Socially-Aware Large Scale Forecasting

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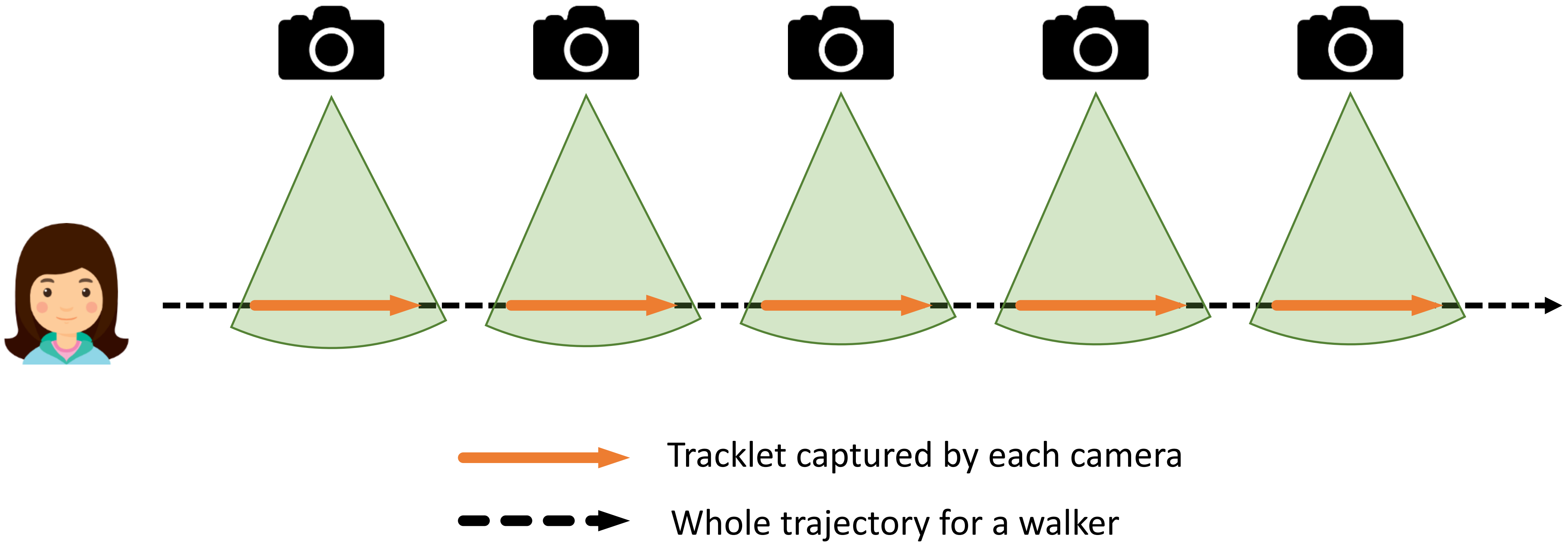
Problem

- Link **tracklets** captured multiple cameras ([example video])



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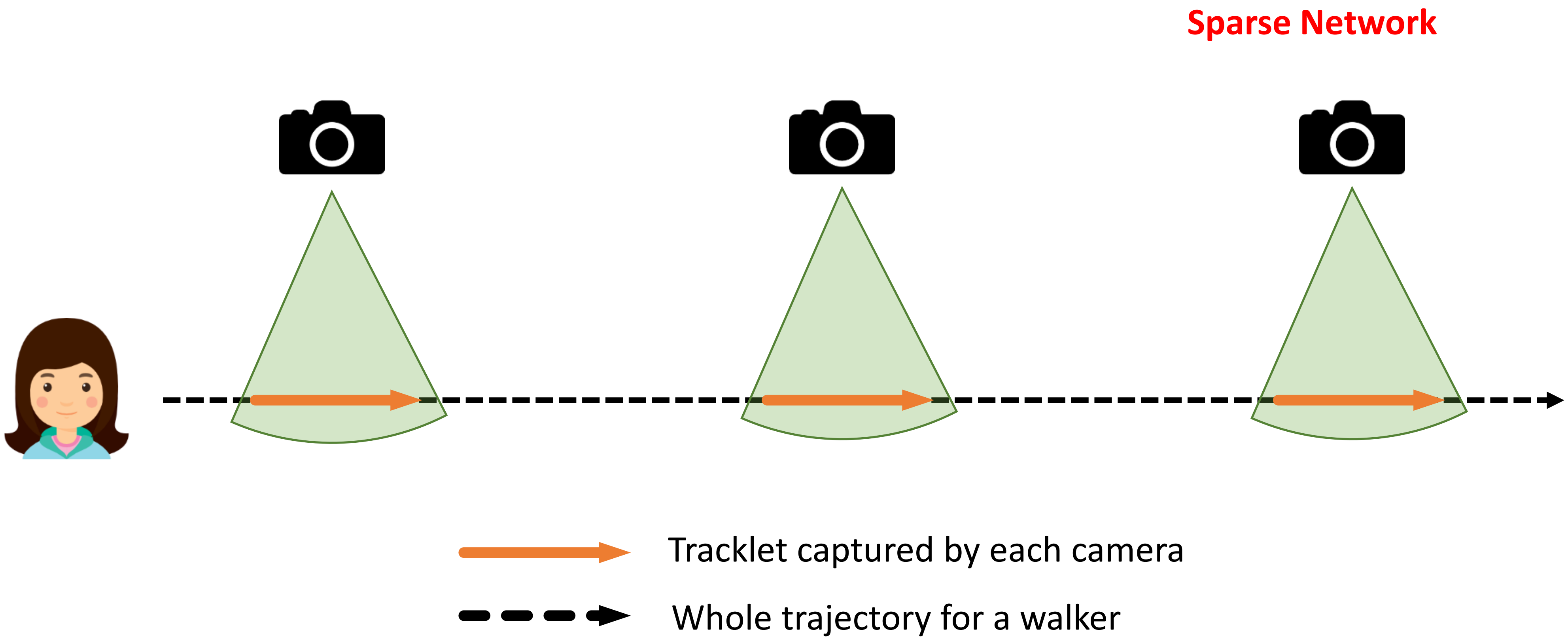

