Multi-Target Tracking and Segmentation via Discriminative Appearance Model

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Outline

- Introduction
- Discriminative Appearance Model
- Multi-target tracking
- Experimental result
- Conclusion

1.Introduction

- Monocular multi-target tracking

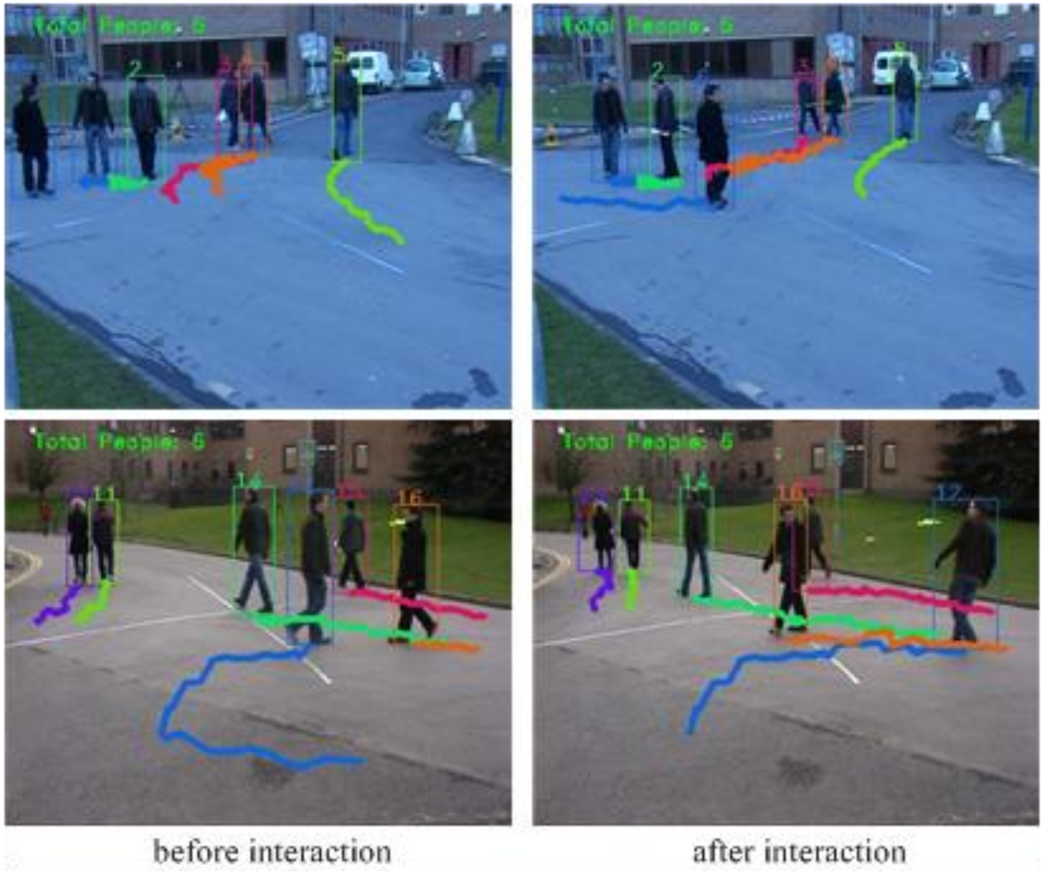


Figure 1. a challenging case from PETS2009.

