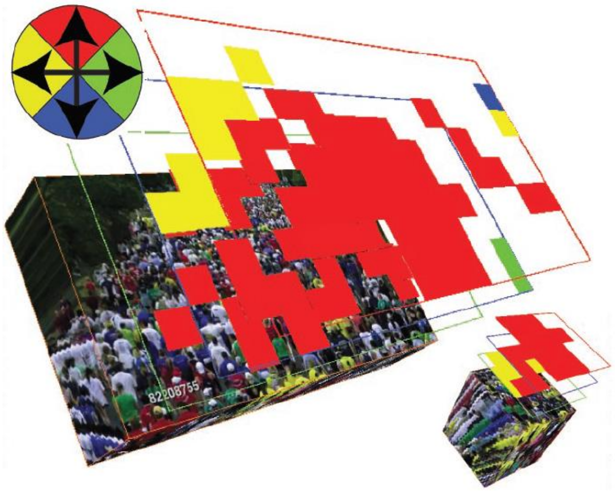


[An iterative image registration technique with an application to stereo vision.](#) B. Lucas and T. Kanade. In IJCAI, volume 3, pages 674–679, 1981.

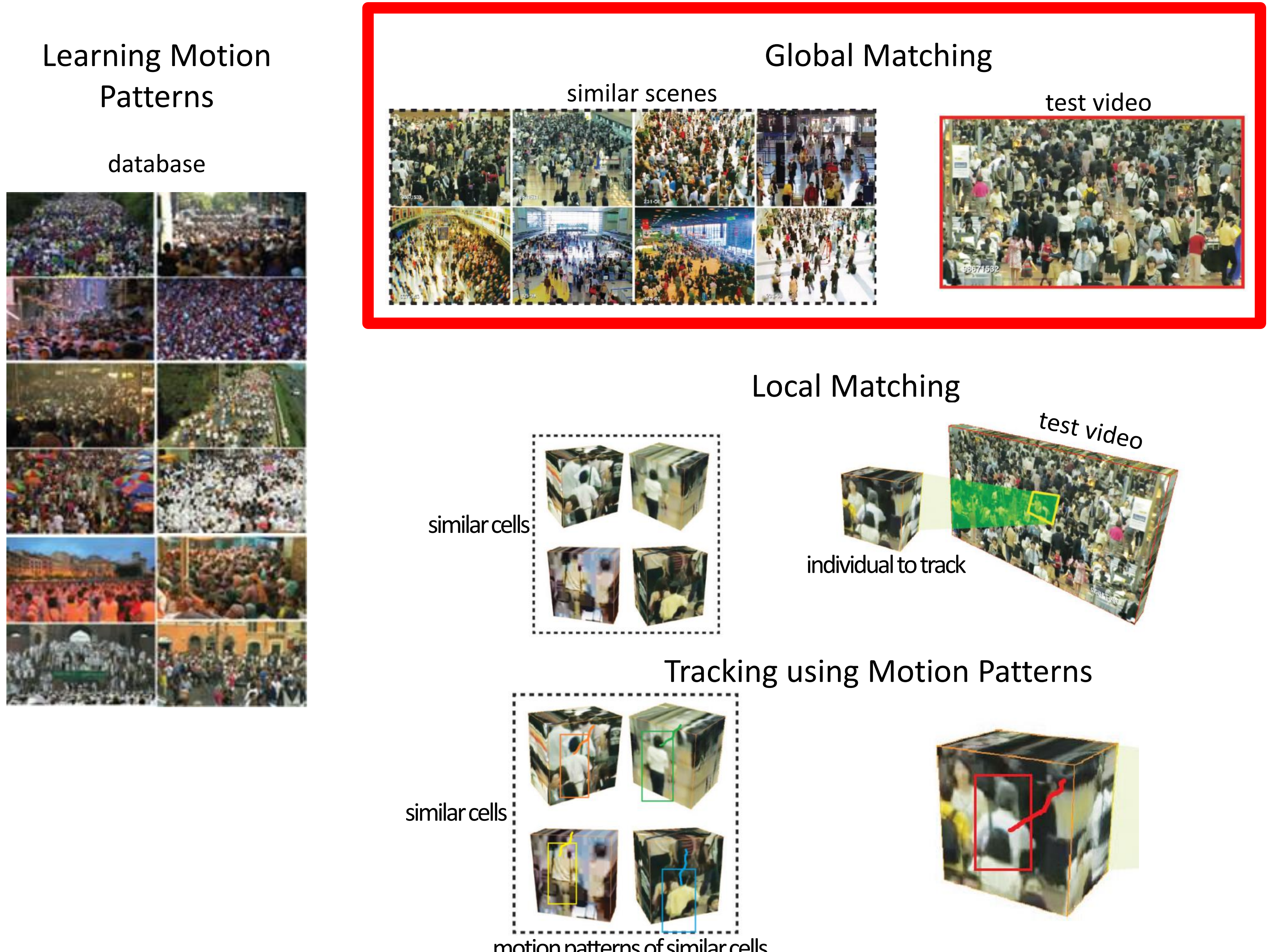
Learning Motion Patterns

Mid-level Representation: Correlated Topic Model

- CTM captures spatial dependencies of different behaviors in the same scene.
- Video(720x480)=> 10 sec clips
