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Crowd modeling based on purposiveness and a destination-driven analysis method

Key words: Crowd modeling; Intelligent video surveillance; Crowd stability

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Crowd modeling problem

□ Background

Toward **surveillance and forewarning** of dangerous accidents in abnormal crowded scenarios, it is imperative to understand crowd motion.

□ Motivation

Accuracy and suitability of crowd modeling directly influence the crowd motion understanding. However, until now, special cases like the pedestrian cross case and cases with high noise levels have not been well studied.

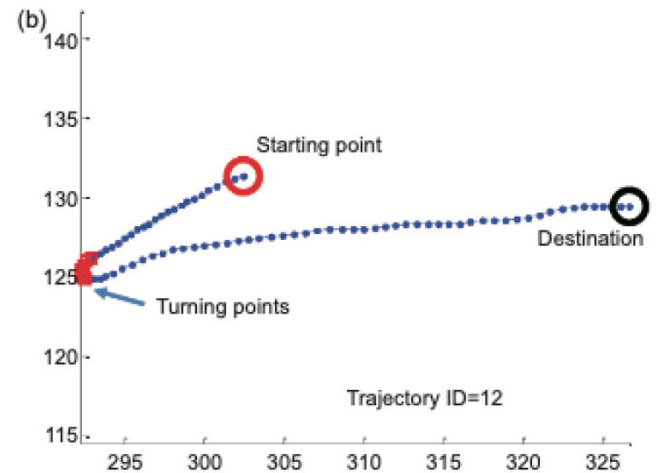
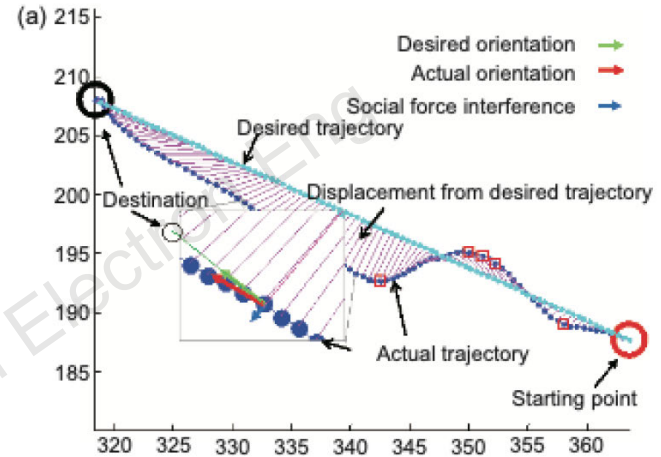
Main idea

1. Represent crowd with **self-driven particles**.
2. Use trajectories to calculate particles' **purposiveness** and estimate the common destinations and inherent structure of crowd.
3. Use common destinations and the crowd structure to evaluate the behavior of **newly arriving pedestrians and crowd stability**.

Pedestrian trajectory



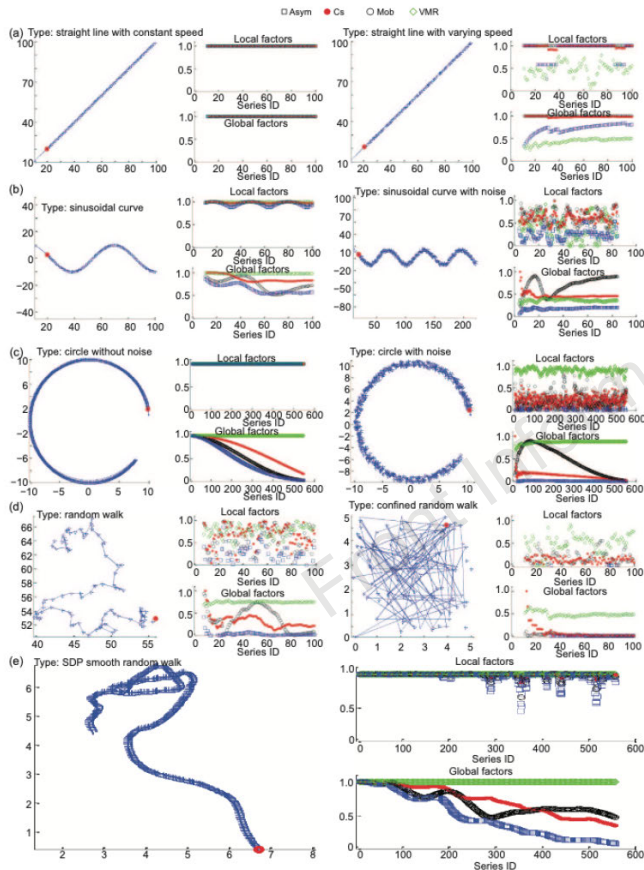
Trajectories at the grand central station in New York City in the half-hour video



