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MotionTrack: Learning Robust Short-term and Long-term Motions for Multi-Object Tracking

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Quick preview

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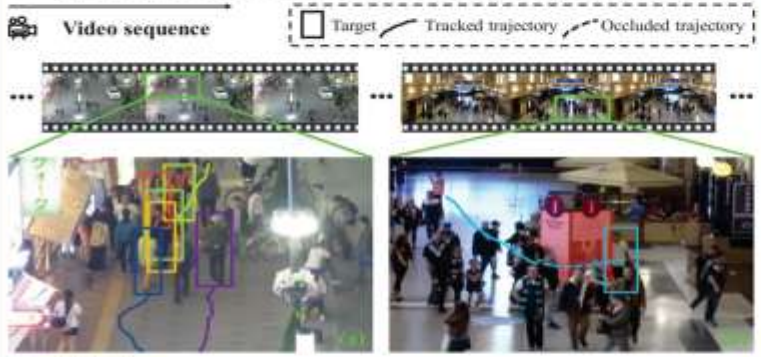
Introduction

Background

- Multi-Object Tracking (MOT) : jointly locate targets through bounding boxes and recognize their identities throughout a whole video.

Motivation

- (a) ***Dense crowds:*** Pedestrians do not move independently in this situation.
- (b) ***Extreme occlusion:*** Pedestrians are easily occluded by fixed facilities.

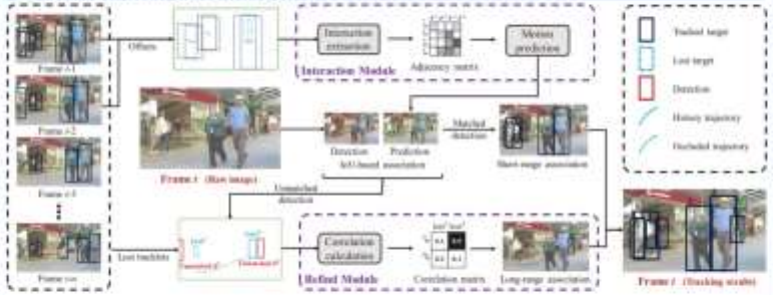


Contribution

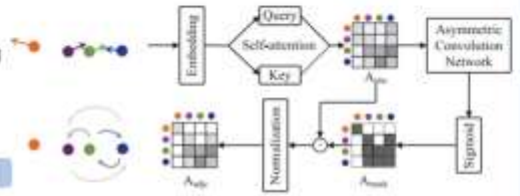
- We propose a simple yet effective multi-object tracker, MotionTrack, to address the short-range and long-range association problems.
- We design a novel Interaction Module to model the interaction between targets, which can handle complex motions in dense crowds.
- We design a novel Refind Module to learn discriminative motion patterns, which can re-identify the lost tracklets with current detections.

Methodology

Overview of MotionTrack

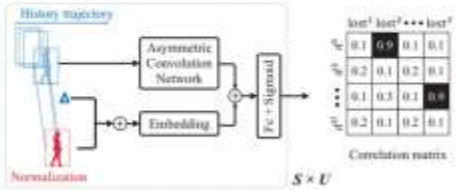


- ***Step 1: Short-range association***. Modeling the inter-tracklet interaction to obtain more accurate predictions and the short-range tracking results.
- ***Step 2: Long-range association***. Re-identifying lost tracklets based on the history trajectory and unmatched detections and then compensating the trajectory during occlusion.



Interaction Module

- To obtain more accurate tracklets, we capture the directed interactions between tracklets and then use them to estimate the offsets between two consecutive frames.



Refind Module

- To refind the lost tracklet, we first identify its matched detection and then refine the occluded trajectory.