1.Introduction

- Two phases:
  - Feature extraction
    - Color histogram ([Huang and Essa 2005],[Zhao et al. 2008])
    - Template ([Senior et al. 2006],[Yang et al. 2009],[Jepson et al. 2001])
    - HOG ([Dalal and Triggs 2005])
  - Data association
    - MHT ([Reid, 1979])
    - JPDAF ([Fortmann 1983], [Rasmussen and Hager 2001])
    - PF ([Okuma et al. 2004],[Li et al. 2008],[Zhou et al 2004])
    - Global method ([Leibe et al. 2007],[Huang et al. 2008],[Zhang et al. 2008])

1.Introduction

- The main features of our work:
  - Discriminative appearance model
  - Motion-based update strategy
  - Two-level multi-target tracking algorithm
- Improve the tracking accuracy, reduce the identity switches and track drifts

2.Discriminative Appearance Model

- 2.1 The representation of appearance model include two parts: $\{Hist\}$ $\{C, P\}$
  - 1) Color histogram in specific space
    - feature spaces: $F = \{w_1 R + w_2 G + w_3 B | w_1, w_2, w_3 \in [-2, 2]\}$

2.Discriminative Appearance Model

Measure the extent of the discriminability

For a certain feature space, two object a and b,

estimate the distribution of the feature values → compute a log likelihood function → use the variance ratio as the mea sure criterion

$$p_a(i) = H_a(i)/n_a$$
$$p_b(i) = H_b(i)/n_b$$

$$L(i) = \log \frac{\max\{p_a(i), \delta\}}{\max\{p_b(i), \delta\}}$$

$$VR(L; p_a, p_b; f) = \frac{\mathrm{var}(L; (p_a + p_b)/2)}{\left[\mathrm{var}(L; p_a) + \mathrm{var}(L; p_b)\right]}$$

Define $\mathrm{var}(L;p)$ like this: $\mathrm{var}(L;p) = \sum_i p(i) L^2(i) - \left[\sum_i p(i) L(i)\right]^2$

2.Discriminative Appearance Model

How to select discriminative feature spaces

- The higher the variance ratio, the better the feature can separate the targets

- Assign new feature spaces for new object according to the following condition

$$f = \arg\max_{f} \{ VR(L; p_{new}, p_{existed}; f)_{\min} \}$$

2.Discriminative Appearance Model

- 2) Probabilistic Appearance Template

  - The color template C
    - color spatial distribution of corresponding pixels of object
  - The probability mask P
    - records the likelihood of corresponding pixels that belong to the object
    - shows the shape information

2.Discriminative Appearance Model

- 2.2 Update the model adaptively
  - Motion-based method to adjust the update ratio

