

ROBUST ONLINE MULTI-OBJECT TRACKING BASED ON KCF TRACKERS AND REASSIGNMENT



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Introduction

Multi-object tracking aims to estimate the states of multiple objects in video sequences while conserving their identifications under appearance and motion variations with time.

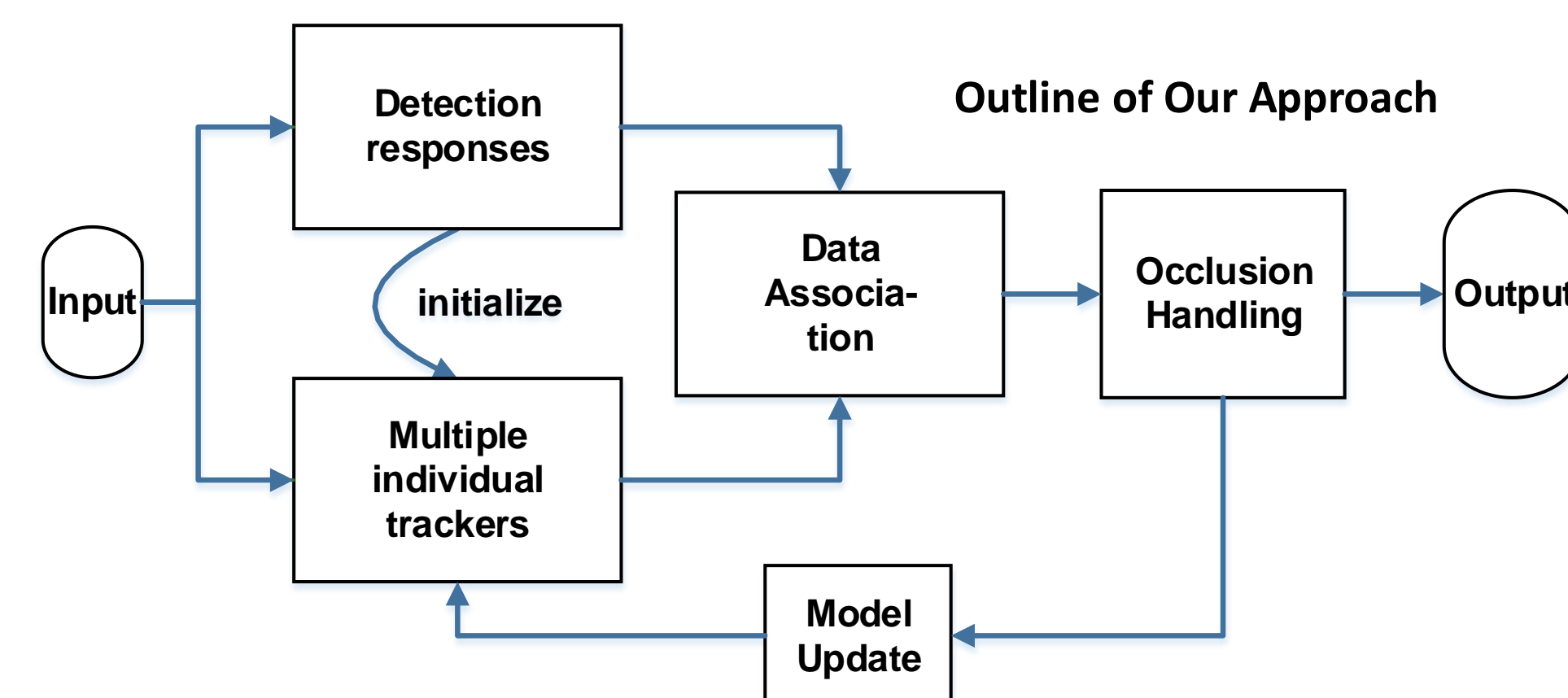
Recently, many tracking-by-detection methods have been proposed because of great improvement on object detection technology. The tracking-by-detection methods generally build long trajectories of objects by associating detections provided by detectors.

Problems:

- *Missed detections* and *false alarms* and inaccurate responses happen frequently in the detection procedure which provides misleading information to tracking algorithms.
- Frequent *occlusions* and *similar appearance* among multiple objects are also difficult to resolve.



