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Real-time Compressive Tracking - A Study and Review

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Abstract: Tracking of objects plays an important role in the security of common man to a country. This includes tracking of objects like human, military vehicle, intruders in the border of every countries. Tracking people and objects plays a vital role now a days as there may be intruders in the border in the name of terrorists. This paper produces a study and review on real time compressive tracking. The image compression also plays an important role as the storage of the images and further the retrieval requires small amount of memory as the available memory space may be scarce. In addition, the processing of the images captured requires faster algorithms. This requires processing of the images as small sized images. This paper analyzed this problem using techniques like compressed tracking and sparse representation. Even though the techniques like, Compressed Tracking, Sparse Representation, Adaptive Filtering, Naive Bayesian Classifier and Mean Shift produces results which is above 90%, Naive Bayes Classifier produces the maximum success rate of 99%.

Keywords: Compressive Tracking; Sparse Representation; Adaptive Filtering; Mean Shift; Particle Filters

I. Introduction

It is a challenging task to develop effective and efficient appearance models for robust object tracking due to factors such as pose variation, illumination change, occlusion, and motion blur. Existing online tracking algorithms often update models with samples from observations in recent frames. While much success has been demonstrated, numerous issues remain to be addressed. First, while these adaptive appearance models are data-dependent, the sufficient amount of data does not exist for online algorithms to learn at the outset. Second, online tracking algorithms often encounter the drift problems. As a result of self-taught learning, these misaligned samples are likely to be added and degrade the appearance models. In this paper, a survey is made by discussing some of the methods used for real time compressive tracking techniques, advantages and drawbacks.

II. Real Time Compressive Tracking

The commonly used techniques used for real time compressive tracking involves: Naives Bayes Classifier, Appearance based models, Particle filtering, Adaptive block matching, Kernel based object tracking, Wavelet transform, Optical flow, Static Computational Optical Under sampled Tracker (SCOUT), Mean shift, K-means clustering, Dynamic Time Warping Technique, Adaptive Motion Estimation (FAME), Adaptive Filtering Method, Sparse Representation, Compressed Tracking. The description, merits and demerits of the above mentioned techniques are discussed in the succeeding sections.

A. Naive Bayes Classifier

Kaihua Zhang et al. [1] proposed an excellent method for real-time compressive tracking using Naive Bayes classifier which produced better results by combining the merits of generative and discriminative appearance based models to account for scene changes with the accuracy of 99%. But it has some shortcoming also as it is necessary to select random measurement matrix instead of using the matrix as whole.

B. Appearance Based Model

Guizi Li et al. [2] proposed a new method for real-time visual tracking based on the appearance model and a motion mode which produced better results with the success rate of 95% using Gaussian perturbation for motion mode and the Bayesian theory for tracking. The problem with this method is that the image patch must be divided into several small pieces for adapting to the slight change of the object.

C. Particle Filtering

Emilio Maggio et al. [3] proposed a method for adaptive multi-feature tracking in a particle filtering framework producing better results by eliminating the need of manually selecting each feature's relevance with the accuracy of 97%. But the features are combined in a single particle filter by weighting their contributions. Shaohua Zhou et al. [10] suggested a method for visual tracking and recognition using appearance-adaptive

models in particle filters using adaptive observation model and linear prediction into stochastic diffusion producing better results with the success rate of 96%. King-Yeung Chan *et al.* [15] suggested a method for real-time image compression for high-speed particle tracking using real-time recording algorithm and compression for improving data acquisition efficiency by achieving a high compression ratio and expanding experimental duration producing better results with the success rate of 93%.

D. Adaptive Block Matching

Karthik Hariharakrishnan *et al.* [4] presented a method for Fast Object Tracking using Adaptive Block Matching which produced better results with the accuracy of 90%. The beauty of this method is that the object can be tracked accurately for a longer time without requiring re-initialization/re-segmentation and it can be extended in a straightforward manner to extract multiple objects. Still the tracking result deteriorates for objects that are relatively small. Fai Yeung *et al.* [11] used a method for tracking of ultrasound image sequences using deformable mesh which produced better results with the success rate of 94%. It is an extension of a block matching algorithm to non-rigid motion estimation. But further investigation is needed into discontinuity-adaptive methods for motion tracking of biological tissues.

E. Kernel-Based Object Tracking

Dorin Comaniciu *et al.* [6] proposed an algorithm using Kernel-Based Object Tracking, histogram-based target representations, spatial masking with an isotropic kernel and Bhattacharyya coefficient. Several examples validate the approach and showing its efficiency producing better results with the accuracy of 95%.