where $$k_{update} = 0.5 - 0.45 * \cos\theta$$

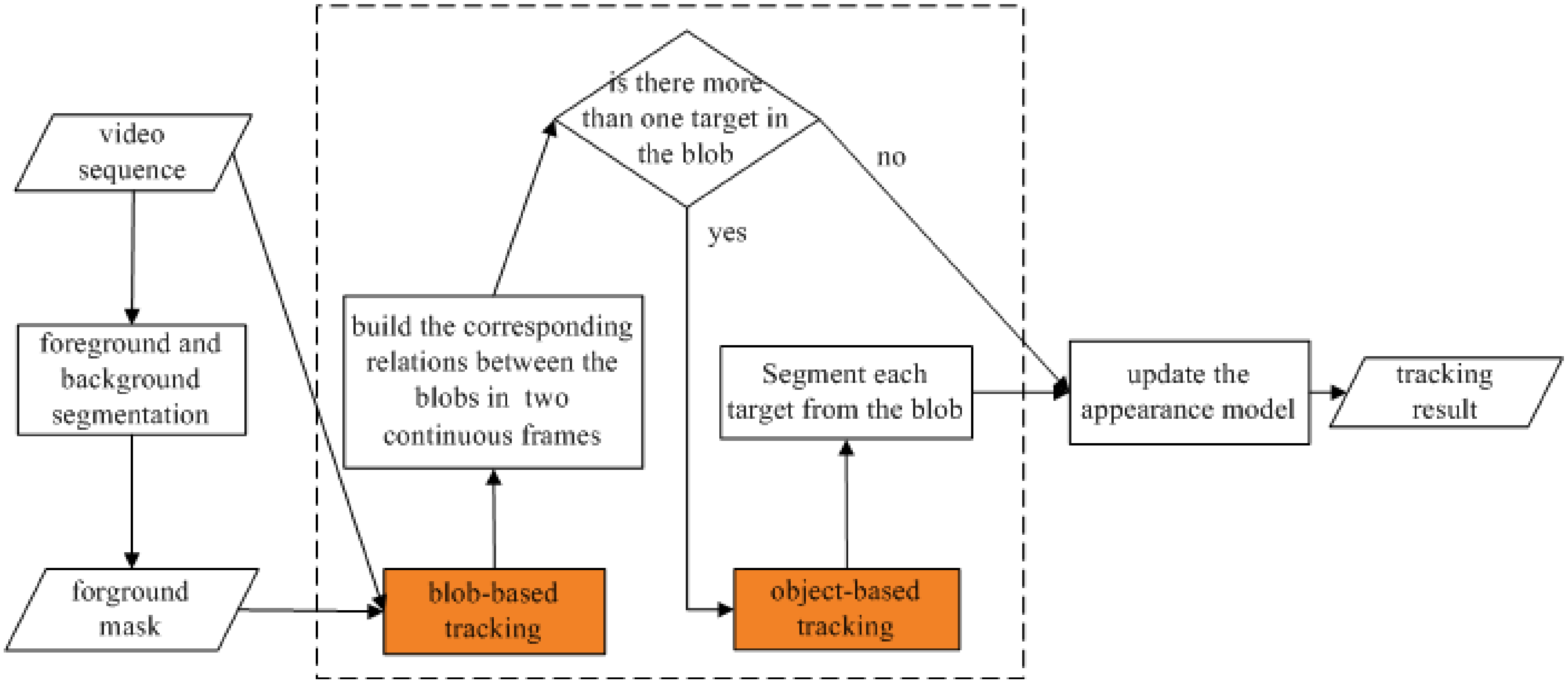
$$\cos\theta = \frac{\overrightarrow{loca_{t-2}loca_{t-1}} \bullet \overrightarrow{loca_{t-1}loca_{t}}}{\left(\left|\overrightarrow{loca_{t-2}loca_{t-1}}\right| * \left|\overrightarrow{loca_{t-1}loca_{t}}\right| + \varepsilon\right)}$$

$$\varepsilon = 1.0$$

so $$k_{update} \in [0.05, 0.95]$$

3.Multi-target Tracking

- Two-level tracking algorithm



Two-level tracking algorithm

Figure 3. The block diagram of our tracking system.

