International Journal of Biotechnology and Biochemistry
ISSN 0973-2691 Volume 13, Number 3 (2017) pp. 275-283
© Research India Publications
http://www.ripublication.com

A Noval System Architecture for Multi Object Tracking Using Multiple Overlapping and Non-Overlapping Cameras

Prof. Swati A. Sagar[1] and Prof. Dr. Anilkumar Holambe[2]

[1]Information Technology Department, BVCOEW,
Savitribai Phule University, Pune, India.

[2]Computer Engg. Department, College of Engg., Osmanabad,
Dr. B. A. M. University, Aurangabad, India.

Abstract

Typically, visual surveillance systems contain multiple cameras with overlapping and non-overlapping views used to improve an accuracy and the area coverage of the surveillance systems. The real-time and continuous capture of video data from cameras requires automatic analysis, object detection and tracking of objects before any malicious activity or event analysis can be performed on the video data. The existing systems rely on back- end database and servers to process video data from multiple cameras to track the objects. However, this paper presents a novel system architecture that allows peer-to-peer communication between the multiple cameras. Each camera is capable of tracking the object individually and equipped with processor, memory and communication medium. In addition, each camera only exchanges a small amount of data for consistent labelling of objects across the multiple cameras in real-time. This research work also presents a survey of multi-camera object/person tracking system. The goals of this research work are three-fold: i) serve as a guideline for researchers who are new to image/video processing and want to contribute to this research area, ii) provides a novel system architecture for consistently tracking of objects in multi-camera video surveillance systems, and iii) provides further research directions required into accuracy and quality-of-service assurance of video surveillance systems.

Keywords: Multiple cameras, tracking, multi-person detection and tracking.

1. INTRODUCTION

Cameras are widely used in various applications of surveillance and statistics gathering such as military, commercial application, sports analysis and public transportation. Tracking of objects is an essential characteristic of video analysis system. Instead of manual viewing and detection of objects from recorded video, real-time automatic detection and tracking of objects is becoming popular among researcher and real-world applications.

Existing research works for object detection is generally classified into background subtraction techniques [2], [4], [13], [15] and temporal difference techniques [1]. The idea behind background subtraction techniques is to build a model of the background and then subtract it from the frames to identify foreground pixels in the scene. These techniques require updation in the background model if there is a change in environment or background scene. According to the survey [16] of existing state-of-the-art object tracking solutions, the system with fixed cameras generally employs the background subtraction technique. On the other hand, the idea of temporal difference technique is to subtract two consecutive frames and then apply a threshold to the output. The pixel with higher difference than the threshold value are inferred as foreground pixels. However, temporal difference technique suffers from the background changing over time and it cannot accurately detect moving objects, as the overlapping part of the object will be removed.

1.1. Observations

We observed that The real-time video data from cameras requires automatic analysis, object detection and tracking of objects before any malicious activity or event analysis can be performed on the real-time captured video data. Due to the limited processing power and limited memory available in the cameras, it is crucial to develop a lightweight computer vision technique for real-time video analysis. Several research techniques proposed for object detection [4], [13], [15], [18]. However, these techniques developed and evaluated on PCs instead of low memory and low computation power based camera devices. In addition, much less attention has been given to the portability of the proposed techniques to an embedded platform.

1.2 Main Idea

The main idea of the proposed system is to develop a system that includes smart camera node which has the ability to perform multi-object tracking individually. The exchange of small amount of data between neigh- boring camera nodes only for the purpose of consistent labelling. Each node consists of a camera board that has a microprocessor, and a wireless mote. The camera board runs the novel background subtraction algorithm proposed in this paper, a fast object labelling technique and a lightweight object tracking algorithm.

A. Contributions

In summary, this research paper makes the following contributions:

1) Classifies state-of-the-art research performed in object detection and tracking using multiple cam- eras.
2) Presents a novel system architecture for coopera- tive object detection and tracking using multiple overlapping and non-overlapping cameras.
3) Proposed a novel object labelling technique across the cameras.
4) proposed a novel object tracking algorithm for multi camera system.
5) Provides guidelines and further research directions required in the object detection and tracking using multiple overlapping and non-overlapping cam- eras.