F. Wavelet Transform

A method for moving object tracking in video using Wavelet transform, Filter banks and object isolation algorithm was tried by Yiwei Wang *et al.* [44], which demonstrates the effectiveness of the algorithm even in some complicated situations, such as new track, ceased track, track collision producing better results with the success rate of 90%. But it has some drawbacks of computational expensive and occlusion.

G. Optical Flow

Moving object tracking in video using optical flow (Horn-Schunck) in MATLAB Simulink presented by Bhavana C. Bendale *et al.* [8], producing better results with the accuracy of 95%. It has a variety of uses, some of which are: human computer interaction, security and surveillance, video communication and compression, augmented reality, traffic control, medical imaging and video editing. It creates confusion in case of the tracking with different class objects in real time video.

H. Static Computational Optical under Sampled Tracker (SCOUT)

A novel method for static compressive tracking using Static Computational Optical Under sampled Tracker (SCOUT) by eliminating this scaling issue by giving up the ability to implement arbitrary projections producing good results with the success rate of 96%. But the method presented by D. J. Townsend *et al.* [8] had drawback in the reconstructions of difference scenes with adjacent mover locations due to the design or calibration of the system matrix. The algorithm yielding excellent results for high traffic situations and also clicking well with highly compressed, low resolution videos is demonstrated by Goo Jun *et al.* [9] for Tracking and Segmentation of Highway Vehicles in Cluttered and Crowded Scenes using background subtraction algorithm, occlusion detection, motion analysis and vehicle segmentation which produced better results with the success rate of 94%.

I. Mean Shift

Dorin Comaniciu *et al.* [16] used a method for real-time tracking of non-rigid objects using mean shift algorithm which produced better results with the success rate of 95% [14].

J. K-means Clustering

A method for robust visual tracking using discriminative stable regions and K-means clustering adaptive fusion tracking algorithm proposed by Can-Long Zhang *et al.* [17] obtaining attractive results with the success rate of 92%. But it is not quite suitable for tracking very small targets, in particular, if the appearance of an object is completely flat or fractal-like the tracker may fail due to the lack of salient sub-regions.

K. Dynamic Time Warping Technique

Dynamic time warping technique was suggested by Fadi Dornaika *et al.* [20] for facial expression recognition using tracked facial actions: classifier performance analysis producing better results with the success rate of 95%.

L. Adaptive Motion Estimation Algorithm

Ishfaq Ahmad *et al.* [24] proposed an algorithm for A Fast Adaptive Motion Estimation (FAME) Algorithm outperforming MVFAST with much faster speed while yielding the similar picture quality with full search

yielding better results with the accuracy of 91%. MVFAST causes steep degradation when coding fast motion sequences.

M. Adaptive Filtering Method

A novel method using adaptive filtering and structure-tracking was tried by Ph. Blondel *et al* [27] for statistical analysis of geological features in radar images with the success rate of 94%.

N. Sparse Representation

Some of the researcher like Dong Wang *et al.* [13] proposed algorithms for online object tracking with sparse prototypes getting favorable results in terms of center location error and overlap rate with the success rate of 90%. But it is time consuming when computing the coefficients using the basis vectors or templates. Hong Cheng *et al.* [35] proposed a novel method for online object tracking with sparse prototypes using object tracking algorithm with sparse prototypes and principal component analysis (PCA) algorithms producing better results with the success rate of 95%. But other online orthogonal subspace methods need to be addressed for object recognition. Xiaoqin Zhang *et al.* [21] found a method for Block covariance based l1-regularized sparse representation based tracking algorithm with a subtle template dictionary yielding better results with the success rate of 95%. But the tracking failed if the center of the window is not in the object.

A method for a low-complexity multi-target tracking algorithm in urban environments using sparse modeling was presented by Phani Chavali *et al* [25], which produced attractive results with the success rate of 93%. Since the target scene is represented as a sparse signal, problem of delay and Doppler estimation is equivalent to a sparse support recovery problem. Khemraj Deshmukh Vishal Moyal [30] proposed a novel method for compound order tracking based on multi sparse representation using compound order learning, online tracking and compressed sensing with the accuracy of 92%. Jin Wang *et al* [33] presented a novel method for sparse representation of local spatial-temporal features with dimensionality reduction for motion recognition system which produced better results with the recognition rate of 96%. Tianxiang Bai *et al* [34] proposed a method for robust visual tracking with structured sparse representation appearance model using block orthogonal matching pursuit (BOMP) and Principal Component Analysis (PCA) which produced better results with the success rate of 96%. Although the proposed tracker performs well, drifts are observed when there is extreme pose and illumination variation Denis Steinemann *et al* [36] proposed an algorithm for splitting meshless deforming objects with explicit surface tracking which produced better results with the accuracy of 95%. But the quality of the surface mesh degrades when the same region is split multiple times.