3.Multi-target Tracking

- 1) blob-based tracking

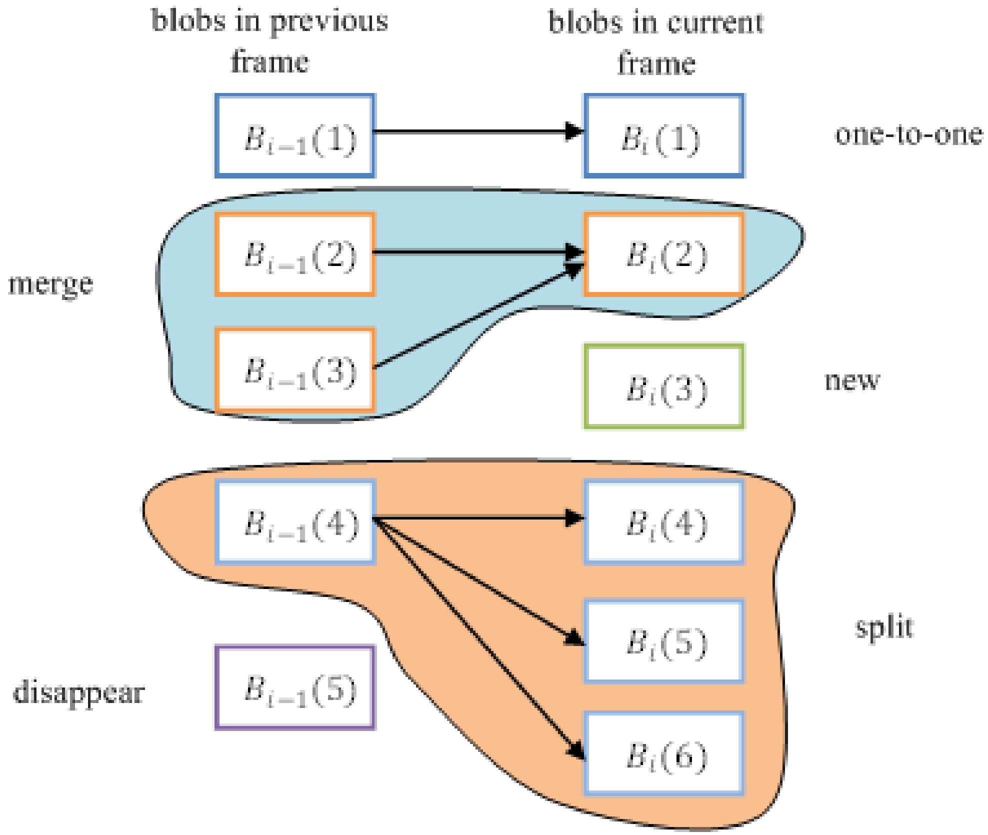


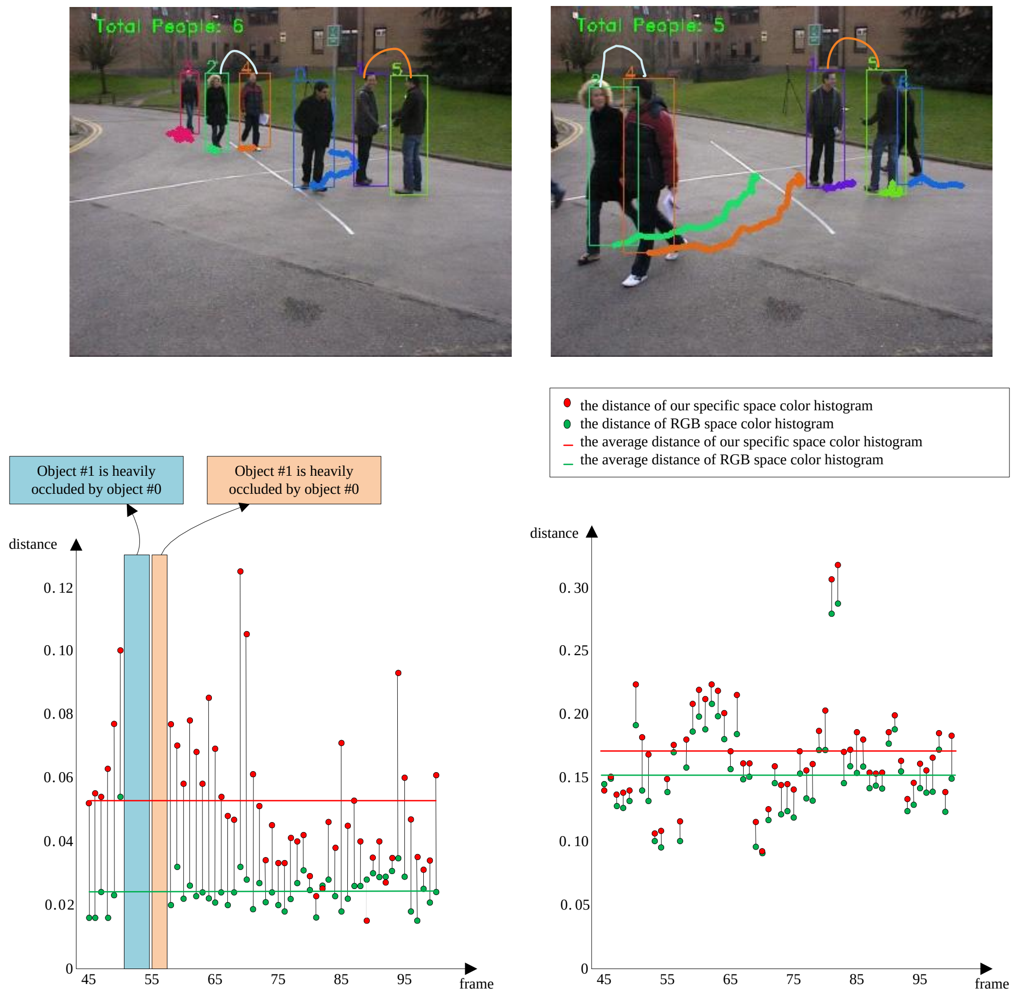
Figure 4. Four conditions in blob-based tracking.