  => 36x24 cells(20x20)
- Optical flow is quantized into directions
  => $\{V_0, V_{up}, V_{down}, V_{left}, V_{right}\}$
- Motion word dictionary is constructed
- Behavior is (hidden) topic from which motion words are generated.



A correlated topic model of science. D. Blei and J. Lafferty. AAS, 1(1):17–35, 2007



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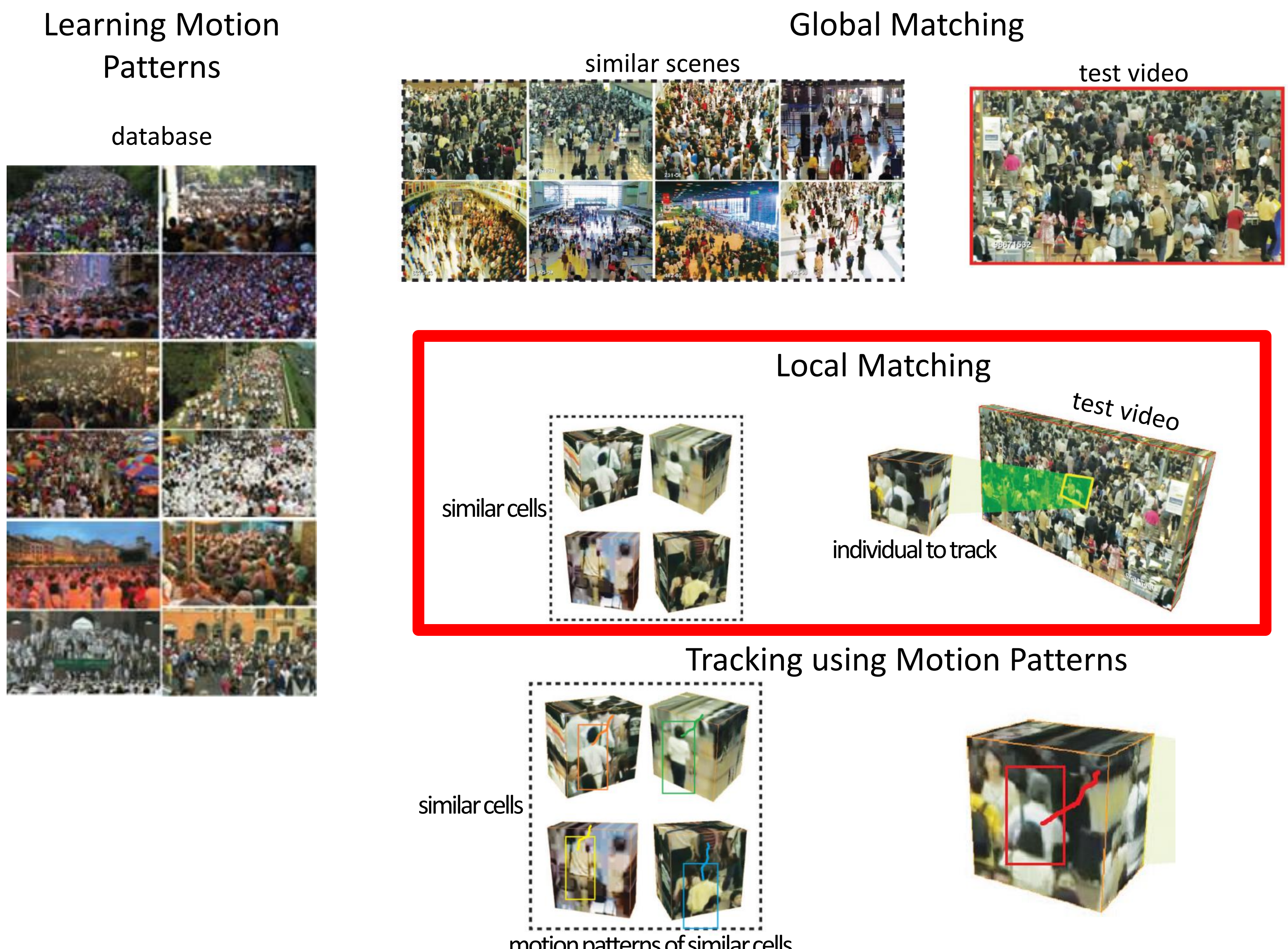
Global Crowded Scene Matching