Methods



• Multiple individual trackers (KCF tracker [1])

Samples:

$$\{P^u x \mid u = 0, \dots, n-1\}$$

Objective function:

$$\min_{\omega} \sum_i L(f(x_i, \omega), y_i) + \lambda \|\omega\|^2$$

Solution (kernel trick):

$$\omega = \sum_i \alpha_i \phi(x_i) \quad \hat{\alpha} = \frac{\hat{y}}{\hat{k} + \lambda}$$

Tracking:

Position of maximum value

$$\mathcal{F}^{-1}(\hat{k}^{xz} \odot \hat{\alpha})$$

• Data association

Multiple individual KCF trackers are divided into two groups: reliable (maximum response are greater than a threshold value μ), and unreliable. We first associate reliable trackers with detections using Hungarian algorithm. Then we conduct the same association operation on the rest detections and unreliable trackers.

$$S = [s_{ij}]_{k \times m}, s_{ij} = -\log(c(T_t^i, D_t^j)),$$

$$c(T_t^i, D_t^j) = -\log(\Lambda_p(T_t^i, D_t^j) \cdot \Lambda_s(T_t^i, D_t^j))$$

• Occlusion handling and reassignment

Trackers which are not associated with detections are occluded. Intuitively, if the occluded is not reappear, it indicates that the object is still in occlusion. Hence, we first attach the occluded object to its occlude and then to re-predict position. Next, reassignment between lost trackers and re-detected objects is based on the measurement of tracker's predicted position and its attached occluder's position, size and appearance.

• Model update

$$W_t^i = \begin{cases} Dw_t^j & \text{if } T_t^i \text{ associates with detection } D_t^j \\ Tw_t^i & \text{otherwise,} \end{cases}$$

$$H_t^i = \begin{cases} Dh_t^j & \text{if } T_t^i \text{ associates with detection } D_t^j \\ Th_t^i & \text{otherwise.} \end{cases}$$

$$\alpha_t^i = \begin{cases} \alpha^i & \text{if } T_t^i \text{ associates with detection } or \text{ Reliable} \\ \alpha_{t-1}^i & \text{otherwise,} \end{cases}$$

$$\hat{x}_t^i = \begin{cases} \hat{x}^i & \text{if } T_t^i \text{ associates with detection } or \text{ Reliable} \\ \hat{x}_{t-1}^i & \text{otherwise.} \end{cases}$$