3.Multi-target Tracking

- 2) object-based tracking

  - Apply Kalman filter to get the predicted center $C_{predicted}$
  - Find a region around $C_{predicted}$ and $C_{current}$ which has the maximum likelihood with the target
  - Coarse-to-fine search strategy

4.Experimental result



(a)object#1 and object#5 (b)object#2 and object#4

Figure 5. The sample comparison of discriminability.

4.Experimental result

heavy occlusion　　turn a corner　　interaction

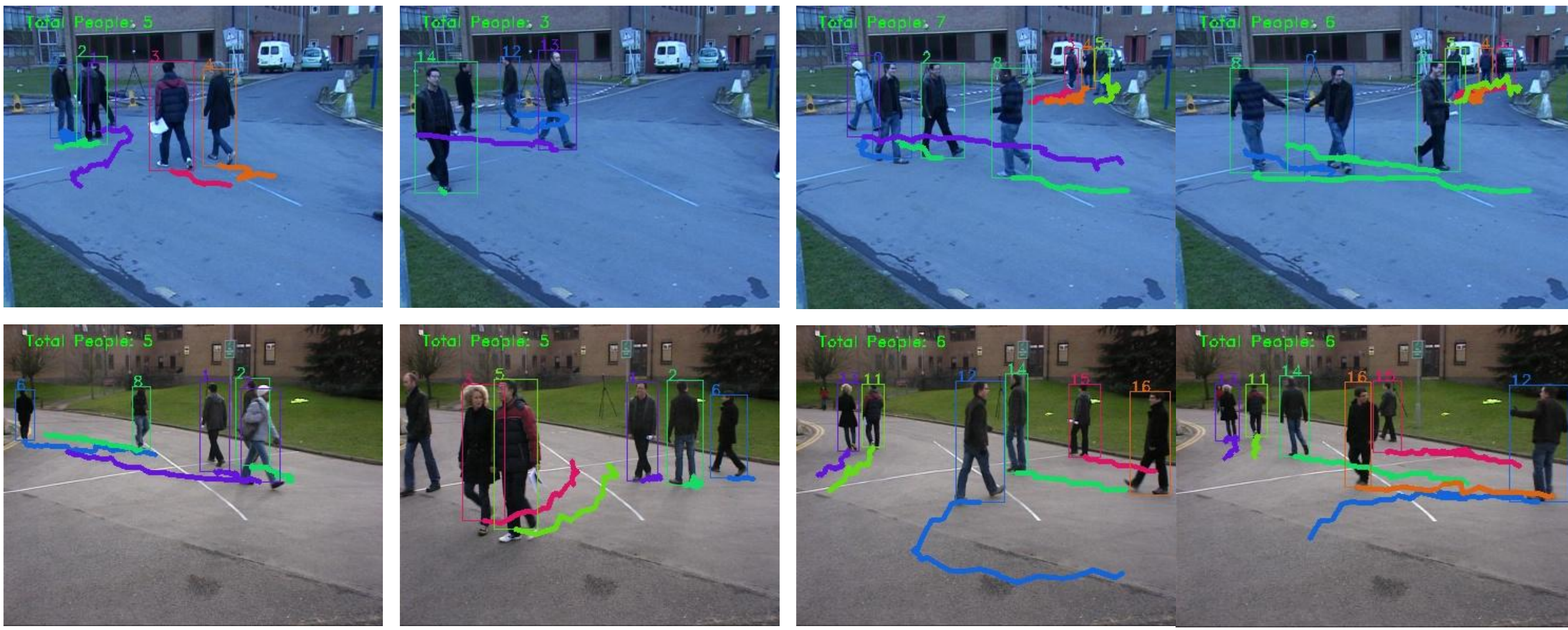


Figure 6. Sample tracking results on PETS2009. Sample results in the top row are from view 6, and in the bottom row are from view 8.

4.Experimental result

frame 51 frame 59

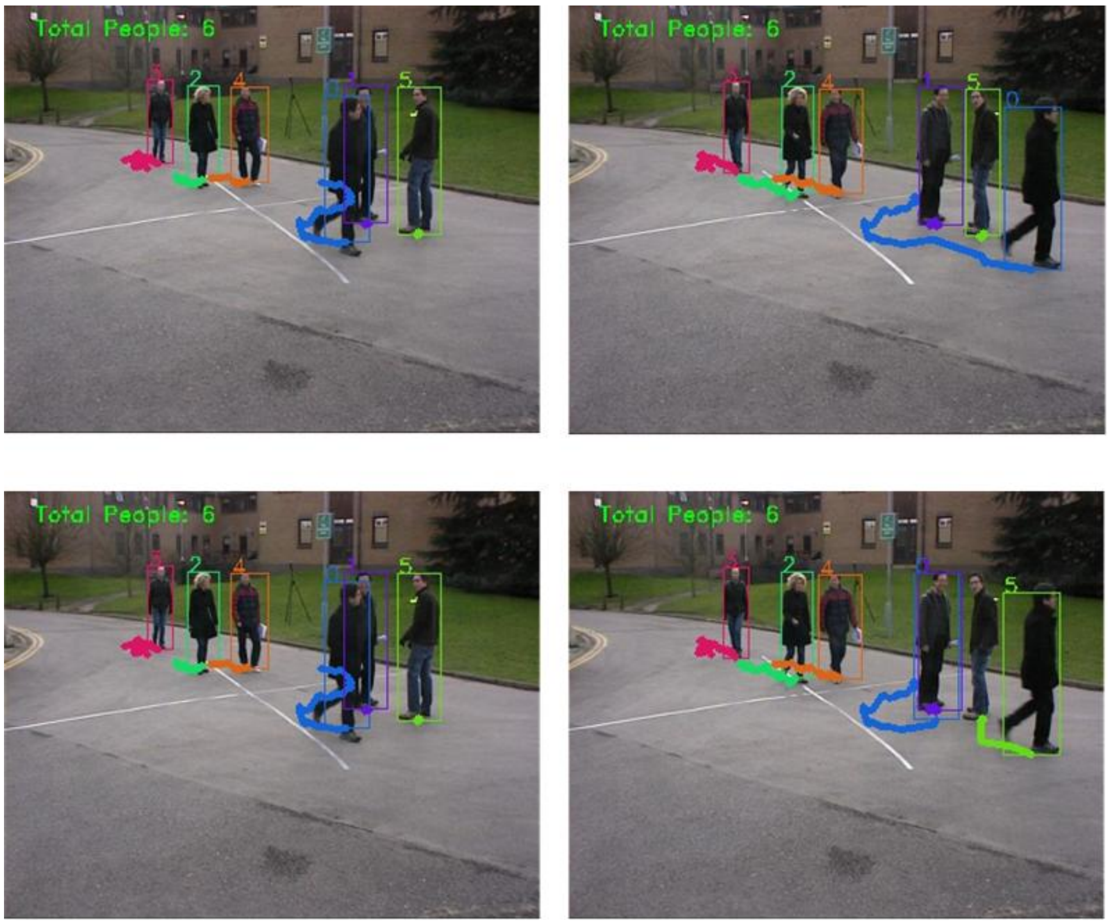


Figure 7. Comparison results in two models.