- Gist scene descriptor is used to retrieve similar scenes from the database.
- Global matching provides semantically similar scenes.

Modeling the Shape of the Scene: A Holistic Representation of the Spatial Envelope, Oliva, A., Torralba, A., International Journal of Computer Vision 42(3), 145-175, 2001.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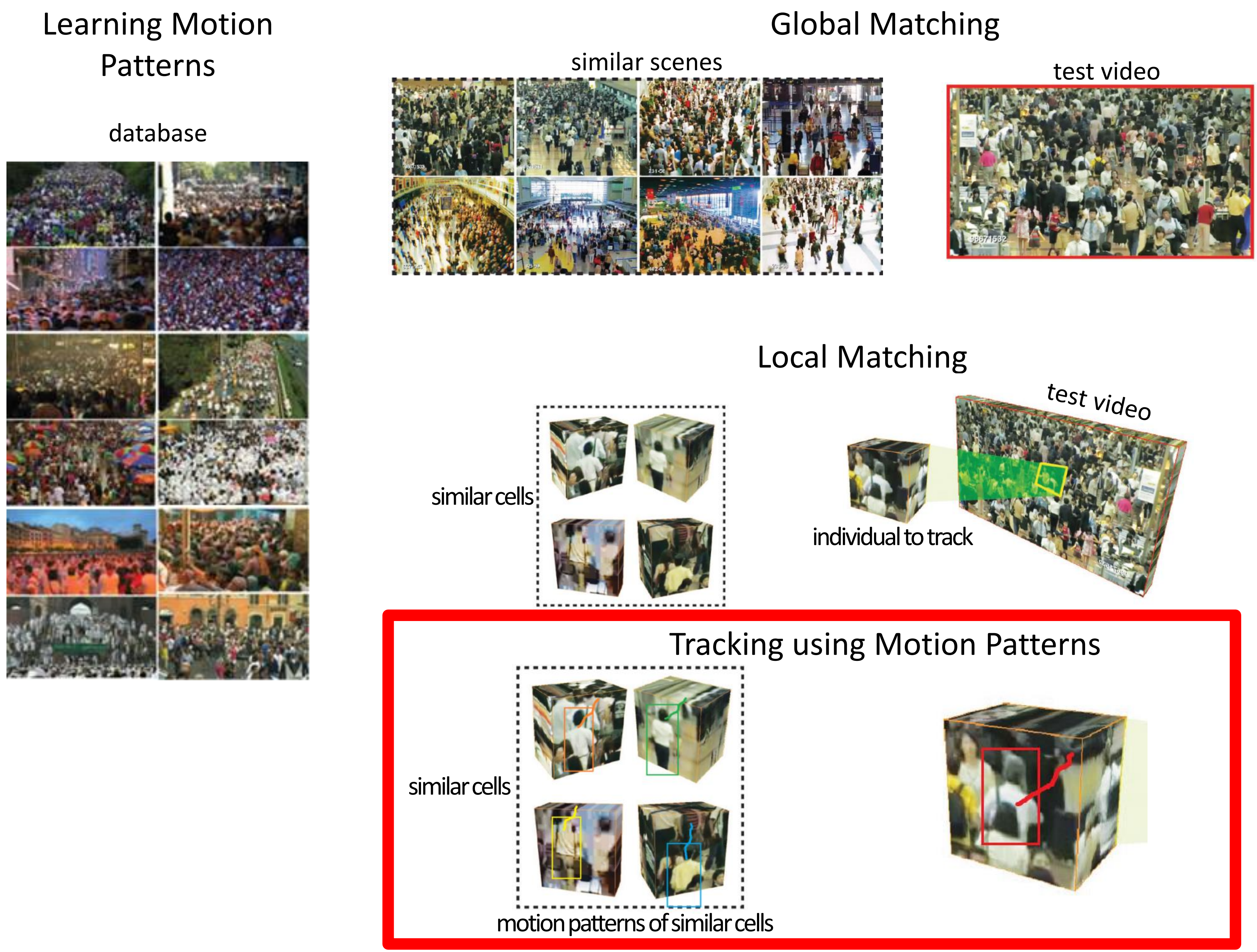
Local Crowd Patch Matching