Results

Comparison with SOTA

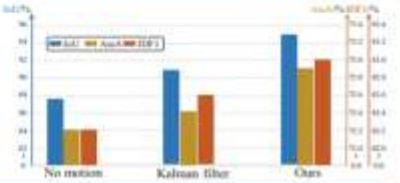
Tracker	Venue	IDF1 ↑	MOTA ↑	HOTA ↑	AssA ↑	DetA ↑	FP ↓	FN ↓	IDs ↓	Frag ↓
ReMOT [55]	IVC'21	72.0	77.0	59.7	57.1	62.8	53034	93612	2853	5304
QuasiDense [30]	CVPR'21	66.3	68.7	53.9	52.7	55.6	26589	146643	3378	8091
SOTMOT [63]	CVPR'21	71.9	71.0	-	-	-	39537	118983	5184	-
SiamMOT [37]	CVPR'21	72.3	76.3	-	-	-	-	-	-	-
CorrTracker [42]	CVPR'21	73.6	76.5	60.7	58.5	62.9	29808	99510	3369	6063
PermaTrackPr [17]	ICCV'21	68.9	73.8	55.5	53.1	58.5	28998	115104	3699	6132
PureMOT [35]	ICCV'21	72.5	73.7	59.3	58.0	60.9	27937	112477	3303	6477
CSTrack [24]	TIP'22	72.6	74.9	59.3	57.9	61.1	23647	114303	3567	7668
RelationTrack [49]	TMM'22	74.7	73.8	61.0	61.5	60.6	27999	118623	1374	2166
TrackFormer [28]	CVPR'22	68.0	74.1	-	-	-	34602	108777	2829	-
MeMOT [3]	CVPR'22	69.0	72.5	56.9	55.2	-	37221	115248	2724	-
MTrack [46]	CVPR'22	73.5	72.1	-	-	-	53501	101844	2028	-
MOTR [58]	ECCV'22	68.6	73.4	57.8	55.7	60.3	-	-	2439	-
ByteTrack [53]	ECCV'22	77.3	80.3	63.1	62.0	64.5	25491	83721	2196	2277
P3AFormer+W&R) [54]	IJCAI'22	78.1	**81.2**	-	-	-	**17281**	86861	1893	-
MotionTrack(ours)	-	**80.1**	81.1	**65.1**	**65.3**	**65.4**	23802	**81660**	**1140**	**1603**

Tracker	Venue	IDF1 ↑	MOTA ↑	HOTA ↑	AssA ↑	DetA ↑	FP ↓	FN ↓	IDs ↓	Frag ↓
PureMOT [35]	IJCV'21	67.3	61.8	54.6	54.7	54.7	103440	88901	8253	7874
CorrTracker [42]	CVPR'21	69.1	65.2	-	-	-	79429	95855	3183	-
SiamMOT [37]	CVPR'21	69.1	67.1	-	-	-	-	-	-	-
SOTMOT [63]	CVPR'21	71.4	68.6	57.4	57.3	57.7	57064	101154	4209	5368
CSTrack [24]	TIP'22	68.6	66.6	54.0	50.0	54.2	**25404**	144358	3196	7632
RelationTrack [49]	TMM'22	70.5	67.2	56.4	56.8	61134	104497	4243	8236	
MeMOT [3]	CVPR'22	66.1	63.7	54.1	55.0	-	47502	137982	1938	-
MTrack [46]	CVPR'22	69.2	63.5	-	-	-	96123	86064	6031	-
ByteTrack [53]	ECCV'22	75.2	77.8	61.3	59.6	63.4	26249	87594	1223	1460
P3AFormer+W&R) [54]	IJCAI'22	76.4	**78.1**	-	-	-	25613	86510	1332	-
MotionTrack(ours)	-	**76.5**	78.0	**62.8**	**61.8**	**64.0**	28629	**84152**	**1165**	**1321**

Comparison for handling occlusions

Setting	#	IDF1 ↑	MOTA ↑	HOTA ↑	AssA ↑	DetA ↑
IoU-based	30	80.9	79.8	69.0	70.6	68.1
	120	80.1	77.6	68.4	70.5	66.9
	Δ	-0.8	-2.2	-0.6	-0.1	-1.2
ReID-based	30	77.2	77.0	66.4	67.1	66.3
	120	70.4	67.5	60.6	60.3	61.6
	Δ	-6.8	-9.5	-5.8	-6.8	-4.7
Ours	30	82.6	80.4	70.2	72.4	68.7
	120	83.3	80.7	70.7	73.2	68.8
	Δ	+0.7	+0.3	+0.5	+0.8	+0.1

Results of Motion Models.