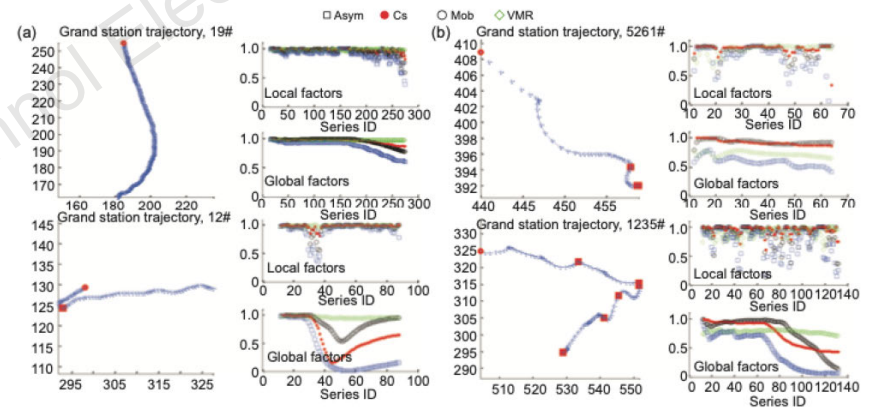
Effect of social forces on trajectories

Purposiveness calculation

- Four parameters for purposiveness calculation: asymmetry (**Asym**), cosine similarity (**CS**), mobility (**Mob**), and variance-to-mean ratio (**VMR**)