The rest of this research paper is organized as follows: Section II describes our motivation. Section III discusses the literature survey. Section IV presents system archi- tecture for ubiquitous applications. Section V suggest open research question in ubiquitous

2. MOTIVATION

We were motivated to perform this survey in order to enumerate and compare state-of-the-art research that proposed techniques for multiple objects tracking using multiple cameras. This research work presents a noval system architecture, a distributed framework designed to detect and track multiple objects across the cameras. This paper can become the starting point for anyone trying to understand, evaluate and develop techniques for multi object detection and tracking using multiple overlapping and non-overlapping cameras.

3. LITERATURESURVEY

A. Multi-camera Tracking with Overlapping camera Views

In the last decade [6], [10], [14] extensively research has been done on object tracking with partially overlap- ping cameras. In a multi-camera system, typically each camera is capable of tracking the objects indivdually. In [5] the authors proposed a novel approach for es- tablishing object correspondence across non-overlapping cameras. The proposed tracking algorithm exploits the redundance in paths that people and cars tend to follow, e.g. roads, walk-ways or corridors, by using motion trends and appearance of objects, to establish correspon- dence.

In [17] authors studied camera handoff, objects asso- ciation problems and proposed a novel multiple camera tracking helmet system. The technique proposed by authors stitch views from multiple cameras mounted on the helmet to one wide view for tracking objects, this simplifies the task of object tracking from multiple cameras. In [8] proposed a novel two-step method for the joint estimation of person position and track assignment in the context of a multi-person tracking system. The method leverages the possibilities offered by an overlap- ping camera setup, using multiview appearance models and occlusion information.

Another research direction [3], [7], [9] to relate the objects across multiple cameras is to convert all coordinates into a common 3D coordinate system. However, this approach depends on full calibration of the cameras that is very expensive and inconvenient. Even though many proposed systems by researchers has capability in camera for object detection and tracking, but the major limitation of those approaches is, they need a central processing system (servers or database) to analyze data and convert them into common 3D space.

B. Object Tracking across Non-overlapping Camera Views

In real-world wide-area surveillance system, it is not always possible to have cameras with overlapping views. Its very expensive and infeasible in some situations. Therefore, detecting and tracking objects across multiple camears with disjoint views becomes challenging task due to the lack of spatial continuity. Research solutions [11], [12] exploit spatio-temporal information to predict the objects positions when they are in the blind region by assuming linear motion model. An example of such technique is Kalman filter.

4. SYSTEMARCHITECTURE

This section presents a novel system architecture de- signed multi objects tracking using multiple overlapping and non-overlapping cameras. The main goal of a multi- camera tracking system is to establish correspondence between observations of objects between multiple cam- eras.