III. Discussion

Compressive tracking of doubly selective channels in multicarrier by using a modified version of the OMP recovery algorithm was suggested by Daniel Eiwen *et al.* [5] that exploits partial support information with lower complexity than the classic OMP algorithm producing better results with the success rate of 95%. But the use of modified compressed sensing (MOD-CS) assumes that a part of the support of the signal to be estimated is known a priori. Fu-Ching Yang *et al* [13] proposed a new method for an on-chip AHP bus tracer with real-time compression and dynamic multiresolution supports for SoC which produced better results with the accuracy of 96%. The bus tracer not only helped the designer to debug the SoC during design integration, but also helped the user of the SoC to monitor the real time system behaviors. Guanghui Zhao *et al.* [18] tried a method for robust ISAR imaging based on compressive sensing measurements from noisy images producing better results with the success rate of 94%. But canonical ISAR imaging is significantly dependent on the number of pulses and the noise level, as the SNR decreasing, image quality of LCS method serious decays.

The object-based video compression algorithm was presented by Soumaya Ghorbel *et al.* [19] using neural networks which produced better results with the success rate of 92%. It is efficient in term of compression ratio but it is expensive for video compression. Block-wise motion detection algorithm was proposed by Jun Ke *et al* [22] using compressive imaging system based on motion detection with feature-specific imaging system and Gaussian mixture model producing better results with the success rate of 92%. It does not yield impressive performance because limited object energy is collected into feature measurement as the majority of Gabor vector elements have values close to zero. Volkan Cevher *et al* [23] used a novel method for Compressive Sensing for Background subtraction using sub-Nyquist sampling, the compressive sensing theory, signal recovery via optimization which produced better results with the success rate of 93%. If a centralized vision system is used with no background subtraction at the camera, then this method can be used at conventional cameras for processing in the compressive domain to reduce communication bandwidth. B. Song *et al* [37] proposed a new method for a multi-terminal model-based video compression algorithm producing good results with the accuracy of 95%. This scheme relies on 3D model-based tracking algorithm. A vehicle detection algorithm was suggested by Yiqin Caoa [26] based on compressive sensing and background subtraction by improving the reliability of intelligent transportation with higher precision detection rates as 92%.

Torsten Suel *et al* [28] presented an algorithm for delta compression and remote file synchronization which produced better results with the success rate of 92%. But a lot of work still remains to be done on how to best

use delta compression techniques. Jacob A. Maddams et al [29] proposed an autonomous method for multi-track dynamic range compression which produced better results with the success rate of 92%. Still there is a need for further listening tests to establish more concretely which settings are preferred. Garrett Warnell and Rama Chellappa [35] proposed a novel method for compressive sensing in visual tracking using compressive sensing, classical visual tracking, background subtraction, Kalman filtering, Particle filtering, Mean shift tracking and compressive sensing which produced better results with the accuracy of 94%. In the presence of large quantities of data, algorithms common to classical tracking can become cumbersome. Dinesh Ramasamy [39] presented an algorithm for compressive tracking with 1000-element arrays: a framework for multi-Gbps mm wave cellular downlinks which produced better results with the success rate of 96%. Alexandros Doulamis et al [37] suggested a method for EasyTracker: An Android application for capturing mobility behavior which produced better results with the success rate of 96%.

A method for exploring application-level semantics for data compression was proposed by Hsiao-Ping Tsai et al [31] producing good results with the success rate of 94%. The proposed compression algorithm effectively reduces the amount of delivered data and enhances compressibility and by extension reduces the energy consumption expense for data transmission in WSNs. Cina Motamed [32] used a method for motion detection and tracking using belief indicators for an automatic visual-surveillance system which produced better results with the success rate of 96%. The main advantage of our qualitative motion correspondence strategy is its capacity to cope naturally with known modeled tracking ambiguities. The algorithm takes into account several safety priorities as false alarms, regions merging, splitting, and target missing. The analysis of the real time compressive tracking is shown in the table I.