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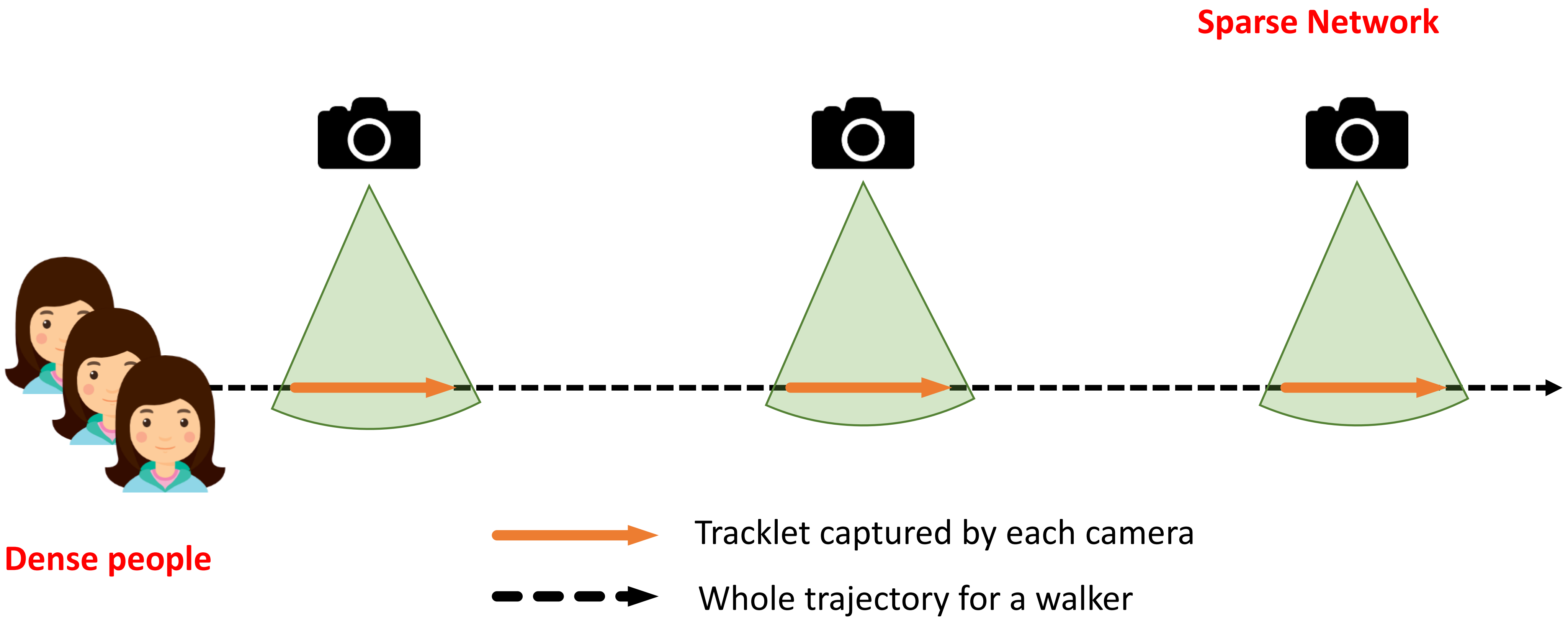
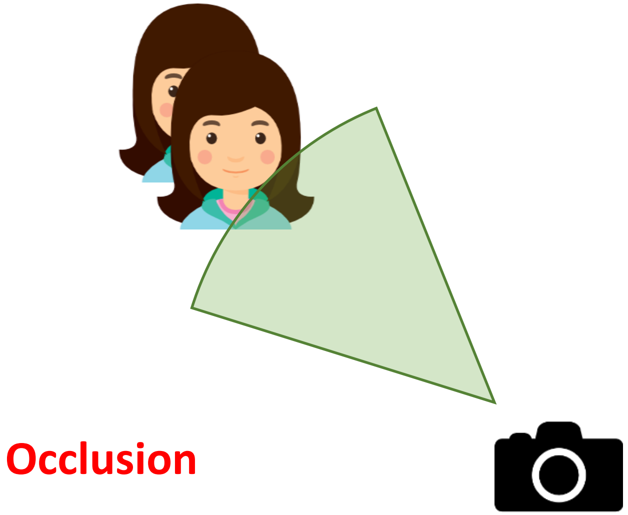
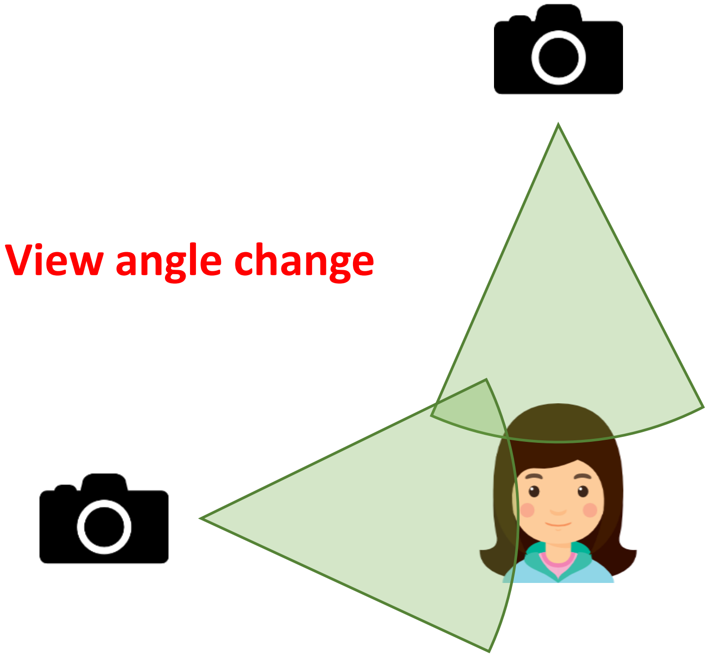