- HOG3D is used to retrieve similar patches from the selected scenes.
- HOG3D demonstrates good performance in action recognition.

A Spatio-Temporal Descriptor Based on 3D-Gradients, Kläser, A., Marszałek, M., Schmid, C., British Machine Vision Conference - sep 2008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Tracking using Motion Patterns

Prediction of system

Prediction by Kalman filter

Using:
- Optical Flow(low-level)
- CTM(mid-level)

Learnt from:
- Test video
- Database of videos

Tracker position for person at location *O*

$$\boxed{P_O} = \boxed{K} + \lambda\boxed{S}$$

Proposed Tracking Algorithm

- Combines:
  - The linear Kalman Filter on the test video
  - The two-step matching process
    - Gist
    - HOG3D
  - The CTM of the local parts of the selected video

Experiments

- Data: Downloaded from video web sites using text queries like "crosswalk", "political rally", "festival", "marathon".
- 2 types of experiment:
  1. Tracking Typical Crowd Behavior
  2. Tracking Rare and Abrupt Events

Experiments

- Test videos are manually annotated to measure the error in pixels.
  - Blue = Typical crowd behavior
  - Red = Rare events

Experiments

- Error = # of pixels between the positions of tracker and individual in each frame
  - Yellow = ground truth
  - Red = tracking results