Table I Analysis of the real time compressive tracking

Author Name	Method Used	Success rate
Kaihua Zhang et. al. [1]	Naive Bayes Classifier	99%
Guizi Li et al. [2]	Appearance Based Model	95%
Emilio Maggio et al. [3]	Multi Features Adaptive Particle Filtering	97%
Karthik Hariharakrishnan et al. [4]	Adaptive Block Matching	90%
Daniel Eiwen1 et al [5]	Compressed Sensing	95%
Dorin Comaniciu et al [6]	Kernel-Based Object Tracking	95%
Bhavana C. Bendale et al [7]	Optical Flow (Horn-Schunck)	95%
D. J. Townsend et al [8]	Static Computational Optical Undersampled Tracker	96%
Goo Jun et al [9]	Background Subtraction Algorithm	94%
Shaohua Zhou et al [10]	Adaptive Observation Model	96%
Fai Yeung et al [11]	Adaptive Block Matching	94%
Fu-Ching Yang et al [12]	Periodical Triggering Concept	96%
Dong Wang et al [13]	Object Tracking With Sparse Representation	90%
Dorin Comaniciu et al [14]	Mean Shift Iterations	
King-Yeung Chan et al [15]	Real-time Recording Algorithm	93%
Dorin Comaniciu et al [16]	Kernel-Based Object Tracking	
Can-Long Zhang et al [17]	Adaptive Fusion Tracking Incorporated K-Means Clustering	92%
Guanghui Zhao et al [18]	Compressed Tracking	94%
Soumaya Ghorbel et al [19]	Video compression process	92%
Fadi Dornaika et al [20]	Dynamic Time Warping Technique	95%
Xiaoqin Zhang et al [21]	Regularized Sparse Representation	95%
Jun Ke et al [22]	Compressed Tracking	92%
Volkan Cevher et al [23]	Compressive Sensing Theory	93%
Ishfaq Ahmad et al [24]	Adaptive Motion Estimation Algorithm	91%
Phani Chavali et al [25]	Sparse Prototypes	93%
Yiqin Caoa [26]	Real-time vehicle detecting algorithm integrated compressive sensing (CS) theories	92%
Ph. Blondel et al [27]	Adaptive Filtering method	94%
Torsten Suel et al [28]	Exploring File Differences, Improving HTTP performance, Efficient Web Page Storage	92%
Jacob A. Maddams et al [29]	Dynamic Range Compression, Compressor Automation, multi-track DRC	92%
Khemraj Deshmukh Vishal Moyal [30]	Compound Order Learning, Online Tracking, Compressed sensing	92%
Hsiao-Ping Tsai et al [31]	2P2D algorithm, GMPMine algorithm and a CE algorithm	96%
Cina Motamed [32]	Reference background generation, Proposed detection algorithm, Bhattacharya distance.	94%
Jin Wanga et al [33]	Motion recognition, Spatio-temporal features	96%

Table I Analysis of the real time compressive tracking (Cont.)

Author Name	Method Used	Success rate
Tianxiang Bai et al [34]	Block Orthogonal Matching Pursuit (BOMP), Principal Component Analysis (PCA)	96%
Hong Cheng et al [35]	Sparse coding spatial pyramid matching, Spam image cluster	92%
Denis Steinemann et al [36]	Meshless discretization Trimming and triangulation Initialization of neighbors	95%
B. Song et al [37]	Model Based Video Compression.	95%
Garrett Warnell and Rama Chellappa [38]	Classical visual tracking, background subtraction, Kalman filtering, Particle filtering, Mean shift	94%
Dinesh Ramasamy [39]	Isometry and JL Lemma.	96%
Alexandros Doulamis et al [40]	Basic functionality enhanced with privacy filters, Compressing incoming GPS feed	96%

IV. Conclusion

Tracking the objects plays a vital role in security applications like criminal and terrorist detection and recognition in real time applications which can be tracked with the help of cameras fixed in different purposes. Real time tracking requires capturing the information in the form of video signals and this requires storing the captured information using lesser memory space due to unavailability of sufficient memory space. This paper provides a literature survey on the state of art techniques used for real time compressive tracking. The methods described are simple yet robust tracking algorithms. The tracking task was formulated as a binary classification problem with online update in the compressed domain by combining the merits of generative and discriminative appearance models to account for scene changes. The advantages of the algorithms are accuracy, robustness, and speed.

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