Possible Solutions

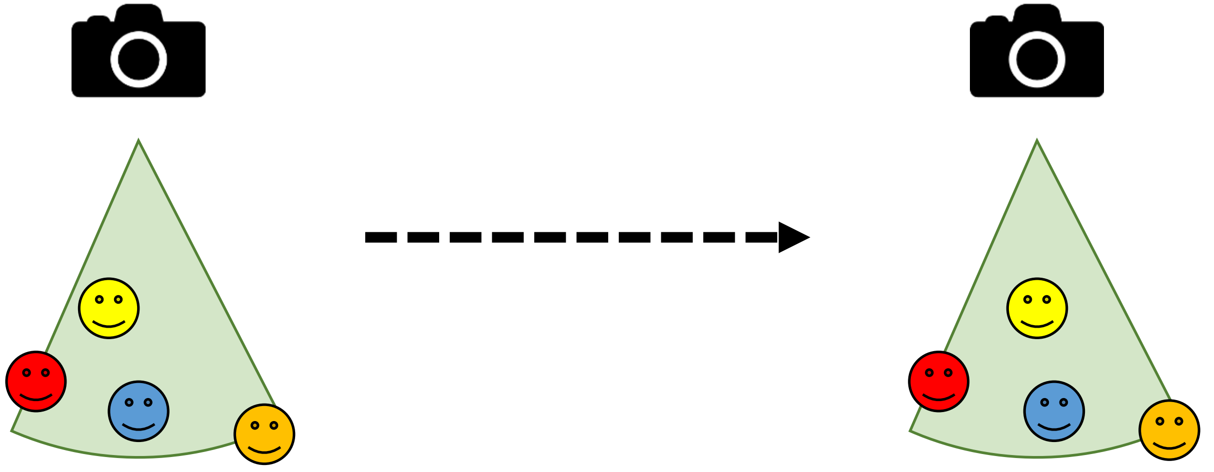
- Appearance based recognition
  - Highly occluded by others
  - View angles change at different cameras





