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Robust Visual Tracking for Multiple Targets with Data Association and Track Management

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ABSTRACT

Multi-object tracking is still a challenging task in computer vision. A robust approach is proposed to realize multi-object tracking using camera networks. Detection algorithms are utilized to detect object regions with confidence scores for initialization of individual particle filters. Since data association is the key issue in Tracking-by-Detection mechanism, an efficient HOG algorithm and SVM classifier algorithm are used for tracking multiple objects. Furthermore, tracking in single cameras is realized by a greedy matching method. Afterwards, 3D geometry positions are obtained from the rectangular relationship between objects. Corresponding objects are tracked in cameras to take the advantages of camera based tracking. The proposed algorithm performs online and does not need any information about the scene, any restrictions of enter-and-exit zones, no assumption of areas where objects are moving on and can be extended to any class of object tracking. Experimental results show the benefits of using camera by the higher accuracy and detect the objects.

Keywords: *Online Multi-Object Tracking; Tracking-By Detection; Data Association; Track Management; Online Learning; Track Existence Probability; Particle Filtering; Affinity Model; Surveillance System.*

1.0 Introduction

A tracking-by-detection approach finds states and IDs of multiple objects with detections of pre-trained detectors. The tracking-by-detection approach often fails in complex scenes when the detection responses are unreliable (e.g., false positive and missing detections, inaccurate detections of object locations and sizes). To track multiple objects in online under difficult situations, various online tracking systems are developed. Based on the Bayesian framework; the online tracking systems perform two recursive procedures to estimate states of multiple objects at each frame. In prediction estimated states up to previous frames are propagated using the object dynamic model. The predicted states are updated by evaluating the likelihood between the predicted states and associated observations using the observation model.

Designs a particle filtering-based framework and carefully guide multiple trackers with detections provided by a boosted object detector. Extends the boosted particle filter using an independent particle set for each target to improve robustness under occlusions. For single and multi target tracking, extends the PDA and JPDA algorithms with the concept of target existence. To enhance detection and tracking performance, exploits an edge let-based part model for describing appearances of objects. For tracking in multi-dimensional state space, develops the scatter search particle filter by embedding scatter search met heuristic into the particle filtering.

However, all of these approaches suffer from template drift when motions and appearances dramatically change since they only rely on outputs of offline trained detectors. In order to solve the drift problems under occlusions uses the continuous confidence map by combining a pretrained detector and an online-trained classifier outputs. To handle partial occlusions in the detection and tracking stages employs deformable part models for describing appearances of objects. Although they show improved performance in many scenarios, both approaches are prone to produce fragmented trajectories under long-term occlusions since any tracking linking process is not adopted.

To resolve both partial and long-term occlusions, the proposed online tracking system takes advantages of batch and online tracking approaches.

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As similar to other online tracking approaches, the visual tracking part is designed based on the Bayesian approach for online tracking, but a novel data association with a track existence probability is incorporated to assign detections into tracks more correctly under partial occlusions. Subsequently, the track management part performs track-to-track association to link fragmented tracks under long term occlusions as similar to tracklet association in batch tracking systems. Lately, in an attempt to combine the both approaches, has presented a tracking system with discriminative part based models.

However, it is significantly different from ours since their system is designed based on the batch tracking framework. Therefore, tracks (or tracklets) are generated by globally associating detections of the entire sequences. It indicates that their system is not suitable for online tracking applications. The two-stage tracking system proposed by is also similar to ours. They produce locally optimized tracks by associating observations with tracks and globally optimized tracks by associating fragmented tracks. They use the greedy method for local association, whereas a novel data association is employed. In addition, the developer use the predefined appearance model, but the online learning part updates discriminative appearance models with online tracking results. As a result, the system is able to distinguish between different objects well, even though the appearances of the objects frequently change.

2.0 Related Work

A robust approach is proposed to realize multi-object tracking using camera networks. Detection algorithms are utilized to detect object regions with confidence scores for initialization of individual particle filters. Since data association is the key issue in Tracking-by-Detection mechanism, an efficient HOG algorithm and SVM classifier algorithm are used for tracking multiple objects. Furthermore, tracking in single cameras is realized by a greedy matching method.

2.1 Support vector machine

More formally, a support vector machine constructs a hyper plane or set of hyper planes in a high- or infinite-dimensional space, which can be used for classification, regression, or other tasks. Intuitively, a good separation is achieved by the hyper plane that has the largest distance to the nearest training data point of any class (so-called functional margin), since in general the larger the margin the lower the generalization error of the classifier.