Result

Table 1. Methods Comparison in PETS'09 S2L1

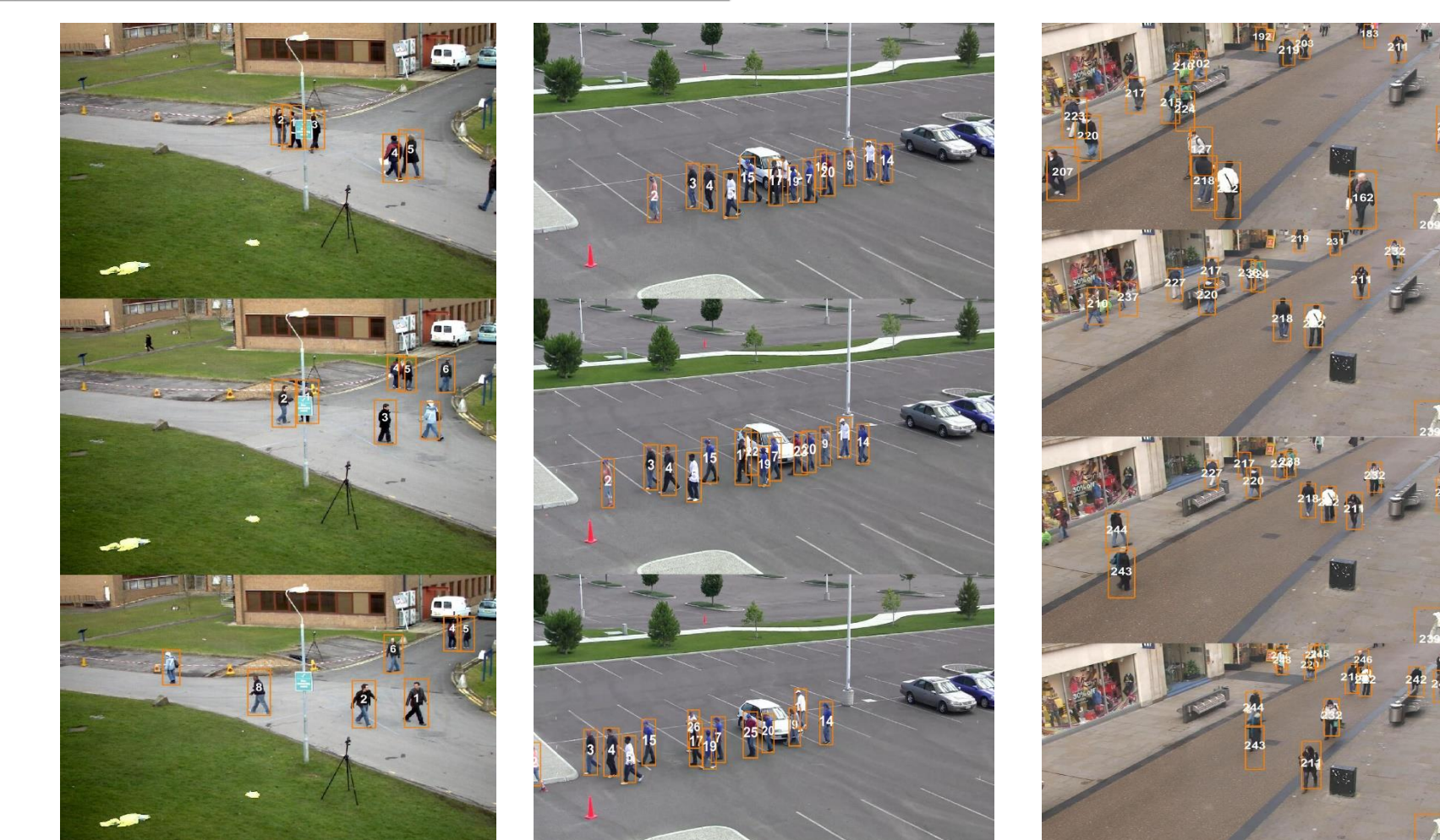
Method	Rec	Pre	MT	ML	Frag	IDS
online						
WZB [5]	-	-	100.0	0.0	11	8
*BY [3]	-	-	100.0	0.0	4	4
PMRB [4]	-	-	100.0	0.0	16	9
Proposed	98.4	96.9	100.0	0.0	7	1
batch						
*MRS [10]	92.4	98.4	91.3	4.3	6	11
*MSR [11]	-	-	78.3	0.0	15	22
AS [12]	89.5	98.7	82.6	0.0	14	18
ASR [13]	90.0	97.6	78.3	4.3	21	38
ZDS [14]	96.5	93.6	89.5	0.0	54	10
WLY+ [15]	94.4	98.4	95.6	0.0	10	5

Table 2. Methods Comparison in ParkingLot

Method	Rec	Pre	MT	ML	Frag	IDS
online						
*BY [3]	91.0	80.1	78.6	0.0	29	10
Proposed	91.0	80.1	85.7	0.0	23	4
batch						
ZDS [14]	85.3	98.2	-	-	-	-
SDO+ [16]	81.7	91.3	-	-	-	-
*AS [12]	69.3	91.3	21.4	7.1	97	68
*ASR [13]	86.8	89.4	78.6	0.0	70	83
*WLY+ [15]	90.8	98.3	78.6	0.0	23	21

Table 3. Methods Comparison in Town Center

Method	Rec	Pre	MT	ML	Frag	IDS
online						
WZB [5]	-	-	64.7	7.9	453	209
PMRB [4]	-	-	56.3	7.4	321	157
*BY [3]	84.4	77.3	65.7	7.0	410	105
Proposed	87.0	65.8	72.1	6.5	312	121
batch						
ZLN [17]	-	-	53.0	9.3	440	243
LPR [18]	-	-	58.6	7.0	363	165



Reference

[1] J. F. Henriques, R. Caseiro, P. Martins, and J. Batista, "High-speed tracking with kernelized correlation filters," *Pattern Analysis and Machine Intelligence, IEEE Transactions on*, vol. 37, no. 3, pp. 583–596, 2015.

Overall, we achieve competitive results to the state-of-the-art online and batch approaches with robustly high Rec, MT and low ML, Frag, IDS. All results indicate that our method by combining the trackers with detections synthetically and including reassignment strategy overcomes the influence of frequent occlusions and false detections.