Socially-Aware Approach

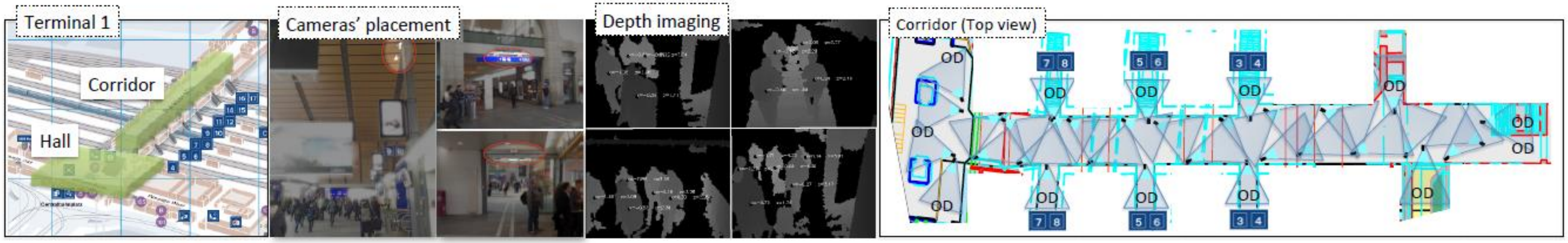
- Social affinity: motion affinity of neighboring individuals (example video)
  - Friends, relatives, and co-workers
  - Leader-follower model



Data Collection

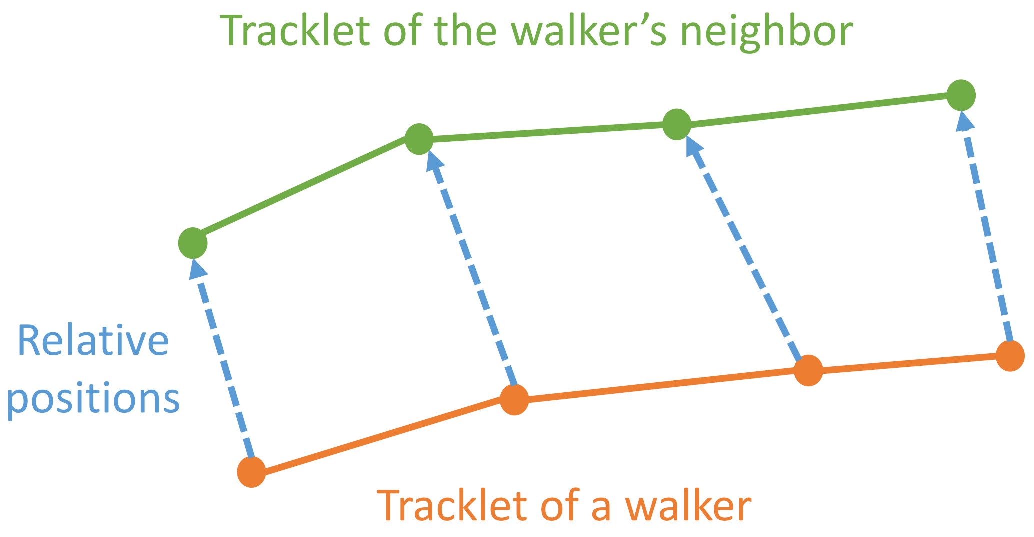
- Deploy a dense camera network in train stations
- Video data processing
  - Walker detection
  - Tracklet generation

Monitoring area	Density	Travel time	Distance	Speed	Traffic / day	Total
$20.000m^2$	up to 1 ped/m^2	1 min	100 m	1.37 m/s	100.000-250.000/terminal	42 million trajectories



SAM Features

- SAM features: the way to quantify the social affinity
- To extract SAM features, first derive the relative positions between the surrounding tracklets in each video