Visualization of Directed Interaction

Visualization of Refinding Targets

Motivation

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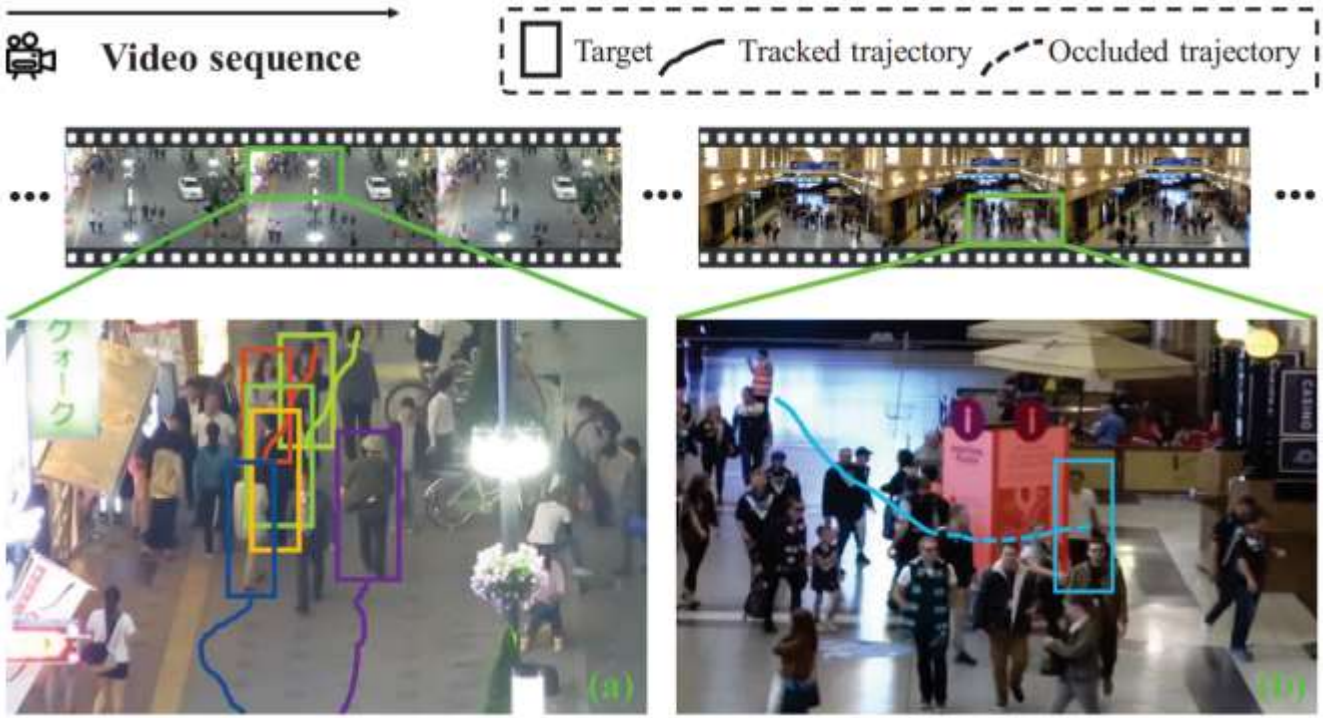
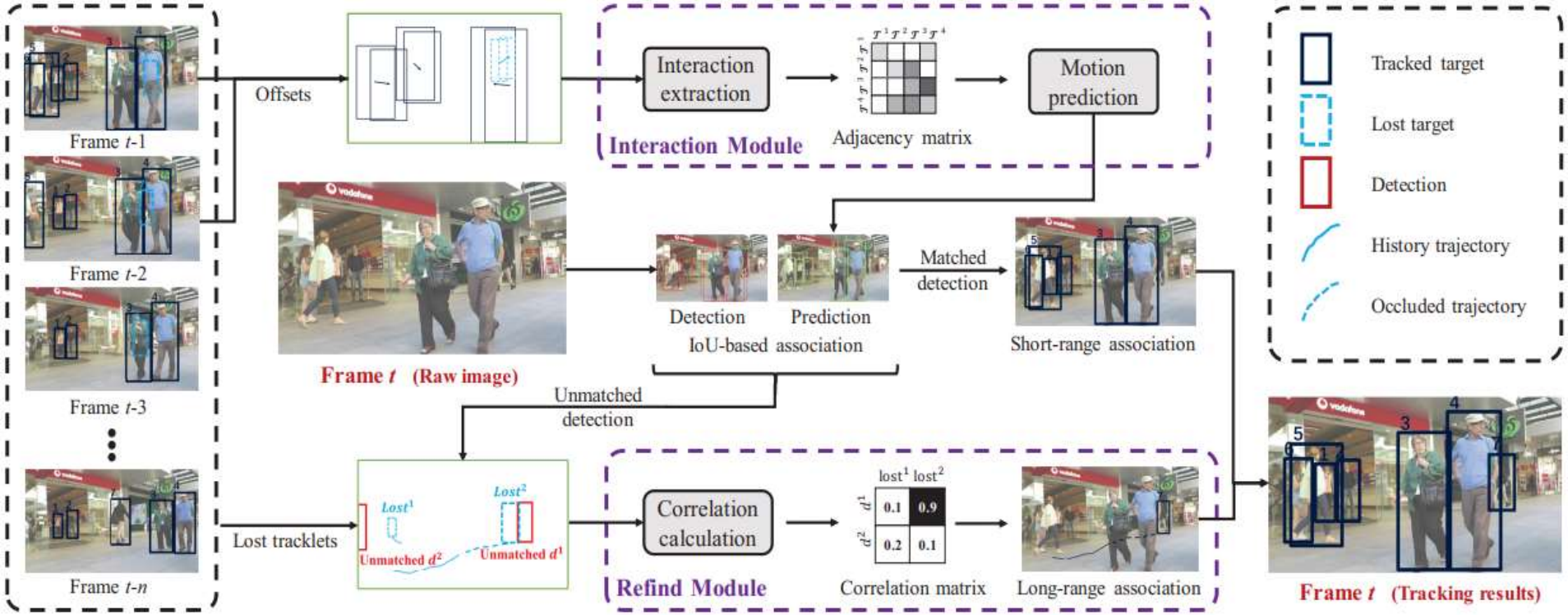
- (b) ***Extreme occlusion：*** Pedestrians are easily occluded by fixed facilities.