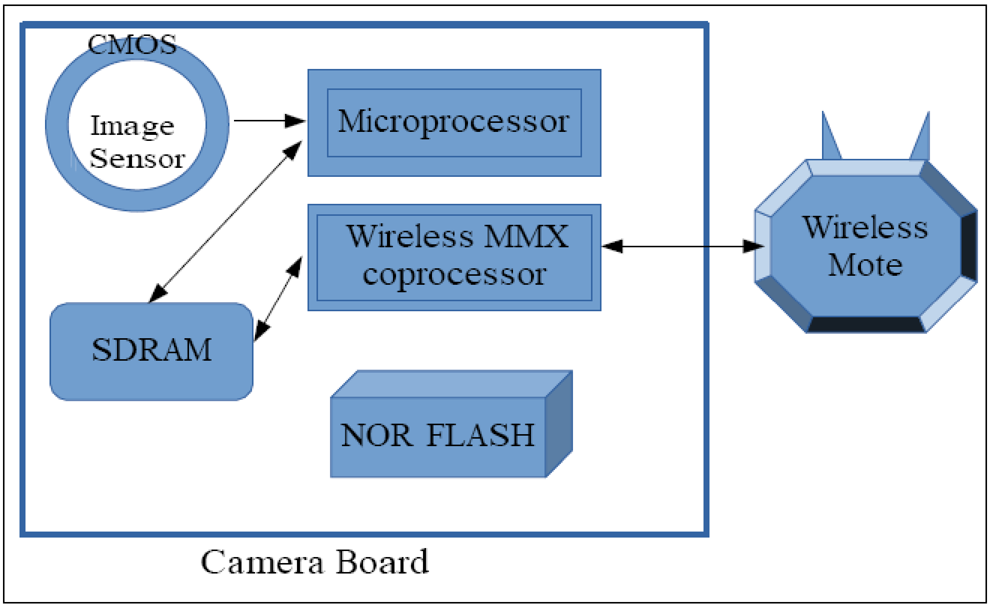

Fig. 1. A novel system architecture for objects detection using camera

Figure 1 shows the principal components of the proposed architecture. The main components include a camera circuit board and a wireless mote. The camera circuit board contains an image sensor, a microprocessor, external memories (such as SDRAM and Flash ROM) and power supply operated on battery. The Flash ROM runs embedded Linux operating system that has a JPEG compression library. The wireless mote consists of a microcontroller and IEEE 802.15.4-compliant radio.

A. Object Detection Technique

To detect an object camera circuit board is integrated with novel algorithm. The proposed algorithm uses a temporal difference method to build a background model. The variation of lighting as well as non-static background, such as water fountains and movement of trees makes the object detection problem very challenging. As we are interested only in detection and tracking of objects, it is crucial to differentiate between non-static background and objects. To achieve this, the proposed algorithm is based on the history of the pixel location. For each frame, the algorithm classifies each pixel either as a background or a foreground pixel. The background pixel is represented by 0 and a foreground pixel is represented by 1. For each pixel, a counter is maintained that stores the number of changes in the state of the pixel during last 30 frames. That is, for every pixel the corresponding counter of that pixel stores the information about the number of times the value of the pixel is changed from 0 to 1 or vice versa. The stability of the pixel value shows that it is a static background pixel and varying value of counter indicates that it is a non-static background. This proposed technique is lightweight because it doesn’t need to store RGB color values or various means or variances, instead only counter value of the pixel and background need to be recorded.

B. A Fast Object Labelling Technique

The object detection technique mentioned above usu- ally contains some white pixels that do not correspond to objects instead they are results of sensing errors, different lighting conditions or other movements of background objects such as trees. These pixels are referred as noise pixels and it is important to remove these noise pixels for accurate detection of objects. The proposed algorithm removes the noise pixels from foreground and then group the foreground pixels into blobs for labelling.

The proposed technique for labelling first forms a blob of objects. To achieve this, it visits every pixel in the binary frame image. When an unvisited foreground (white or pixel with value 1) is found, then a search is performed around that pixel to grow a blob until all white pixels gets connected to the previously found one. Every searched pixel is marked as visited. A predefined threshold value is used for the minimum blob size. If the threshold value is greater than the number of pixels in a blob then that blob is removed from the foreground and it is inferred as a group of noise pixels. These noise pixels are eliminated by settings all pixels in that blob to 0 (black). The each blob found in the frame gets a label.

C. Object Tracking Algorithm

Tracking multiple objects through multiple cameras is very complex and challenging task when it needs to be performed on camera with limited processing power and memory. Therefore, we used a PC for computation and tracking of multiple objects across multiple cameras. A rectangular box is formed around each foreground blob for tracking of objects.

For each detected blob, a new tracker is created and blob data is transferred to a PC for further computation. The intensity histogram of the detected blob is built and saved as the model histogram. In addition, the tracker also keeps the coordinates of the box formed around the blob and a label that will be used for tracking of the object. Each tracker from different camera’s view are matched with similarity coefficient. If the similarity coefficient is greater than the threshold, then objects are detected across multiple cameras and same lable is used for objects across multiple cameras.

5. RESEARCH QUESTIONS

Due to the limited processing power and limited memory available in the cameras, it is crucial to develop a lightweight computer vision technique for real-time video analysis.

Existing research solution failed to ad- dress challenges and research problems of the portability of the proposed techniques to an embedded platform.