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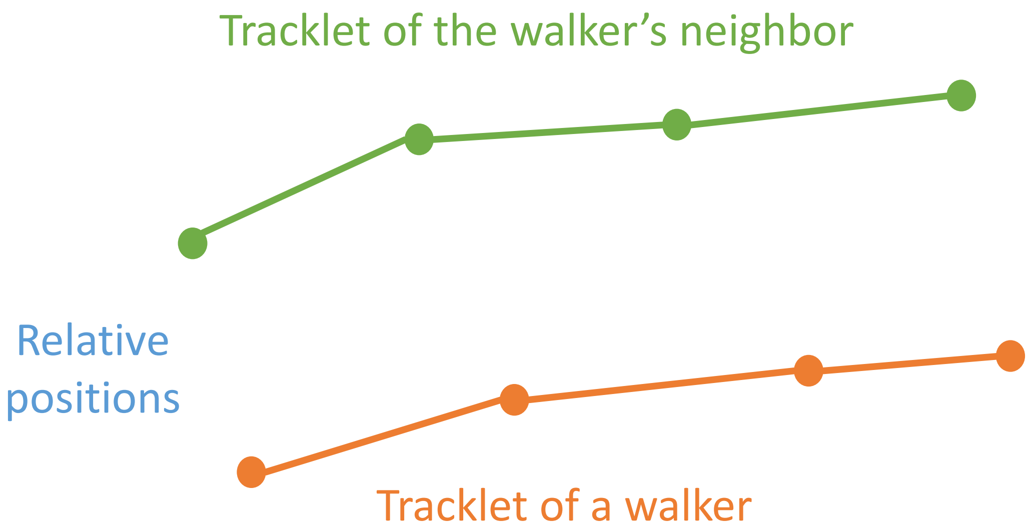
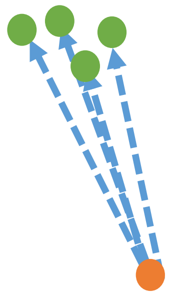
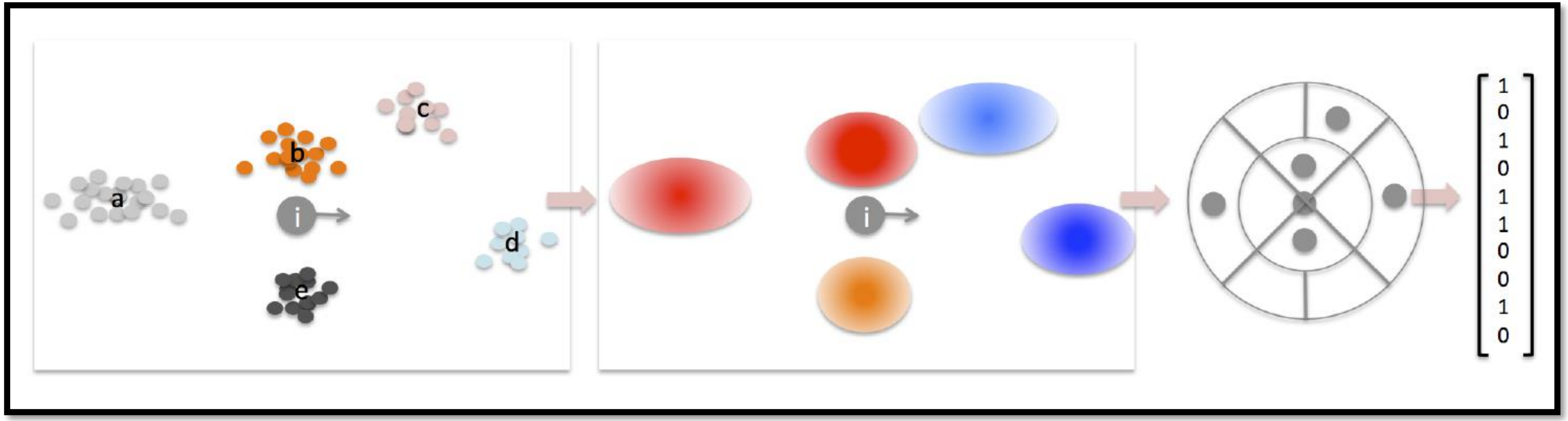




Use the position of the walker as the reference

SAM Features

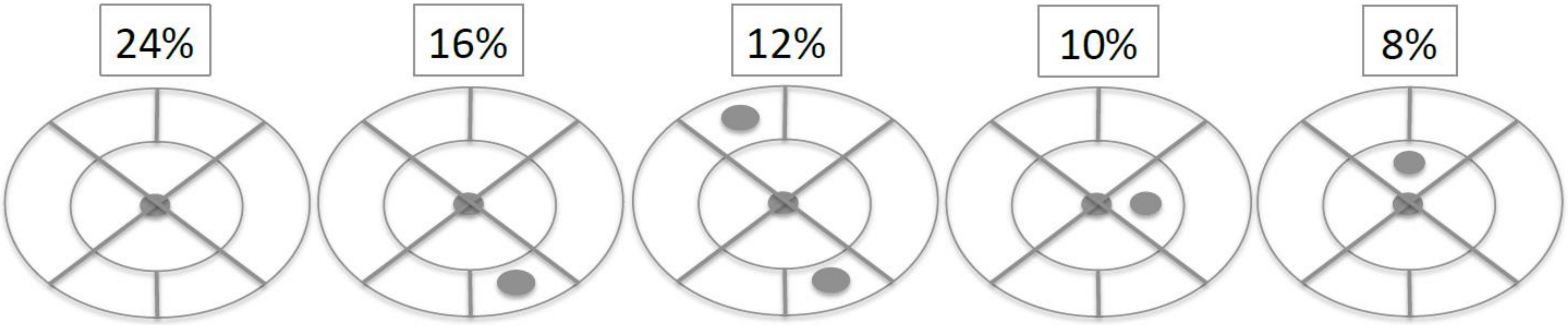
- Extract SAM features



Relative positions → **Cluster centers** → **Spatial binning** → **Feature vector**