SVMs are helpful in text and hypertext categorization as their application can significantly reduce the need for labeled training instances in both the standard inductive and transductive settings. Classification of images can also be performed using SVMs. Experimental results show that SVMs achieve significantly higher search accuracy than traditional query refinement schemes after just three to four rounds of relevance feedback.

2.2 Histogram of gradient

Histogram of Oriented Gradients (HOG) is feature descriptors used in computer vision and image processing for the purpose of object detection. The technique counts occurrences of gradient orientation in localized portions of an image. This method is similar to that of edge orientation histograms, scale-invariant feature transform descriptors, and shape contexts, but differs in that it is computed on a dense grid of uniformly spaced cells and uses overlapping local contrast normalization for improved accuracy.

3.0 System Design

An online tracking system is proposed, which can robustly track multiple objects even in complex scenes but also be suitable for online tracking applications.

In order to correctly assign detections with tracks under partial occlusions, the visual tracking part associates online detections with existing tracks by evaluating track existence probabilities as well as the likelihoods of them, and updates states of tracks with associated detections.

However, it is still difficult to track objects when no detection is available for a long time. In this case, the track management part terminates tracks with low existence probabilities and associates the terminated tracks with other tracks or detections belong to the same objects so as to link them.

For successful association in the other two parts, the online model learning part incrementally learns discriminative appearance models with updated tracking results.

It allows us to distinguish between tracked objects and background, but also between interacting objects (i.e. closely spaced objects).

The proposed system produces long trajectories without future frames and any iterative optimization in complex scenes.

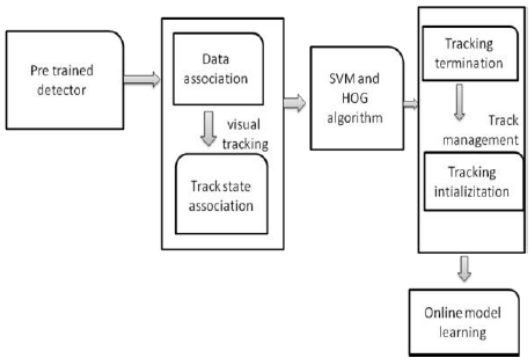
The user has to evaluate the performance of this system and the key parts of the system using challenging tracking datasets.

The main contributions of this work include: (1) a fully automated online tracking system to track objects robustly through severe occlusions;

(2) a Bayesian tracking method based on a novel data association to update states of tracks with online detections;

(3) a track management method to associate fragmented tracks; (4) an online learning method to learn discriminative appearance models of tracked objects.

Fig 1: System Architecture



3.1 Visual tracking

The objective of video tracking is to associate target objects in consecutive video frames. The association can be especially difficult when the objects are moving fast relative to the frame rate. Another situation that increases the complexity of the problem is when the tracked object changes orientation over time. For these situations video tracking systems usually employ a motion model which describes how the image of the target might change for different.

At each frame, object hypotheses are detected using a pre-trained detector and used as an input of this system. Based on the proposed data association, the provided detections are associated with existing tracks and existence probabilities of tracks are updated. Then, track states are estimated with the associated detections using particle filtering.

3.2 Track management

Track Link and Termination: Once long-term occlusion occurs, it is extremely difficult in tracking an occluded object because the observation of the track could not be available and the appearance of the occluded object is significantly different from the updated reference model of the object. To deal with the long-term occlusion, the associated fragmented tracks to link them.

A terminated track is considered as a fragmented track or a complete track.

The link detections when the ratio of an overlapped area over an union area of detections is more than 0.5. If more than two detections are overlapped in neighboring frames with the maximum ratio based on the greedy algorithm.

3.3 Online model learning

Discriminative appearance, shape and motion models of describing tracked objects are learned by updated tracking results. A Track is represented using several cues Ti = {Ai, Si, Mi}, where Ai, Si and Mi are appearance, shape and motion models, respectively. The appearance descriptors extracted from the tail (i.e. the last refined position) and the head (i.e. the first refined position) of the track. The shape affinity between tracks is evaluated with their heights and widths. The motion affinity of predicted position with the velocity and the refined position is assumed to follow the Gaussian distribution. Using the Kalman filtering, the forward velocity and refined positions are estimated from the head to the tail, while the backward velocity positions are estimated from the tail to the head.

4.0 Conclusion

An online multi-object tracking system consisting of three main parts. The visual tracking part based on a novel data association with track existence probability allows us to track objects robustly under partial occlusions.

To deal with long-term occlusions, the track management part performs track-to-track association to link fragmented tracks. For successful association in other two parts, the online learning part incrementally updates discriminative appearance models with online tracking results.

The experimental results using challenging tracking datasets have shown the improved performance of the proposed system, compared to other state-of art tracking systems.

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