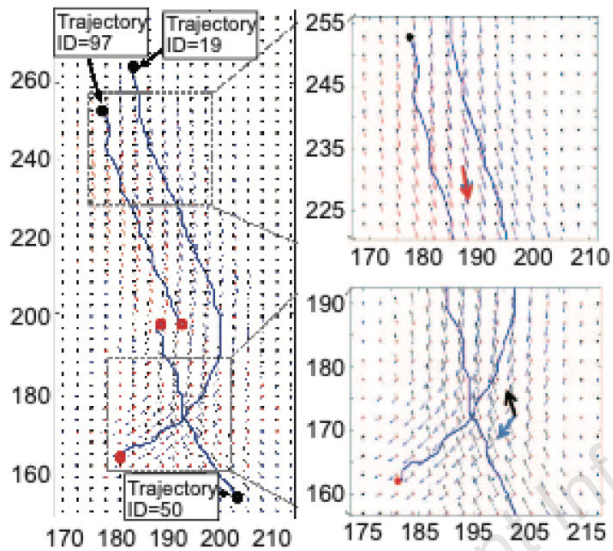


Purposiveness evaluation of a **synthetic dataset**

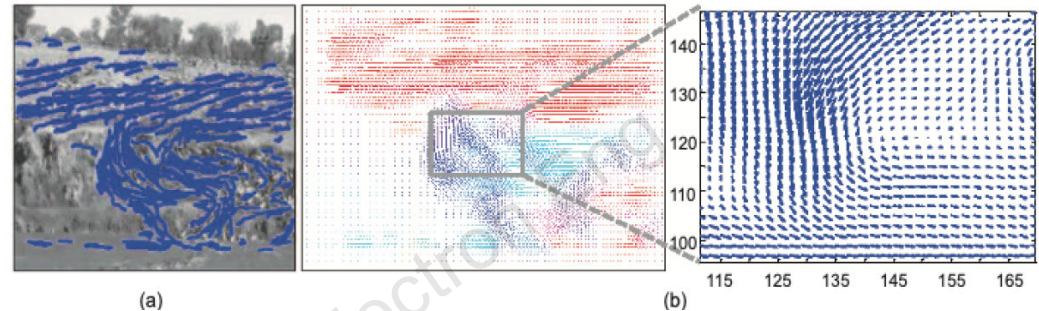


Purposiveness evaluation of a **real dataset**

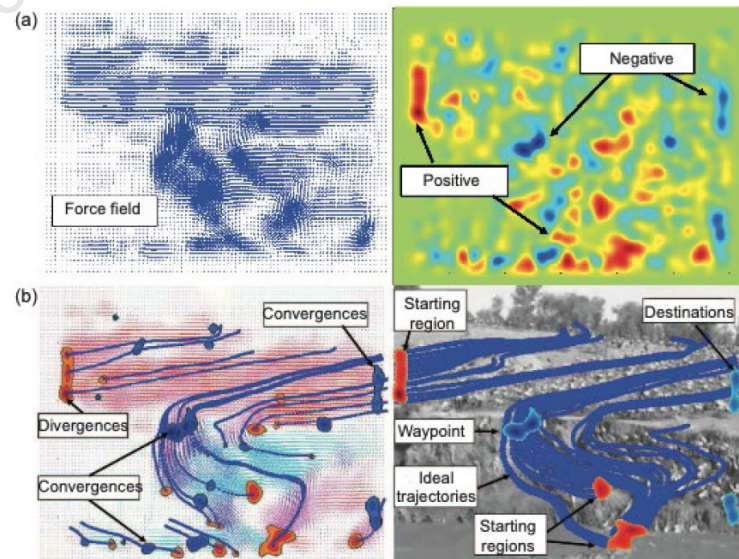
Destination estimation



Force field of multilayer trajectories



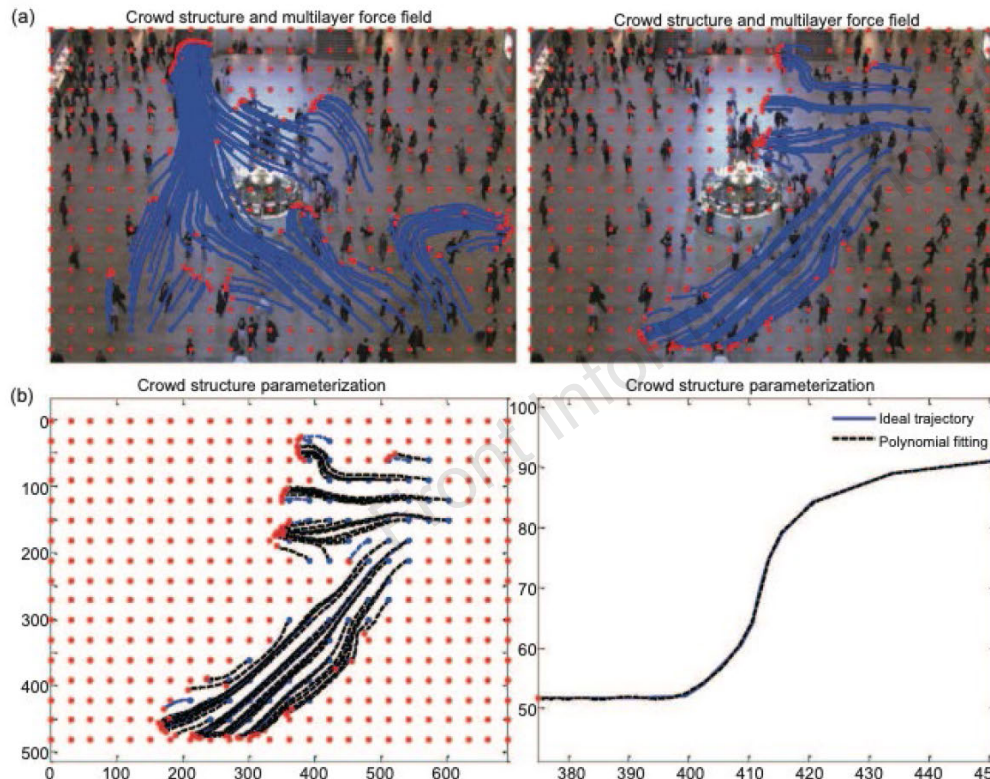
Multilayer force field of the real wildebeest migration video