SAM Features

- Most common SAM features in the dataset



Single walker **With a stranger** **With two strangers** **With a leader** **With a friend**

SAM Features

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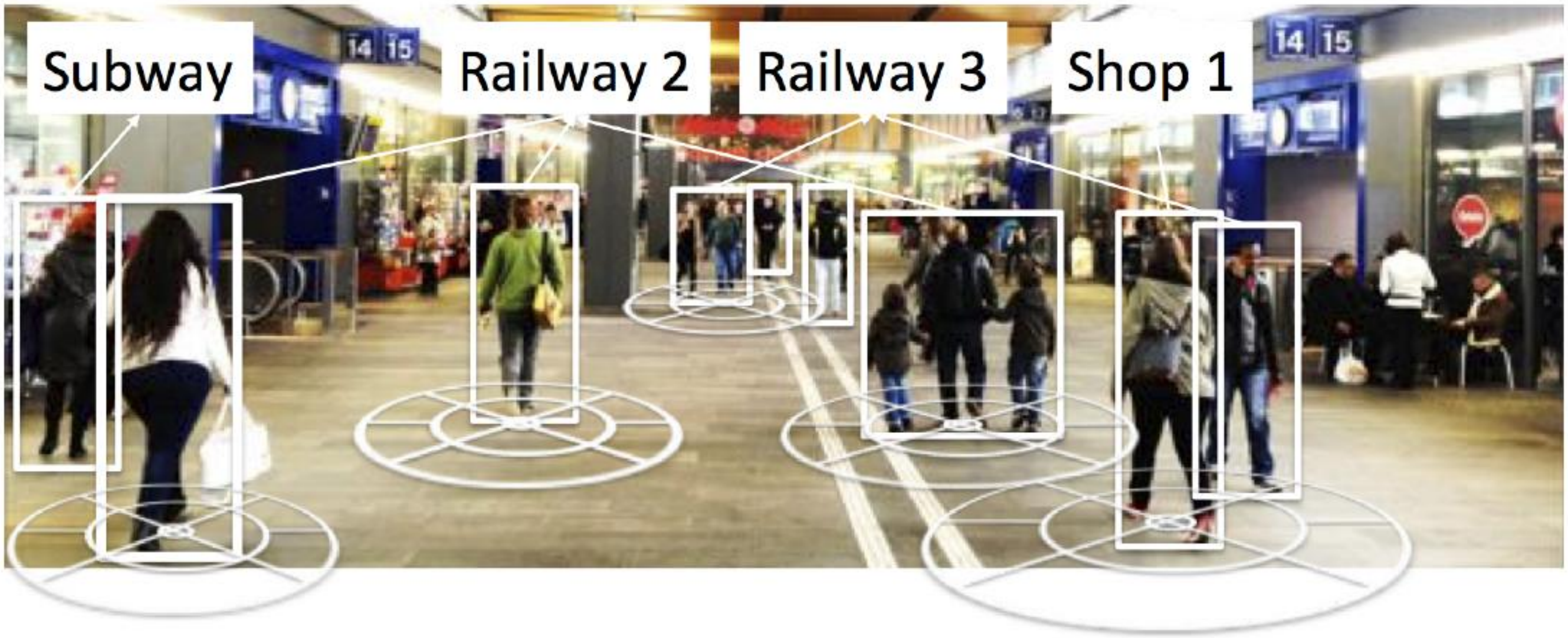

Problem Formulation

- A sparse network of cameras for a public place (a railway terminal)
- Entry points of the place: **origin**
- Exit points of the place: **destination**
- Tracklet sets: O, D, X
- The **trajectory** for a walker: $t = (o_t, x_t^1, x_t^2, \dots, x_t^n, d_t)$

GOAL: find all trajectories connecting origins and destinations

Problem Formulation

- The set of all trajectories, T
- **Find T that maximize its likelihood based on tracklet observations X**

$$\max_T P(T|X) = \max_T \frac{P(T,X)}{P(X)} = \max_T P(T,X) = \max_T P(X|T)P(T)$$