Tracking result with our discriminative appearance model

Tracking result with appearance model in RGB color space

4.Experimental result

frame 45 frame 88 frame89 frame92

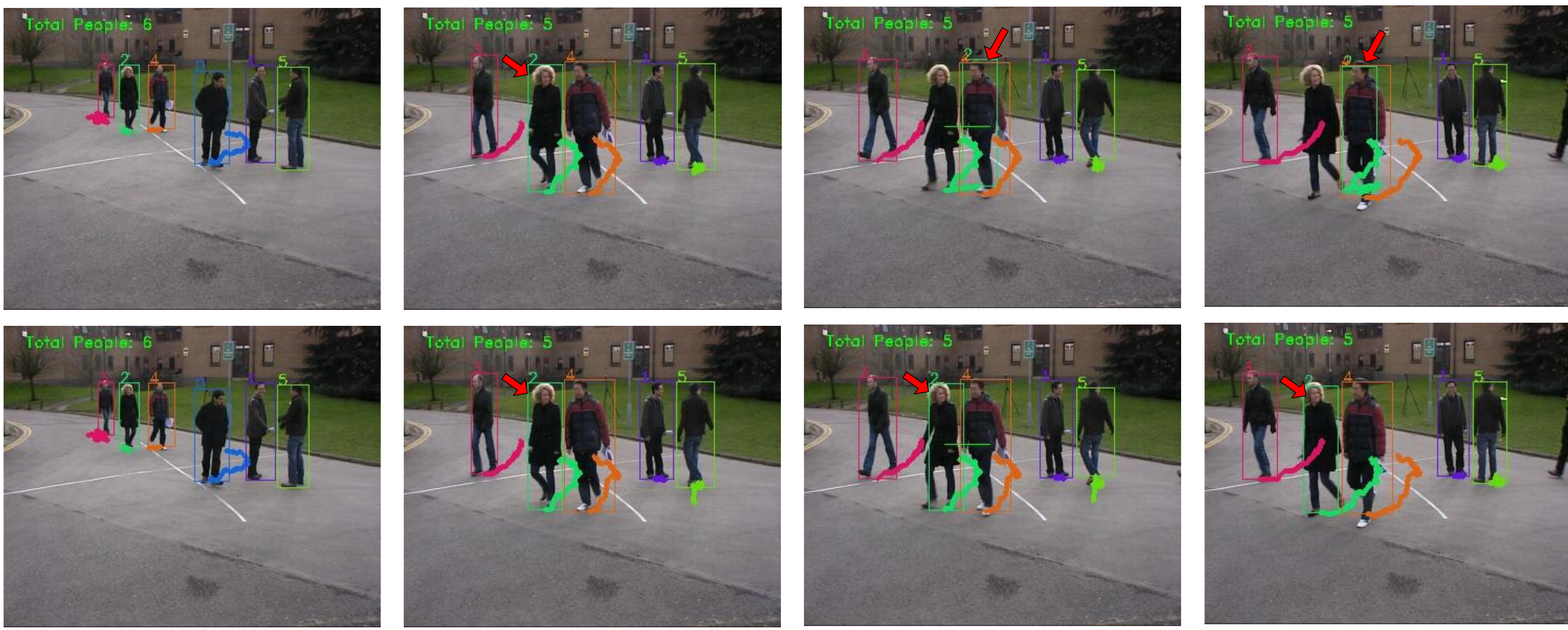
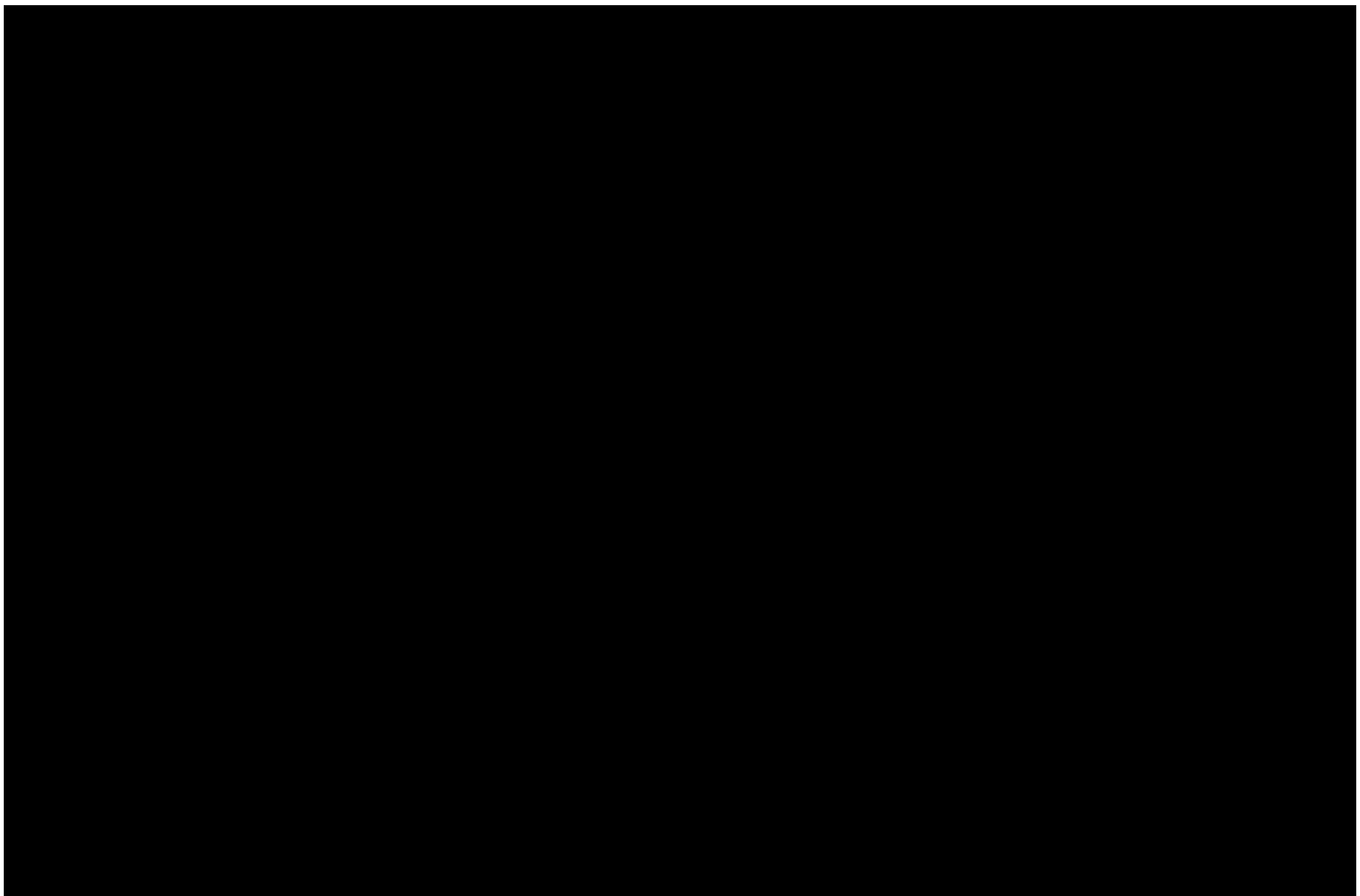


Figure 8. Comparison examples in two update strategies.

5. Conclusion

- A novel appearance model focusing on the discriminability between different targets
- Two-level tracking algorithm
- Handle with pose changes, abrupt motion and heavy occlusions very well
- Future works
  - integrate the model with other optimized data association framework
  - improve our algorithm to reduce the tracking failure caused by detection errors

Demo



Thank you!