Destination estimation via the divergence map

Destination-driven crowd structure establishment

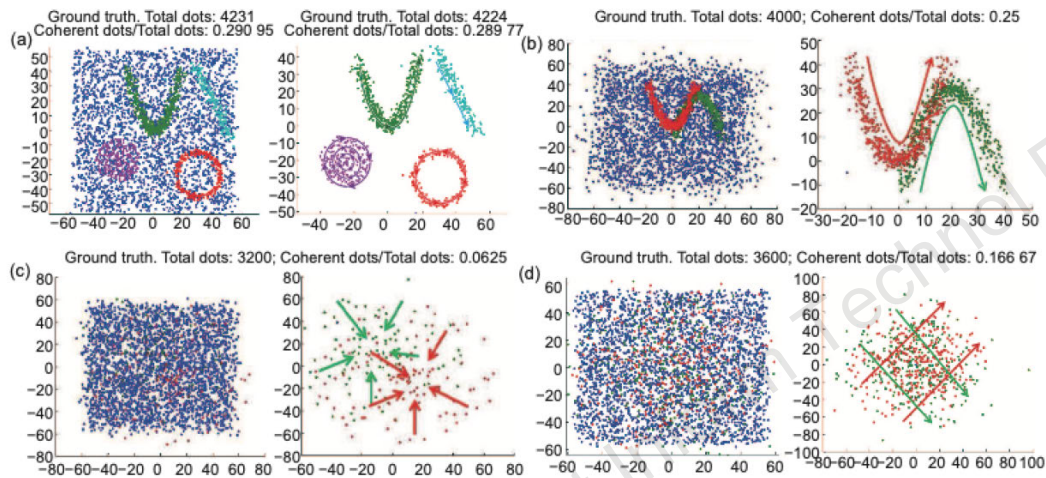
- Unify the release position of the free particles and the step number of the ideal trajectories to obtain a generalized representation of the crowd structure.



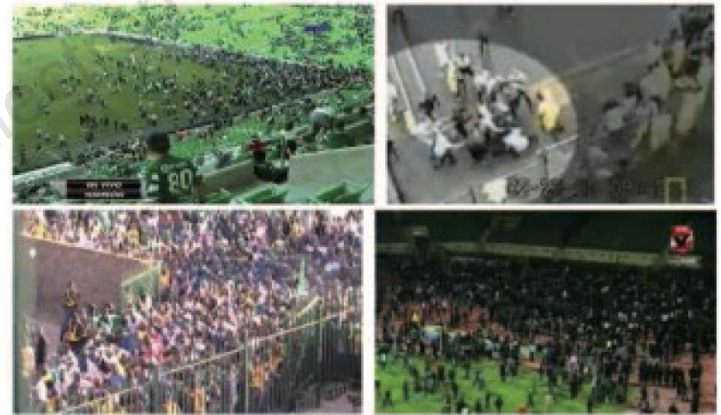
A **drastic variation** from the ideal trajectories means that the structure is **unstable**.