Problem formulation

- Conditional probability $P(X|T)$

$$P(X|T) = \prod_{t \in T} \prod_{x \in X_t} P_{tp}\,(x)$$

- The trajectory probability $P(T)$

$$P(T) = \prod_{t \in T} P(t)$$

$$P(t) = P_{OD}(o_t, d_t) P(x_t^1 | o_t) P(x_t^2 | x_t^1) \ldots \mathrm{P}(\mathrm{d_t} | x_t^n)$$

Problem Formulation

- Log likelihood conversion

Whether x_i and x_j linked together

Whether x_i in some trajectory

Whether o and d in the same trajectory

$$\min_f C(f) = \sum \alpha_i f_i + \sum \beta_{ij} f_{ij} + \sum \gamma_{od} f_{od}$$

$-\log(P_{tp}(x_i))$

$-\log(P(x_i|x_j))$

$-\log(P_{OD}(o,d))$

Help to remove short or dubious tracklets

Determined by ***SAM feature*** and smoothness

Provide some cues about the start and end of trajectories

Optimization

- The formulized problem is similar with a **network-flow problem**
- Except **the prior term**
- Using heuristic to **amortize** the prior terms into transition terms

$$\min_f C(f) = \sum \alpha_i f_i + \sum \beta_{ij} f_{ij} + \sum \gamma_{od} f_{od}$$

- Solve by **k-shortest path approach**

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$$\min_f C(f) = \sum \alpha_i f_i + \sum \boldsymbol{\widetilde{\beta_{ij}} f_{ij}}$$