Overview of MotionTrack



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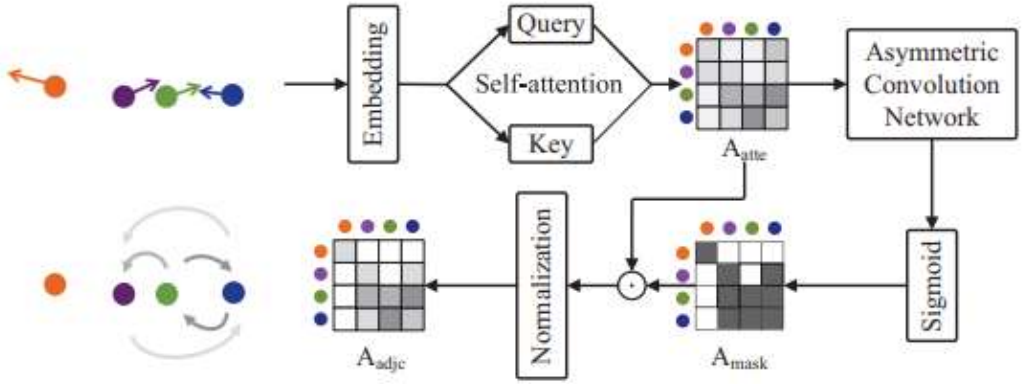
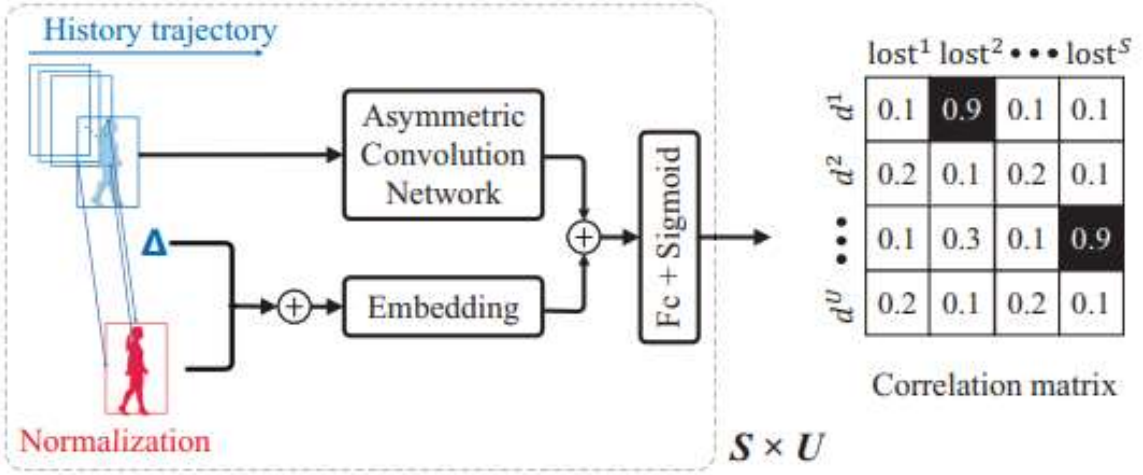
Model architecture