Ideal trajectory parameterization of the grand central station

Experiment datasets

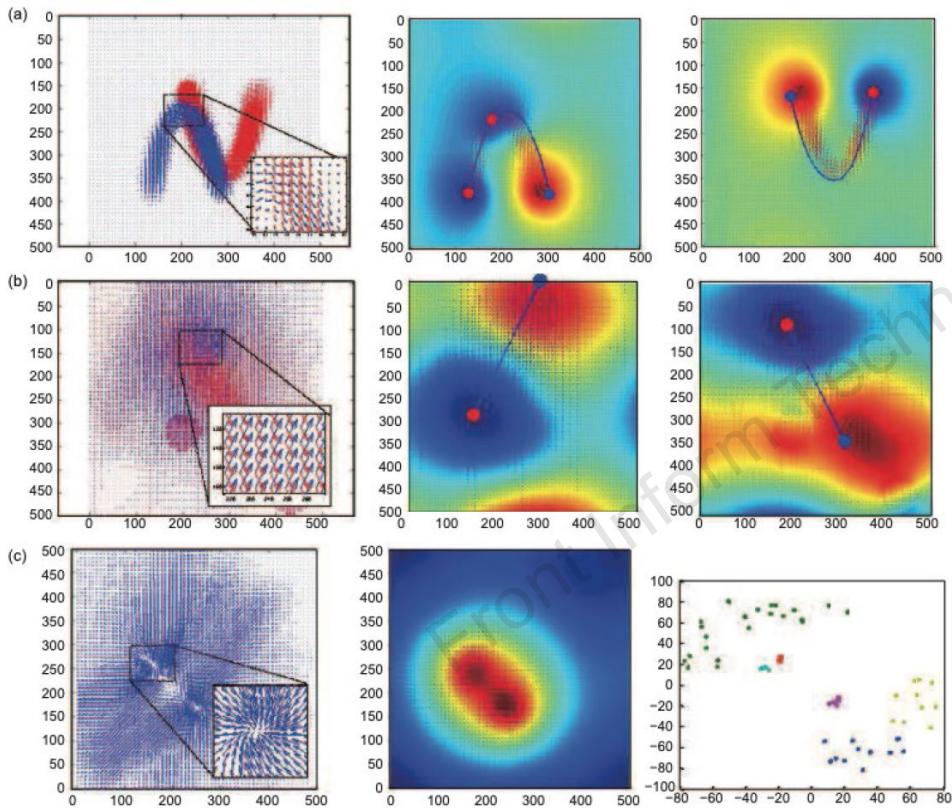


Synthetic datasets

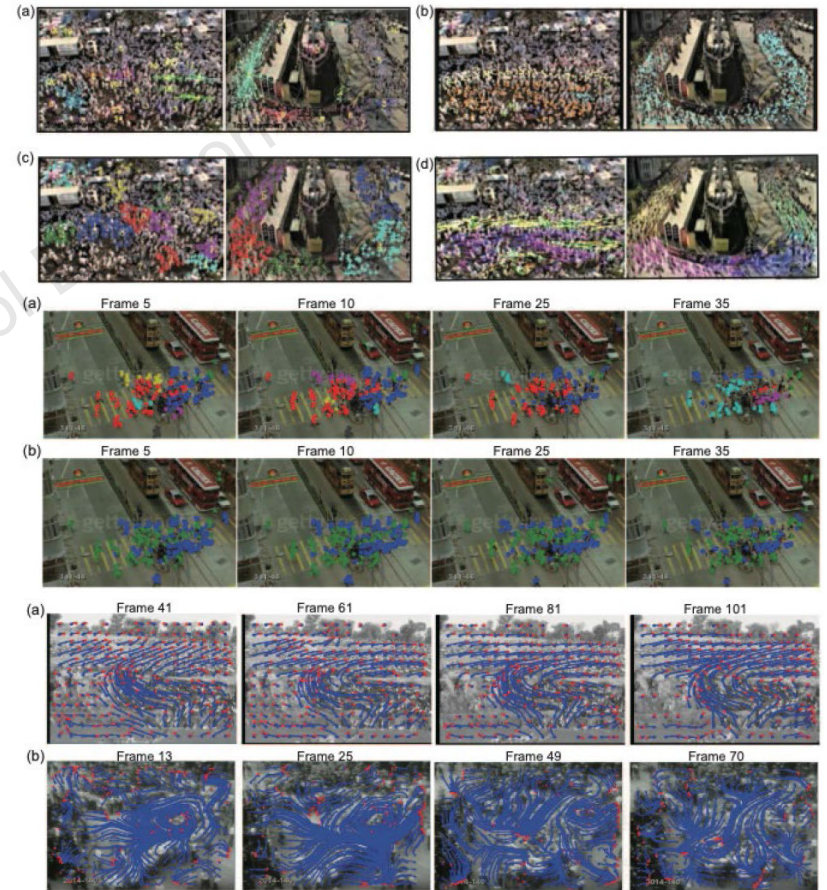


Real case datasets

Experiment results



Synthetic datasets



Real case datasets

Discussion

- Our approach achieves the **best** performance among the four methods in Table 1. In Table 2, our method obtains the **largest** DR, the **smallest** FAR, and the **smallest** count error.

Table 1 Crowd pattern detection results (synthetic cases dataset)

Approach	Normalized mutual information			
	Set 1, 4 shapes, 4 patterns	Set 2, double V, 2 patterns	Set 2, crossing, 2 patterns	Set 2, gathering, 4 patterns
Ncuts	0.28	0.622	0.385	0.226
K-means	0.21	0.766	0.113	0.261
Mean-shift	0.20	0.692	0.255	0.155
Coherence filter	0.890 (4 patterns)	0.919 (3 patterns)	0.324 (31 patterns)	0.189 (6 patterns)