1st Experiment

Tracking typical crowd behavior

No Prior

Batch-mode tracking

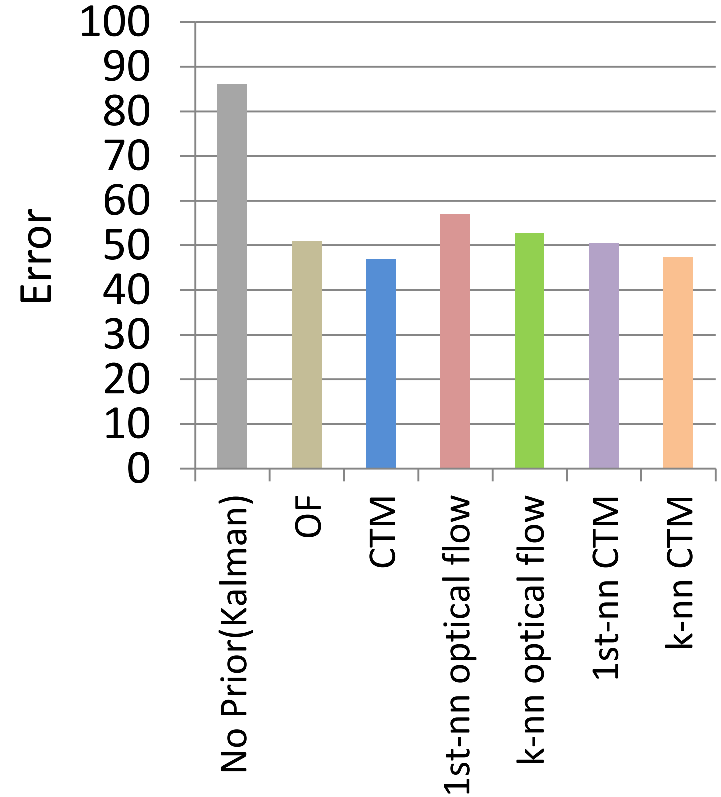
Training and testing video are from the same scene

Proposed data-driven tracking

Motion priors are transferred from the database of crowd videos

Results for tracking typical crowd behavior

		Error
No prior		86.24
Learned on test video	OF	50.93
	CTM	46.93
Learned on database	1^{st}-nn OF	57.06
	3-nn OF	52.76
	1^{st}-nn CTM	50.59
	3-nn CTM	47.47



Error is measured in pixels.

2^{nd} Experiment

Tracking rare events

No motion prior

Batch-mode tracking

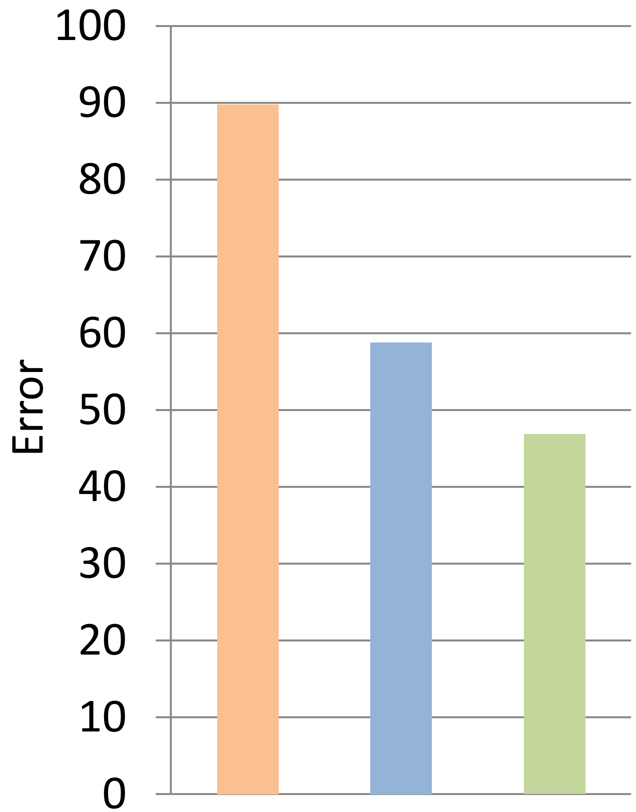
Data-driven tracking

Results for tracking rare events

- Red
  Ground Truth
- Yellow
  Batch mode
- Green
  Data-driven

Results for tracking rare events

		Error
No prior		89.8
Learned on test video	CTM	58.82
Learned on database	k-nn CTM	46.88



k=3

Error is measured in pixels.

Resources

- Website: http://www.di.ens.fr/willow/research/datadriven/index.html