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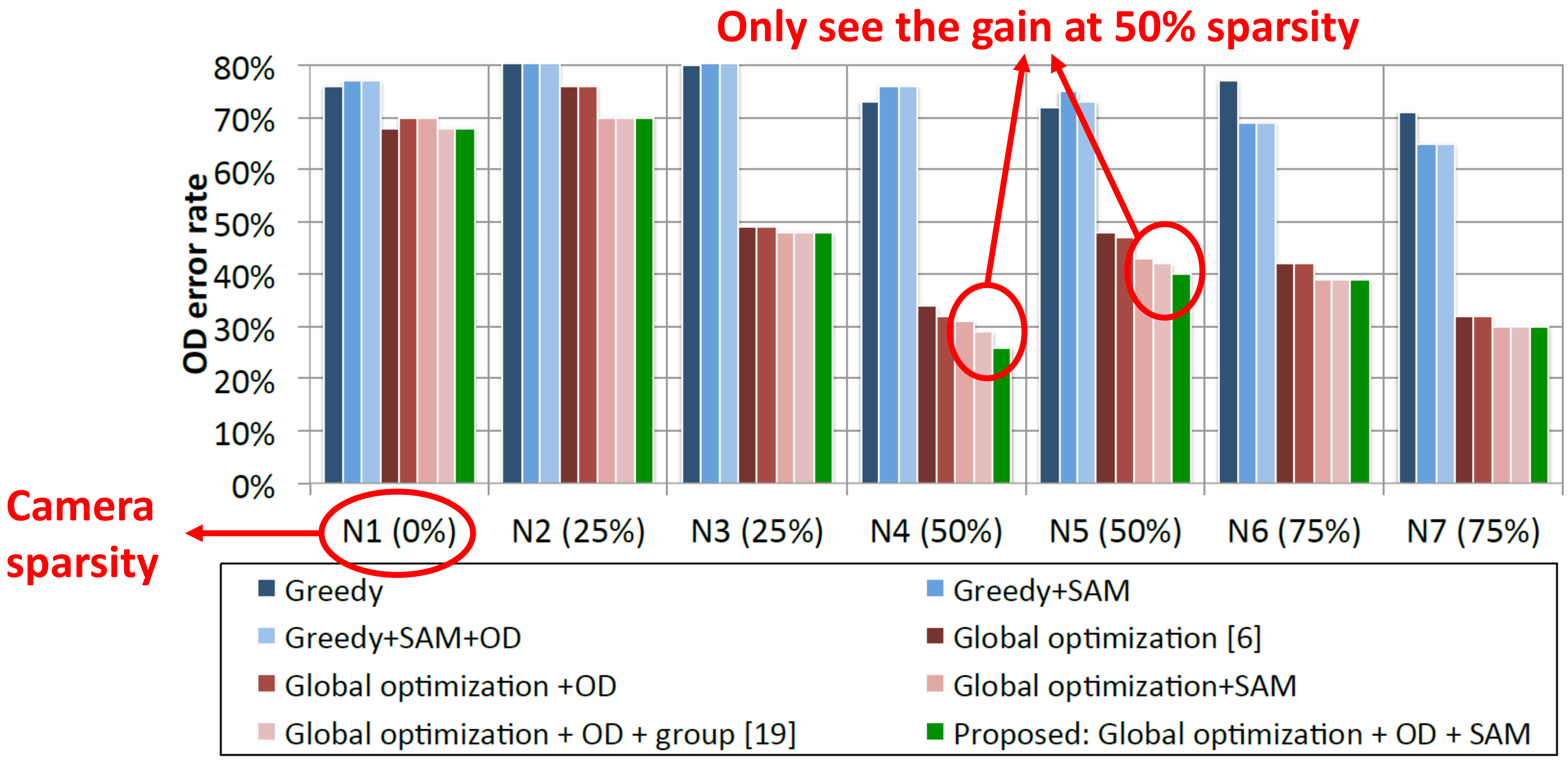
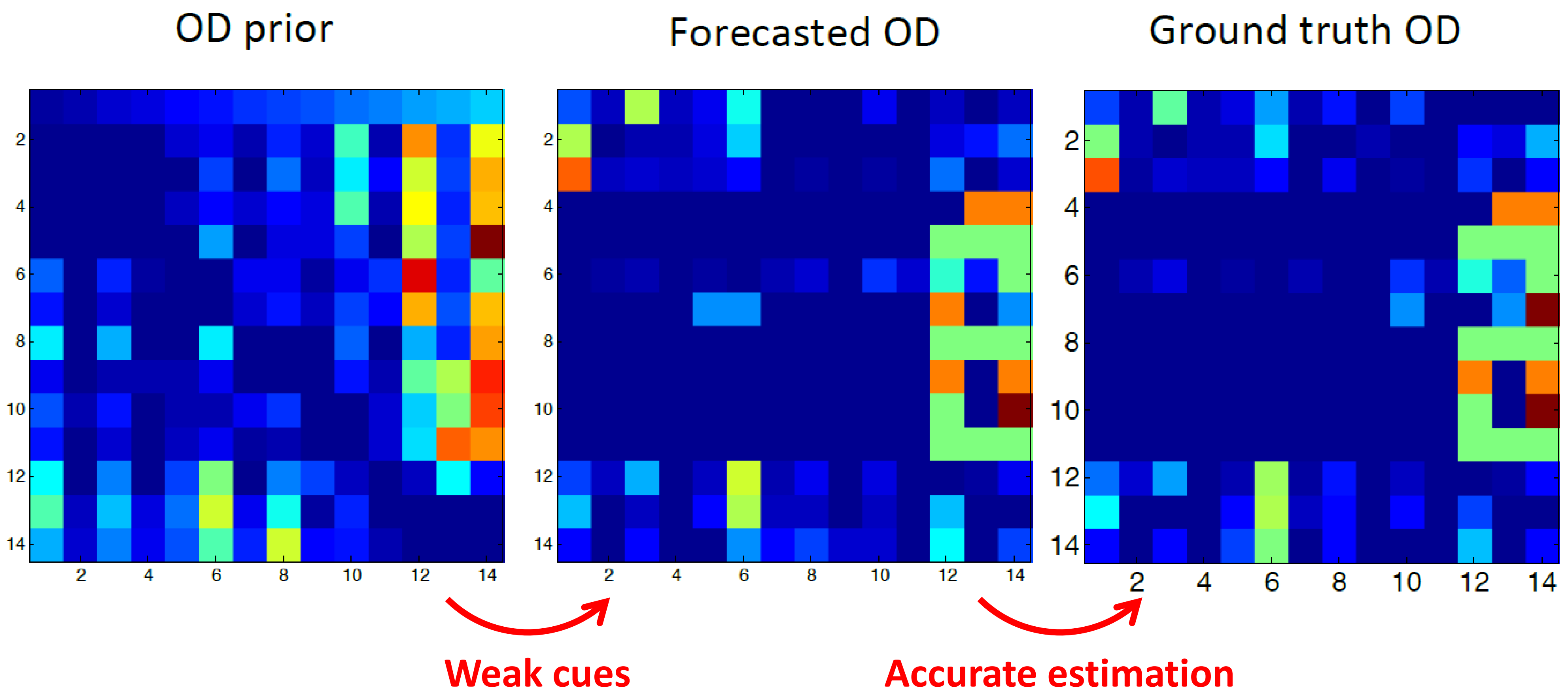
Results

- Origin and destination tracklet matching error



Results

- Qualitative results: origin-destination distribution



Conclusion

- Collect a **dataset** with 42 million of tracklets
- There are **social affinities** among crowded walkers
- Such features can be used to **improve the trajectory linking quality**
- Future work: learn how to deploy limited number of cameras to maximize the performance