The need to lightweight object detection and tracking solutions generates a number of important research questions:

- How to estimate efficiently the trajectory of an object as the object moves in an area of interest.
- How to perform subspace mapping effectively and efficiently.
- How often background information is needed to be updated and how frequently system needs to consult to the context information database.
- How to effectively and efficiently communicate with peer nodes.
- How to exploit the redundance in paths that people and cars tend to follow, e.g. roads, walk-ways or corridors, by using motion trends and appearance of objects, to establish correspondence

6. CONCLUSION

The real-time and continuous capture of video data from cameras requires automatic analysis, object detection and tracking of objects before any malicious activity or event analysis can be performed on the video data. The existing systems rely on back-end database and servers to process video data from multiple cameras to track the objects. This research paper presents a novel sys- tem architecture that allows peer-to-peer communication between the multiple cameras. Each camera is capable of tracking the object individually and equipped with processor, memory and communication medium. This paper can also become the starting point for anyone trying to understand, evaluate and develop techniques for multi object detection and tracking using multiple overlapping and non-overlapping cameras.

REFERENCES

[1] C. H. Anderson, P. J. Burt, and G. S. V. D. Wal. Change detection and tracking using pyramid tranform techniques. Pro- cedding of the SPIE Intelligent Robots and Computer Vision, 1985.

[2] M. Casares and S. Velipasalar. Light-weight salient foreground detection for embedded smart cameras. Procedding of the ACM/IEEE Intl Conf.on Distributed Smart Cameras, 2008.

[3] C. del Blanco, R. Mohedano, N. Garcia, L. Salgado, and F. Jaureguizar. Color-based 3d particle filtering for robust tracking in heterogeneous environments. Procedding of the 2nd ACM/IEEE Intl Conf. on Distributed Smart Cameras, 2008.

[4] I. Haritaoglu, D. Harwood, and L. S. Davis. Real-time surveil- lance of people and their activities. Procedding of the IEEE Trans. on Pattern Analysis and Machine Intelligence, 2000.

[5] Omar Javed, Zeeshan Rasheed, Khurram Shafique, and Mubarak Shah. Tracking across multiple cameras with disjoint views. Procedding of the Ninth IEEE International Conference on Computer Vision (ICCV 2003), 2003.

[6] S. Khan and M. Shah. Consistent labeling of tracked objects in multiple cameras with overlapping fields of view. Procedding of the IEEE Trans. on Pattern Analysis and Machine Intelligence, 2003.

[7] L. Lee, R. Romano, and G. Stein. Monitoring activities from multiple video streams: Establishing a common coordinate frame. Procedding of the IEEE Trans. on PAMI, 2000.

[8] Dariu M. Gavrila Martijn C. Liem. Joint multi-person detection and tracking from overlapping cameras. Procedding of the Computer Vision and Image Understanding, 2014.

[9] A. Mittal and L. Davis. M2 tracker: A multi-view approach to segmenting and tracking people in a cluttered scene. Procedding of the Intl Journal of Computer Vision, 2003.

[10] B. Moller, T. Plotz, and G. Fink. Calibration-free camera hand- over for fast and reliable person tracking in multi-camera setups. Procedding of the Proc. of Intl Conf. on Pattern Recognition, 2008.

[11] E. Monari, J. Maerker, and K. Kroschel. A robust and efficient approach for human tracking in multi-camera systems. Pro- cedding of the IEEE Intl Conf. on Advanced Video and Signal Based Surveillance, 2009.

[12] R. Pflugfelder and H. Bischof. Tracking across non-overlapping views via geometry. Procedding of the Intl Conf. on Pattern Recognition, 2008.

[13] C. Stauffer and W. E. L. Grimson. Learning patterns of activity using real-time tracking. Procedding of the IEEE Trans. on Pattern Analysis and Machine Intelligence, 2000.

[14] S. Velipasalar, J. Schlessman, C. Chen, W. Wolf, and J. Singh. A scalable clustered camera system for multiple object tracking. Procedding of the EURASIP Journal on Image and Video Processing, 2008.

[15] C. R. Wren, A. Azarbayejani, T. Darrell, and A. P. Pentland. Pfinder: Real-time tracking of the human body. Procedding of the IEEE Transaction on Pattern Analysis and Machine Intelligence, 1997.

[16] A. Yilmaz, O. Javed, and M. Shah. Object tracking: A survey. Procedding of

the ACM Computing Surveys, 2006.

[17] Zirui. Zhang and Jun. Cheng. Multi-camera tracking helmet system. Procedding of the Journal of Image and Graphics, 2013.

[18] Z. Zivkovic. Improved adaptive gausian mixture model for background subtraction. Procedding of the International con- ference on the Pattern Recognition, 2004.