Interaction Module

- To obtain more accurate tracklets, we capture the directed interactions between tracklets and then use them to estimate the offsets between two consecutive frames.



Refind Module

- To refind the lost tracklet, we first identify its matched detection and then refine the occluded trajectory.

Comparison with SOTA

MOT17

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ReMOT [45]	IVC'21	72.0	77.0	59.7	57.1	62.8	33204	93612	2853	5304
QuasiDense [30]	CVPR'21	66.3	68.7	53.9	52.7	55.6	26589	146643	3378	8091
SOTMOT [55]	CVPR'21	71.9	71.0	-	-	-	39537	118983	5184	-
SiamMOT [23]	CVPR'21	72.3	76.3	-	-	-	-	-	-	-
CorrTracker [42]	CVPR'21	73.6	76.5	60.7	58.5	62.9	29808	99510	3369	6063
PermaTrackPr [37]	ICCV'21	68.9	73.8	55.5	53.1	58.5	28998	115104	3699	6132
FairMOT [53]	IJCV'21	72.3	73.7	59.3	58.0	60.9	27507	117477	3303	8073
CSTrack [24]	TIP'22	72.6	74.9	59.3	57.9	61.1	23847	114303	3567	7668
RelationTrack [48]	TMM'22	74.7	73.8	61.0	61.5	60.6	27999	118623	1374	2166
TrackFormer [26]	CVPR'22	68.0	74.1	-	-	-	34602	108777	2829	-
MeMOT [7]	CVPR'22	69.0	72.5	56.9	55.2	-	37221	115248	2724	-
MTrack [46]	CVPR'22	73.5	72.1	-	-	-	53361	101844	2028	-
MOTR [50]	ECCV'22	68.6	73.4	57.8	55.7	60.3	-	-	2439	-
ByteTrack [52]	ECCV'22	77.3	80.3	63.1	62.0	64.5	25491	83721	2196	2277
P3AFormer(+W&B) [54]	ECCV'22	78.1	**81.2**	-	-	-	**17281**	86861	1893	-
MotionTrack(ours)	-	**80.1**	81.1	**65.1**	**65.1**	**65.4**	23802	**81660**	**1140**	**1605**

MOT20

Tracker	Venue	IDF1 ↑	MOTA ↑	HOTA ↑	AssA ↑	DetA ↑	FP ↓	FN ↓	IDs ↓	Frag ↓
FairMOT [53]	IJCV'21	67.3	61.8	54.6	54.7	54.7	103440	88901	5243	7874
CorrTracker [42]	CVPR'21	69.1	65.2	-	-	-	79429	95855	5183	-
SiamMOT [23]	CVPR'21	69.1	67.1	-	-	-	-	-	-	-
SOTMOT [55]	CVPR'21	71.4	68.6	57.4	57.3	57.7	57064	101154	4209	7568
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P3AFormer(+W&B) [54]	ECCV'22	76.4	**78.1**	-	-	-	25413	86510	1332	-
MotionTrack(ours)	-	**76.5**	78.0	**62.8**	**61.8**	**64.0**	28629	**84152**	**1165**	**1321**