Ours	0.971 (1 layer, 4 patterns)	0.991 (2 layers, 2 patterns)	0.933 (2 layers, 2 patterns)	0.8201 (1 layer, 2 patterns)

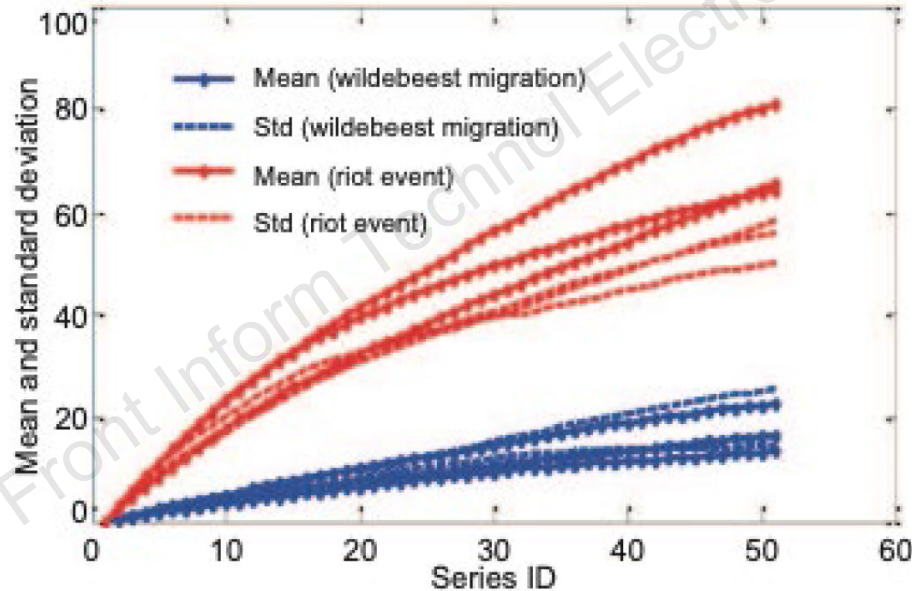
Table 2 Crowd pattern detection results using a real case dataset

Method	DR	FAR	Count error
Our method	0.77	0.12	1.62
Coherence filter	0.62	0.22	1.95
Bayesian detection	0.57	0.20	2.88
ALDENTE	0.41	0.34	3.15

DR: detection rate; FAR: false alarm rate

Discussion

- The smaller mean and standard deviation mean that the crowd structure is stable for wildebeest and riot event crowd.



Comparison of two typical crowd motions

Conclusions

- ❑ The proposed purposiveness is a suitable description of a middle-density human crowd.
- ❑ Combining the collectiveness and other motion representation methods, our novel crowd modeling is feasible and accurate.
- ❑ Our proposed method performs the best among four methods.
- ❑ The wildebeest migration crowd and riot event crowd show the stability.