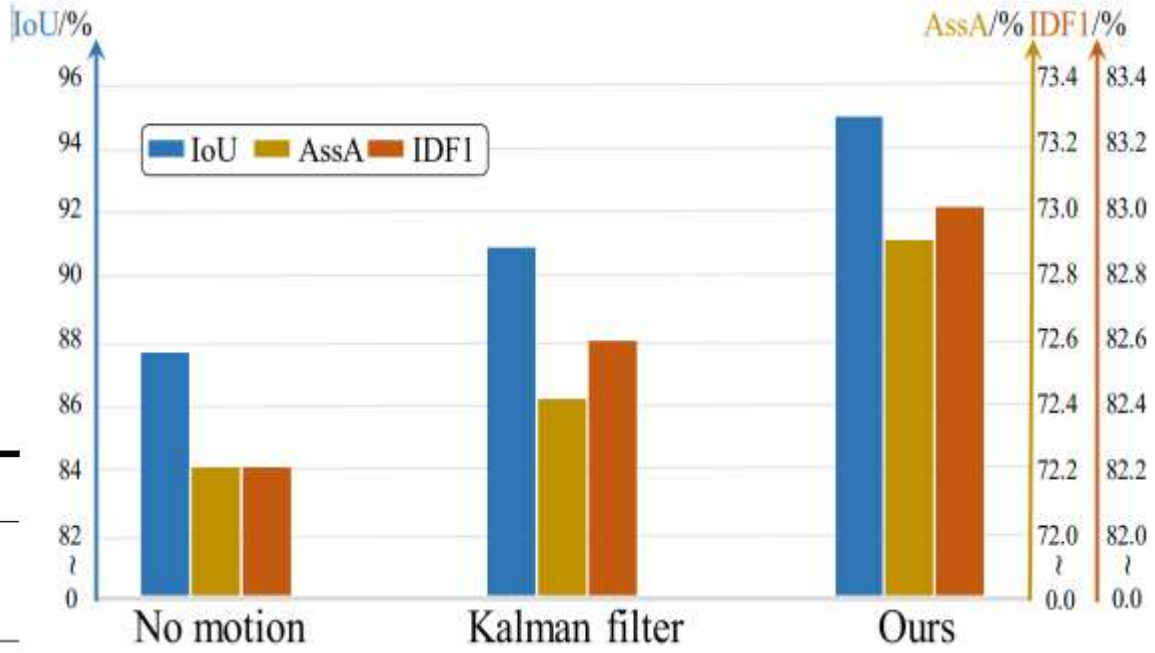
Ablation Study

Setting	IDF1 ↑	MOTA ↑	HOTA ↑	AssA ↑	DetA ↑	IDs ↓
Baseline	82.6	80.4	70.2	72.4	68.7	402
Baseline+I	83.0	80.5	70.5	72.9	68.8	390
Baseline+I+R	83.7	80.7	70.8	73.5	68.9	378

Comparison for handling occlusions

Setting	#	IDF1 ↑	MOTA ↑	HOTA ↑	AssA ↑	DetA ↑
IoU-based	30	80.9	79.8	69.0	70.6	68.1
	120	80.1	77.6	68.4	70.5	66.9
	Δ	**-0.8**	**-2.2**	**-0.6**	**-0.1**	**-1.2**
ReID-based	30	77.2	77.0	66.4	67.1	66.3
	120	70.4	67.5	60.6	60.3	61.6
	Δ	**-6.8**	**-9.5**	**-5.8**	**-6.8**	**-4.7**
Ours	30	82.6	80.4	70.2	72.4	68.7
	120	83.3	80.7	70.7	73.2	68.8
	Δ	**+0.7**	**+0.3**	**+0.5**	**+0.8**	**+0.1**

Results of Motion Model

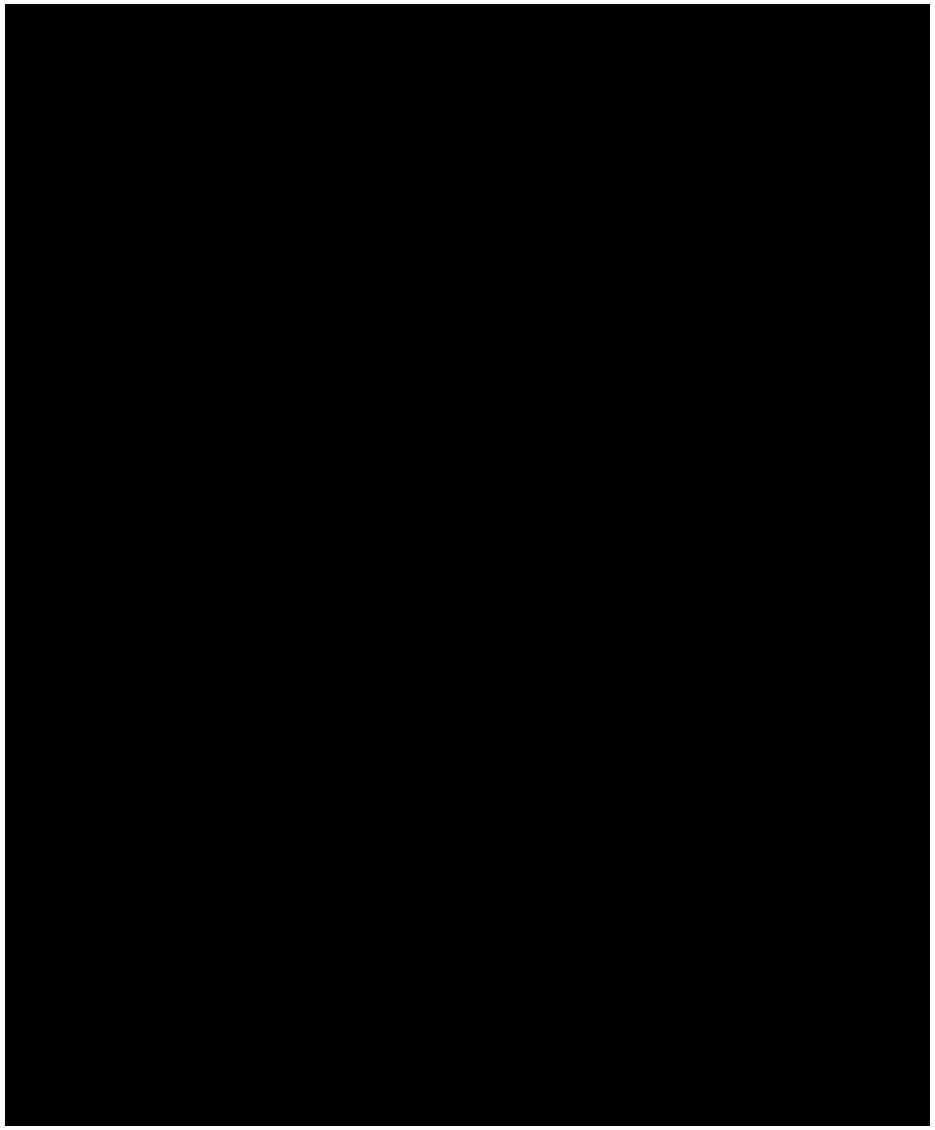


Evaluation for crowds and occlusions

Setting	⩾ 20	⩾ 40	⩾ 60	⩾ 80	⩾ 100
Baseline	77.2	73.6	75.2	73.3	71.5
Ours	78.3	75.1	76.8	74.1	72.4
Improvement	**+1.1**	**+1.5**	**+1.6**	**+0.8**	**+0.9**

video demos

Different colored boxes represent different identities and red bolded boxes represent the location during occlusion after the long-term refind. For the cases in our demo video (red bolded), almost all other methods fail to track them (tracklets before and after crowds or occlusion have different identities



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Thank you for listening !

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